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User's Guide for the Three-Dimensional Stability Analysis/Design (3DSAD) Program

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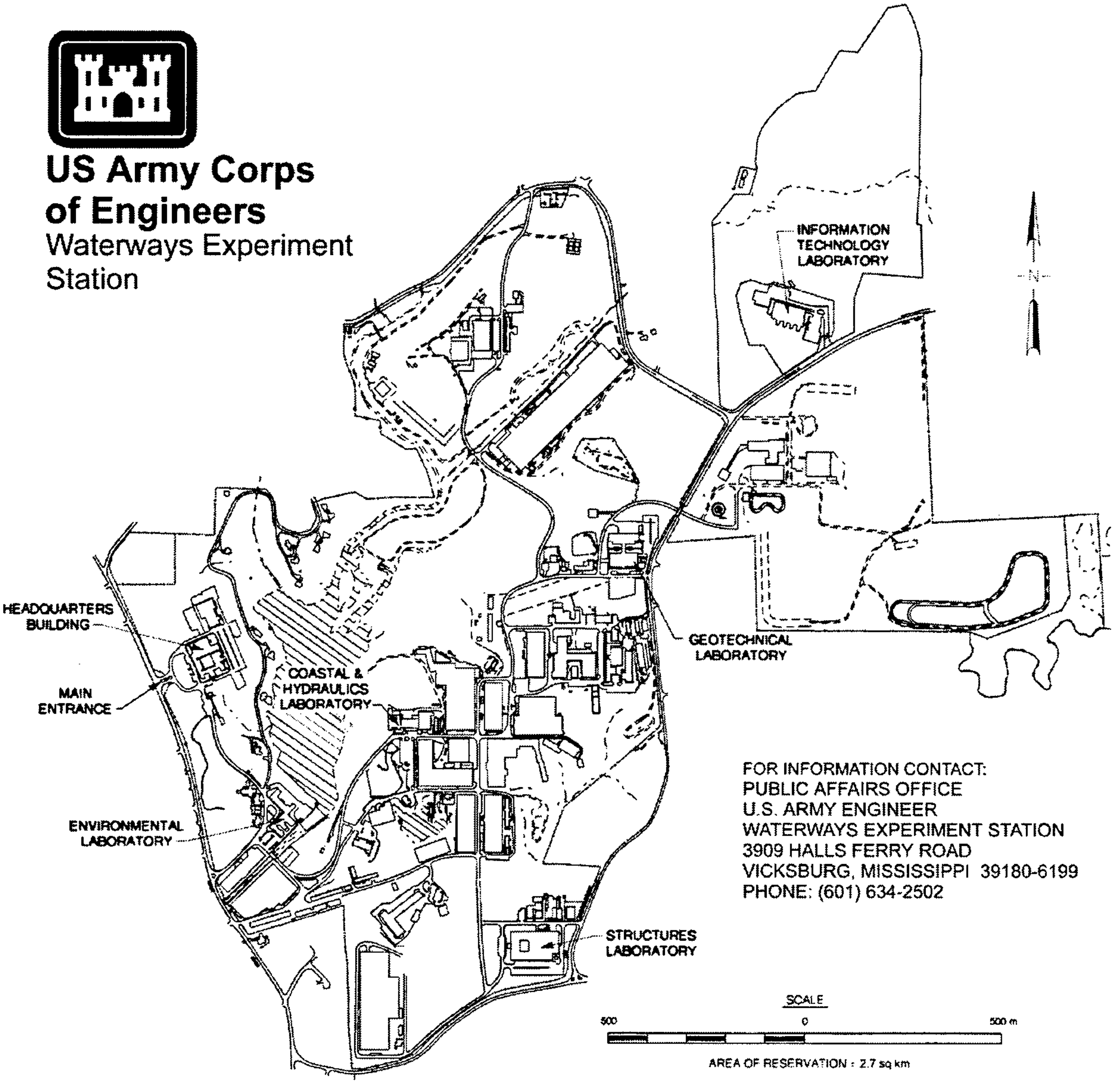
Prepared for Headquarters, U.S. Army Corps of Engineers

US Army Corps of Engineers
Waterways Experiment Station



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Preface

The report herein was written to document the updated version of the Three-Dimensional Stability Analysis/Design (3DSAD) computer program. The work was done under the guidance of the Massive Concrete Structures subgroup sponsored under the Computer-Aided Structural Engineering (CASE) project funded by Headquarters, U.S. Army Corps of Engineers.

This report was originated by Ms. Deborah K. Martin, Computer-Aided Engineering Division (CAED), Information Technology Laboratory (ITL), U.S. Army Engineer Waterways Experiment Station (WES), and completed by Dr. Fred T. Tracy, CAED, and Mr. Mark R. Elliott, DynCorp. Mr. Elliott is also acknowledged for the development of the Windows version of 3DSAD documented in this report. Contributions to the Locks chapter were provided by Ms. Monica Greenwell, Louisville District, Mr. John Burnworth, Vicksburg District, Mr. Robert Taylor, Great Lakes and Ohio River Division, Mr. Richard K. Rutherford, Huntington District, and Dr. Robert M. Ebeling, WES.

The work was coordinated under the general supervision of Mr. H. Wayne Jones, Chief, CAED, and Dr. N. Radhakrishnan, Director, ITL. Mr. Jones is also the Program Manager of the CASE project.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Robin R. Cababa, EN.

1 Introduction

Description of Report

Purpose

The Computer-Aided Structural Engineering (CASE) Task Group on three-dimensional stability (now a part of the Massive Concrete Structures Task Group) developed a three-dimensional stability analysis/design (3DSAD) computer program to aid design engineers in performing their computations. The program was developed in stages, and thus several reports and modules were written. This report consolidates the documentation for the modules thus far completed into a single manuscript.

Outline

An introduction is first given where an overview of 3DSAD and the individual modules are given. Second, the general modules are described in detail with example problems for each module given. A reference guide containing a listing of commands by category with description, syntax, and examples is also given for each module. Third, the specific modules for dams (CDAMS) are described. Here, explanations on doing an analysis, design, and the six standard load cases are presented. Finally, the ability to do a nonstandard problem is illustrated where the user first runs CDAMS to get data files, then modifies the produced data, and finally manually runs the general modules to get the needed results. This concept will be illustrated by applying it to analyze locks examples provided by practicing Corps engineers.

Both general purpose and specific modules have been developed. Currently, the four general modules are as follows:

a. *Geometry.* Defines geometry based on two-dimensional (2-D) cross sections extruded into the third dimension, eight-node brick elements, and clusters of planar polygons and bicubic patches. Performs volume, weight, and centroid computations. Utilizes interactive computer graphics.

b. *Loads.* Computes forces and moments for the defined loads on a general 3-D structure. Uses all of the capability of the General Geometry Module to define and display loads as "pressure volumes."

Can define point loads. Allows the definition of different load cases. Can begin with a description of soil and water levels and apply these to geometric pieces.

c. *Analysis.* Performs overturning, bearing, and sliding computations for any planar or near-planar base.

d. *Free-Body.* "Clips" the structure and loads by an arbitrary plane to produce a "free body" so that computations can be performed on the new part.

In addition to the general capabilities that are useful for any 3-D structure, 3DSAD also provides for simplified geometry and loads input, along with criteria check and design modules, for specific structures. Specific structure modules have currently been developed for dams (CDAMS). CDAMS in fact creates data files for the general geometry, loads, and analysis modules so an analysis can be done with a minimum of effort from the user. After an analysis has been done, the criteria check module tells of deficiencies so the user can fix the geometry and cycle again. Figure 1 shows a general schematic of 3DSAD.

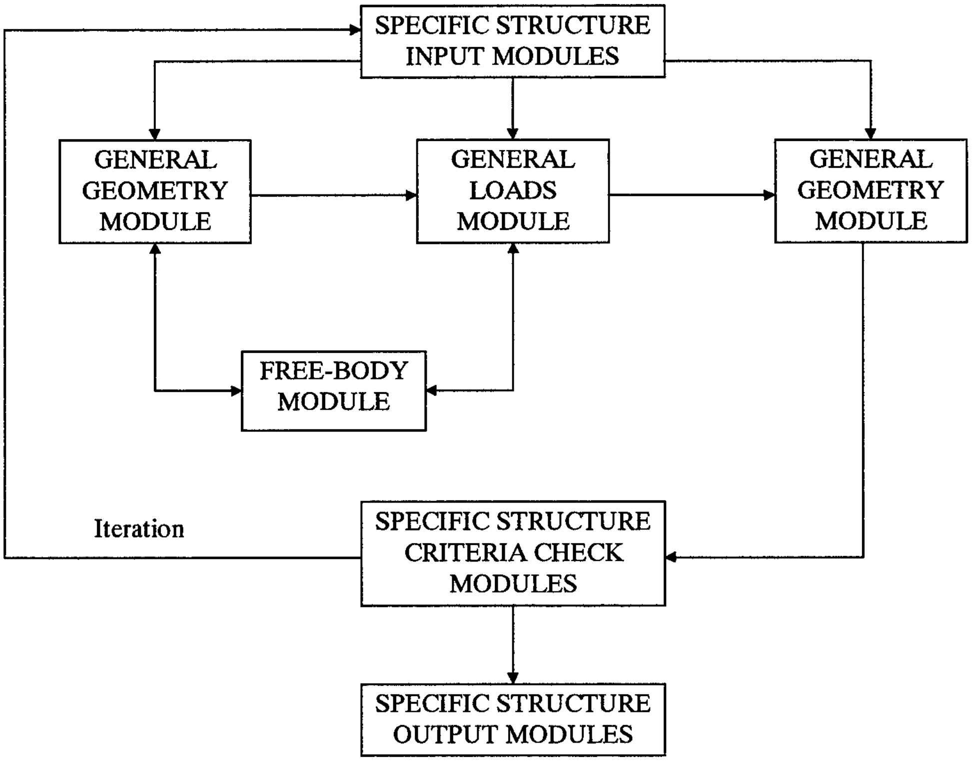


Figure 1. General schematic of 3DSAD

Coordinate System

The coordinate system used in all computations is shown in Figure 2, and this is a right-handed system.

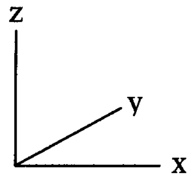


Figure 2. Coordinate system

Description of Modules

A brief description of the modules will now be given.

General Geometry Module

The General Geometry Module is used to define the geometry of the structure, display it, and then compute mass properties. There are three basic ways to define geometry:

a. Block. A 2-D cross section that is extruded into the third dimension.

b. Brick. Eight-node finite element brick element.

c. Surfaces. A group of planar polygons and bicubic patches fitted together to form a solid.

Each individual piece of geometry is given a four-character name for identification. The pieces are combined to form the complete structure. The ability to clip the geometry by an arbitrary plane is also available in 3DSAD.

The volume, weight, and centroid of each named piece of geometry and the sum total of them are all available by giving the VOLUME command. Most of the computations are done using exact line and surface integrals, making the results very accurate and the running time extremely small.

General Loads Module

The General Loads Module uses three methods to construct loads.

a. Pressure volume. Applying a density and direction to a volumetric piece.

b. Point load. Applying a force at a point.

c. Simplified load commands. Giving water and soil elevations and identifying where on the structure they are to be applied.

Pressure volumes and point loads can also be combined to form load cases.

The forces and moments about the global origin of each named load description and the sum total of each, respectively, can be computed by giving the FORCE command. As with doing the mass properties, most of the computations are done using exact line and surface integrals, making the results very accurate and the running time extremely small.

General Analysis Module

Most programs for stability use a 2-D analysis with a rectangular base. However, the General Analysis Module does a general 3-D analysis and allows for a definition of a general planar or near-planar base oriented in any way in space. The analysis uses the general flexure formula (limit equilibrium analysis) for computing base pressures from a resultant force and uplift. When a base is found to be in noncompression, an iterative process is used with the uplift being recomputed at each iteration and then added to the input to obtain the total resultant. When convergence is achieved, the results are printed.

Free-Body Module

The practicing engineer not only needs to perform an analysis at the base of the structure but also at other elevations and cross sections. Therefore, the ability to "clip" the structure with a single or multiple planes is needed to produce a free body containing a new definition of geometry and loads. The Free-Body Module is a utility written to facilitate this process. This rigid body type analysis is good for a coarse approximation of the stresses within the structure. If a more detailed analysis is required, the finite element method should be used.

CDAMS

CDAMS is a set of specific structure modules for dams. An overflow with optional pier and nonoverflow cross section is available through the Dams Input Module. As long as the given dam can be constructed by using the variables given, then CDAMS can be used to perform the stability computations. Six standard load cases as outlined in Engineer Manual 1110-2-2200 are available. The Criteria Check Module automatically checks sliding, maximum bearing, and percentage of effective base criteria for each load case requested.

Interactive Graphics

The geometry can be interactively displayed on the screen using PLOT, ROTP, WINDOW, ZOOM, etc., commands. Each piece of geometry can also be assigned a color. Shaded, hidden line, and translucency options are also available.

Installing 3DSAD

Insert the distribution diskette into your machine's 3 ½ in. floppy drive. From the Windows Explorer, click on that drive's icon in the *Folders* half of Explorer. The file name *Setup.exe* will appear on the *Files* side. Double click the *Setup.exe* file.

An alternative method is to click your system's *Start* button and select the *Run...* choice. Type in the drive letter of the 3 ½ in. floppy drive, a backslash, and "Setup" (A:\Setup). Click on the *OK* button or press the *Enter* key.

The installation routine will guide you through the process on installing the program on your machine, giving you the opportunity to place the executable and sample data files wherever you wish, and also allow you to cancel at any time. Key points are the following:

a. Select the directory in which you want 3DSAD to be installed. By default it will be *C:\Program Files\CASE\3DSAD*. You may change this default by either typing in a new destination directory or by pressing the *Browse* button and selecting one by navigating your machine's directory structure.

b. Next you will be asked whether or not you want to back up any files that might be replaced by the installation routine.

c. If you answered *Yes* to the above question, you will be asked where you want any replaced files to be copied. The default is *C:\Program Files\CASE\3DSAD\Backup*. You may change this default by either typing in a new destination directory or by pressing the *Browse* button and selecting one by navigating your machine's directory structure.

d. The installation program will now copy all the necessary files onto your system based on the directories that you chose.

When complete, a new item will be placed on your system's main menu bar under the *Programs* menu choice. This item will be called *CASE Programs*. When you click on this new menu item, another submenu will appear that will have the item *3DSAD*.

Starting 3DSAD

Start the program by clicking your system menu *Start* button, *Programs,* then the *CASE Programs – 3DSAD* menu sequence. An alternate method is to open the Windows Explorer and find the subdirectory you told the installation routine to install the program in, then double click on the file *3DSAD.exe*. Creating a short cut is a way to access 3DSAD even quicker.

Location of Data Files

By default the program will look for data files in the same directory where the executable was originally installed. You can change where the program will look for data and write output files by selecting the *Change Data Directory* menu choice located on the main menu bar under the *File* option. You can access the menu at any time you are at the `COMMAND?` prompt.

Click on the *File* main menu choice, and then click the *Change Data Directory* option. A standard Windows *Open File* dialog box will appear at the upper left corner of the program's main window. Use the dialog box to navigate your machine's directory structure and **choose any file** in the directory you want to be the current one, then click the *OK* button. You can also type in a file name; it does not matter if it exists or not. Nothing will happen to the file that was chosen or typed. Windows just needs a file name so it can parse out the drive letter and full path.

An alternative to the above procedure is carry out the following steps:

a. Click on the system *Start* button and select *Settings*, and then *Task Bar and Start Menu....* A dialog box will appear.

b. Click on the *Start Menu Programs* tab and choose the *Advanced* button. A Windows Explorer window will appear with the "Start Menu" subdirectory highlighted.

NOTE: On a machine running Windows NT, you will need to carry out the following steps, but start at the *Start Menu* under the *All Users* directory instead of your individual user directory. For those running Windows 95, the *Programs* directory that is highlighted is the right place from which to start.

c. Click on the plus sign (+) next to the *Programs* directory under the *Start Menu* directory. An expanded list of items will appear, each one corresponding to an item on your system's main menu (the same thing that appears when you press the *Start* button and then select the *Programs* menu choice).

d. Find the item called *CASE Programs* and click it one time. A list of shortcuts will appear on the right side (the *Files* side) of the Explorer window. Find the item named *3DSAD* and **right click** that item. A pop-up menu will appear, with the last item being *Properties*. Click the *Properties* choice. A dialog box will appear with two tabs: *General* and *Shortcut*. Click the *Shortcut* tab to bring it to the front if it is not there already.

e. There is a text box called *Start in*. The directory in this box is the directory in which the program will look for files. If you want the program to look for files in another place, other than the directory where the executable was installed, type in the full path name to that directory in this text box. When finished, click the *Apply* button, then the *OK* button. Then close out the Windows Explorer window and the *Taskbar Properties* dialog box.

For additional information about Windows shortcuts, refer to your systems on-line and/or hard copy documentation.

Uninstalling 3DSAD

Do not just delete the files in the directory where the program was installed. Instead, do the following:

a. Click on the system's *Start* button and click the *Settings* selection.

b. Choose *Control Panel.*

c. Find the *Control Panel* item called *Add/Remove Programs* and double click it.

d. In the list box, find the item called *CASE Program 3DSAD* and click it so it is highlighted.

e. Click the *Add/Remove* button and follow the system's instructions.

2 General Geometry Module

Introduction

The General Geometry Module is used to define the geometry of the structure, display it, and then compute mass properties.

Geometry definition

As described in the introduction, there are three basic ways to define geometry:

a. *Block.* A 2-D cross section that is extruded into the third dimension.

b. *Brick.* Eight-node finite element brick element.

c. *Surfaces.* A group of planar polygons and bicubic patches fitted together to form a solid.

Each individual piece of geometry is given a four-character name for identification. The pieces are combined to form the complete structure.

A block is constructed by first defining points that describe a cross section, any curves between the points, and then defining the sweep to form the solid object. Figure 3 shows an example of a nonoverflow cross section of a dam, and Figure 4 shows the generated 3-D block. Note that the culvert requires the need to define holes. Once the block has been created, it can be rotated or moved to any new position. The sweep or extrusion can be either straight back into the third dimension or axisymmetrically if a polar coordinate system has been turned on.

The brick is simply an eight-node finite element brick, and it works well as a tool to fill in nonstandard geometry. Figure 5 shows an example of a brick.

Surfaces are used to do a boundary representation of a solid piece of geometry. Along with planar pieces, bicubic patches are also available. These can exactly match bicubic B-Spline surfaces. An example of this type of geometry is given in Figure 6.

The ability to clip the geometry by an arbitrary plane is also available in 3DSAD. All clipped geometry is constructed using the boundary representation shown in Figure 6.

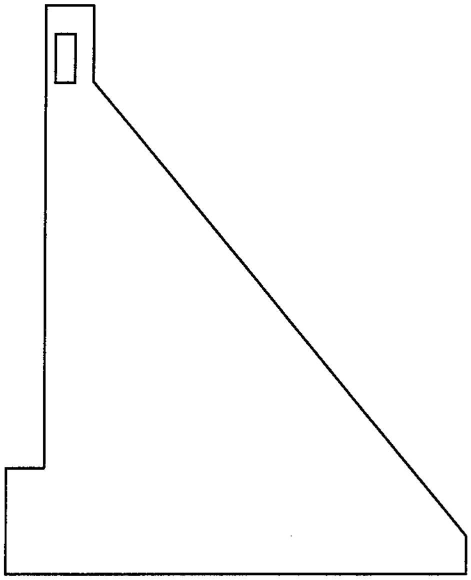


Figure 3. Nonoverflow dam cross section

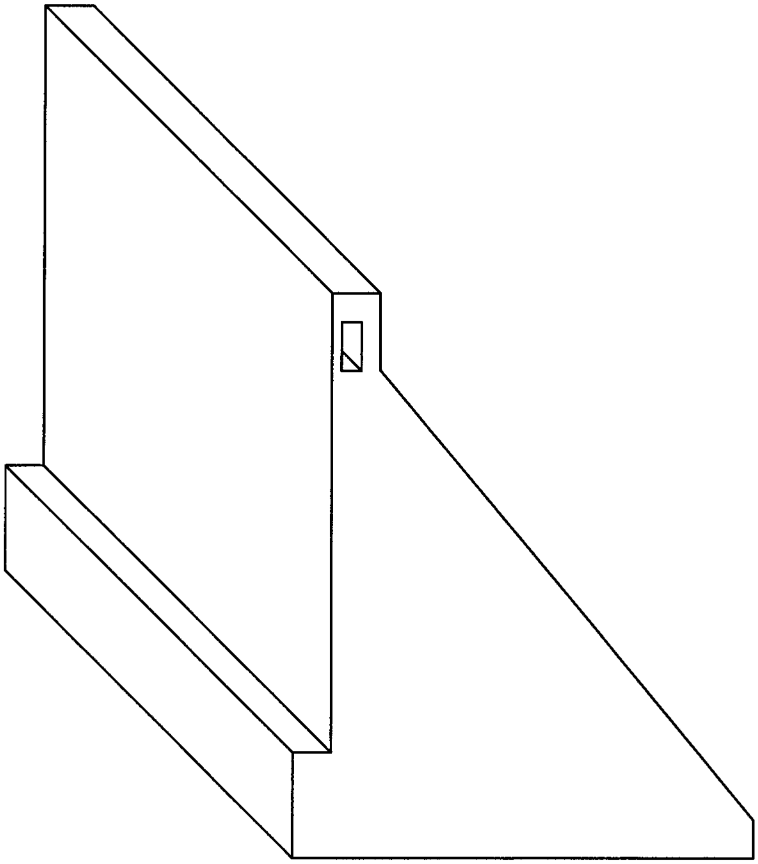


Figure 4. 3-D block

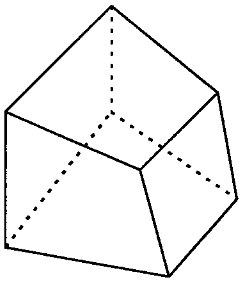


Figure 5. Eight-node brick

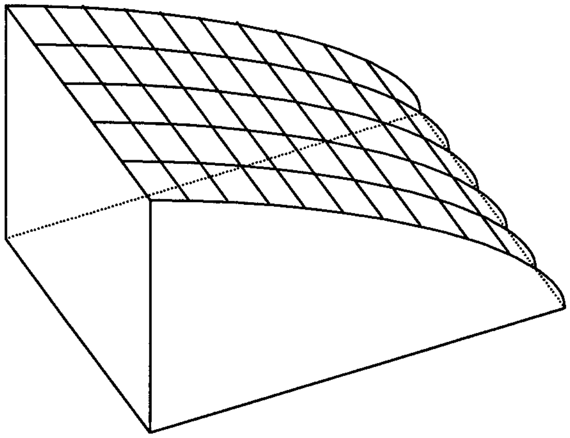


Figure 6. Boundary representation

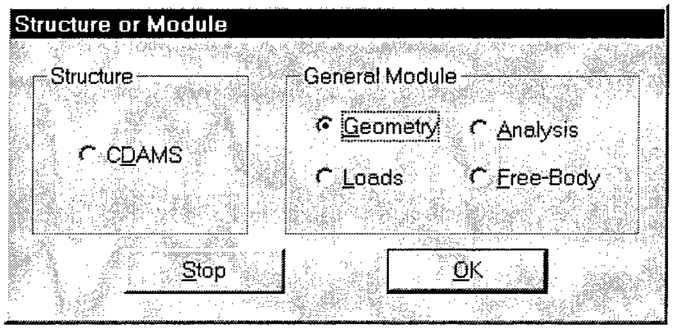
Mass properties

The volume, weight, and centroid of each named piece of geometry and the sum total of them are all available by giving the VOLUME command. Most of the computations are done using exact line and surface integrals, making the results very accurate and the running time extremely small.

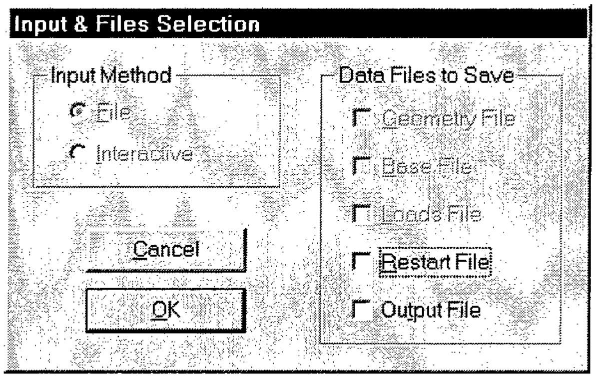
Running the Program

After the program is initiated, the following text appears on screen, and you are presented the following dialog box from which you select which module to use:

```
********************************
*  CASE PROGRAM    #X8100      *
*       VERSION    #1998/10/01 *
********************************
```



Select the option button marked *Geometry* and then select the *OK* button (selecting *Stop* will end the program). You are then presented with the following dialog box, with which you identify whether or not you want to save as permanent output the results of the run, and/or a restart file. If you choose not to save data in permanent files, the program will generate temporary files for use during the session.



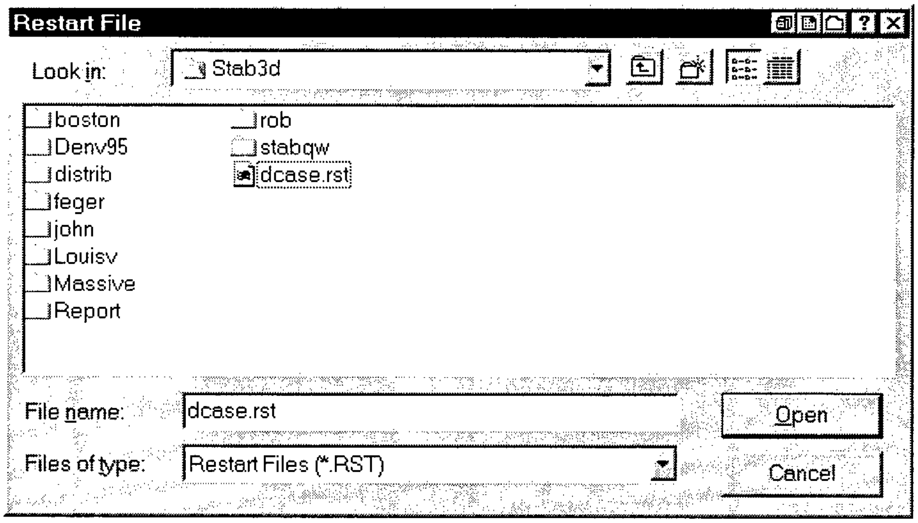
If you choose to save data in permanent files, click on the *Restart File* and/or the *Output File* check boxes and then select the *OK* button. You can turn off a selected option by clicking on the check box a second time. Selecting the *Cancel* button has the same effect as clearing both of the check boxes. Once you select the *OK* button, the following line appears on screen:

```
ENTERING GENERAL GEOMETRY MODULE.
```

If you elected to not save permanent files, you will be presented with the

```
COMMAND?
```

prompt; but if you chose to save data in permanent files, a dialog box will appear that allows you to choose a file name or enter a new one. The dialog box title bar identifies which type of file is being saved, and the default extension filter automatically shows only those files matching the proper file extension. If you chose to save both types of files, you are first prompted for the *Restart File* and then an *Output File*. The following example would appear if the *Restart File* option were selected:



Selecting an existing file will cause the data in the existing file to be overwritten. Typing in a new file name will cause that file to be created and used until such time as a new one is entered.

The *Restart File* saves all data pertaining to building a structure. These include any data input from another data file. The *Output File* stores the resulting weight and centroid of the structure in the form of a point load and is used as input into the General Loads Module; for example:

```
100 PTLD WT 17.584 20.000 11.004 0. 0. -8067.939
```

Once a file name is selected or entered and the *Open* button selected, the dialog box disappears and you are presented with the `COMMAND?` prompt. Selecting the *Cancel* button will cause the program to generate a temporary file for use instead of a named permanent file.

The `COMMAND?` prompt is the point to which you are returned when the program has processed the previous command and is ready to perform additional tasks. Help is available for each valid command by typing the command name followed by a space and a question mark. The proper syntax and available options for the entered command are presented. If you type in just a question mark, all available commands for the General Geometry Module are given as follows:

```
                        ------
                    DATA BUILDING
                        ------

                   XY XZ YZ RTZ
                      POINTS
            CIRCULAR ELLIPTICAL QUADRATIC
                   BLOCK FACE BR8
             TRANSLATE ROTD COPY REFLECT
```

```
          ------
          UTILITY
          ------

       INPUT VOLUME
      END GO RETURN
       CLIP CLEAR

          ------
         PLOTTING
          ------

     PLOT WINDOW ZOOM
      ROTP ISOMETRIC
      LABEL NOLABEL
  SOLID DASH HIDE SHADED
     COLOR BACKGROUND
     ERASE INITIALIZE
```

The basic command sequence is as follows:

Command	Meaning
INPUT FILENAME	Read data from file FILENAME.
PLOT	Plot data.
VOLUME	Compute volume, weight, and centroid.
RETURN	Return to main menu.

Each command will now be described in detail.

Commands

When giving a command, only the minimum number of letters of a command need to be given. The user can, however, type the entire word if he prefers. Commands and their accompanying data can be put into a data file or typed interactively while running the program. In giving the format for the commands, actual letters to be typed will be enclosed in the quotes to distinguish them from variable names. The quotes do not have to be typed when the user issues the command. The required letters are shown in all capitals; the optional letters are shown in lower case letters.

Data building

Blocks such as the nonoverflow cross section shown in Figures 3 and 4 are generated by first defining a cross section in either the x-y, x-z, or y-z plane and then extruding the cross section into the third dimension. Figure 7 shows an example of a cylinder where the circular cross section was generated in the x-y plane. Four points and four circular arcs between them were first defined, and then the BLOCK command was given. The data-building commands will now be described.

```
100 XY
110 POINTS 4
120 1 -5. 20. 5.
130 2  0. 15. 5.
140 3  5. 20. 5.
150 4  0. 25. 5.
160 CIRC 1 2 5.
170 CIRC 2 3 5.
180 CIRC 3 4 5.
190 CIRC 4 1 5.
200 BLOCK CYL1 0.15 40.
210 1. 1.
220 4 1 2 3 4
```

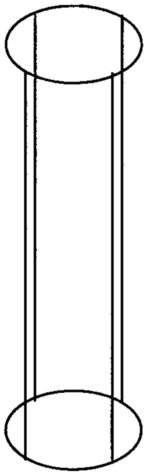


Figure 7. Example cylinder

XY. The format for the XY command is

"XY"

This command turns on the flag that states that all CIRCULAR and ELLIPTICAL commands define circular and elliptical arcs in the x-y plane, and all BLOCK commands start with cross sections in the x-y plane and grow in the z direction (Figure 7). This condition is held until an XZ, YZ, or RTZ command is encountered.

XZ. The format for the XZ command is

"XZ"

This command is like XY except that circular and elliptical arcs are defined in the x-z plane, and blocks start with cross sections in the x-z plane and grow in the y direction. XZ is assumed until an XY, YZ, or RTZ command is encountered. XZ is the default condition.

YZ. The format for the YZ command is

"YZ"

This command is like XY and XZ except that circular and elliptical arcs are defined in the y-z plane, and blocks start with cross sections in the y-z plane and grow in the x direction. YZ remains in effect until an XY, XZ, or RTZ command is encountered.

RTZ. The RTZ command establishes a local polar coordinate system (r, θ, z) in space. The z axis is established by two specified points (x_1, y_1, z_1) and (x_2, y_2, z_2), and (x_1, y_1, z_1) is the new origin. The format of the command is

"RTZ" X1 Y1 Z1 X2 Y2 Z2

where

X1, Y1, Z1 = (x_1, y_1, z_1)

X2, Y2, Z2 = (x_2, y_2, z_2)

θ is zero in the r-θ plane where the new local z axis strikes the r-θ plane when projected vertically. If the new local z axis is vertical, θ is zero along the line parallel to the x axis and passing through (x_1, y_1, z_1). All coordinates of points are specified in this system until another is specified. Also, the BLOCK command now expects an angle in degrees to produce a volume swept by a rotation rather than a translation. The cross section for a block can have curved or straight-line segments as before, but the points defining the cross section must all have the same θ value. Figure 8 shows a sample data file with its plot. RTZ is in effect until the XY, XZ, or YZ command is given.

```
10 RTZ 6. 5. 0. 6. 5. 1.
20 POINTS 4
30 1 10. 30. 2.
40 2 10. 30. 10.
50 3 15. 30. 10.
60 4 15. 30.  2.
70 BLOCK SPIN 0.1 90.
80 1. 1.
90 4 1 2 3 4
```

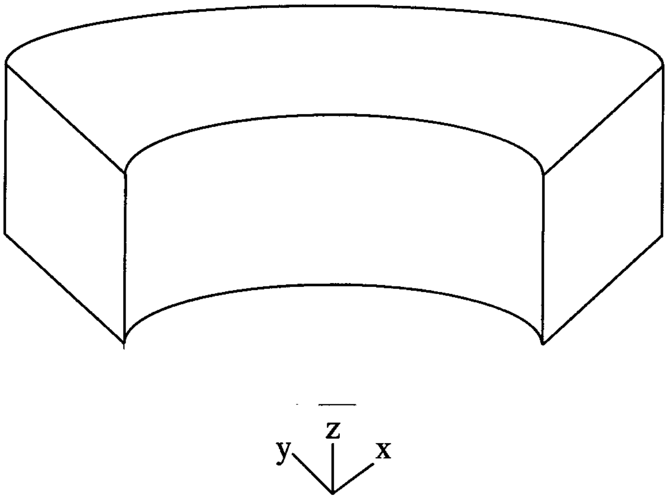


Figure 8. RTZ example

POINTS. The user first defines points using the POINTS command. The format is

"Points" NPT
N1 X1 Y1 Z1
N2 X2 Y2 Z2
.
.
NNPT XNPT YNPT ZNPT

or

N1 R1 THETA1 Z1
N2 R2 THETA2 Z2
.
.
NNPT RNPT THETANPT ZNPT

where

NPT = number of points

N1 = identification tag for 1st point

N2 = identification tag for 2nd point

.
.

NNPT = identification tag for NPTth point

X1 Y1 Z1 = 1st (x, y, z) point

X2 Y2 Z2 = 2nd (x, y, z) point

XNPT YNPT ZPNT = NPTth (x, y, z) point

R1 THETA1 Z1 = 1st (r, θ, z) point

R2 THETA2 Z2 = 2nd (r, θ, z) point

.
.

RNPT THETANPT ZNPT = NPTth (r, θ, z) point

After the first line, an identification number and (x, y, z) or (r, θ, z) coordinates for each point are given depending on whether planar or polar coordinates are specified by XY, XZ, YZ, or RTZ. Figures 7 and 8 show examples of data files having the POINTS command used. Note the line numbers before the geometry definition data.

CIRCULAR. After the user has defined the cross-section type and points in the specified coordinate system, he must then define any curved-line segments. That is, line segments between points are assumed straight unless otherwise specified. One option for curved-line segments is the circular arc. The possible ways of defining the circular are

"Circular" N1 N2 R
"Circular" N1 N2 R "Left"
"Circular" N1 N2 R "Right"

where

N1 = 1st point of circular arc

N2 = 2nd point of circular arc

R = radius of circular arc

"Left" = flag stating that center of circle is to left of line segment

"Right" = flag stating that center of circle is to right of line segment

N1 and N2 are two point numbers connected by a circular arc of radius R. "Left" or "Right" designates to which side of the line segment N1 to N2 is the center of the circle. The question of left or right depends on which side of the cross section you are looking. Therefore, the user must be looking in the -z direction if XY is specified, the -y direction if XZ is specified, the -x direction if YZ is specified, and the -θ direction if RTZ is specified to correctly decide if the center of the circle is left or right of the line segment. "Left" is the default. Figure 9 shows a modified version of the data file in Figure 7 where the outcome is the same, and Figure 10 shows the same cylinder defined in the XZ plane. Because the viewer typically looks in the +y direction rather than the -y direction required for an XZ block, orientation for the two cases appear different.

ELLIPTICAL. Another option for curved-line segments is the elliptical arc. The possible ways of defining the elliptical are

"Elliptical" N1 N2 A B
"Elliptical" N1 N2 A B "Left"
"Elliptical" N1 N2 A B "Right"

where

N1 = 1st point of elliptical arc

N2 = 2nd point of elliptical arc

A = semimajor axis of ellipse

B = semiminor axis of ellipse

"Left" = flag stating that center of ellipse is to left of line segment

"Right" = flag stating that center of ellipse is to right of line segment

```
100 XY
110 POINTS 4
120 1 -5. 20. 5.
130 2  0. 15. 5.
140 3  5. 20. 5.
150 4  0. 25. 5.
160 CIRC 1 2 5.
170 CIRC 3 2 5. RIGHT
180 CIRC 3 4 5. LEFT
190 CIRC 4 1 5.
200 BLOCK CYL2 0.15 40.
210 1. 1.
220 4 1 2 3 4
```

Figure 9. CIRCULAR command example for XY

```
100 XZ
110 POINTS 4
120 1 -5. 5. 20.
130 2  0. 5. 15.
140 3  5. 5. 20.
150 4  0. 5. 25.
160 CIRC 2 1 5.
170 CIRC 2 3 5. RIGHT
180 CIRC 4 3 5. LEFT
190 CIRC 1 4 5.
200 BLOCK CYL3 0.15 40.
210 1. 1.
220 4 4 3 2 1
```

Figure 10. CIRCULAR command example for XZ

N1 and N2 are two point numbers connected by an elliptical arc having semimajor axis length A and semiminor axis length B. “Left” and “Right” have the same meaning as in the CIRCULAR command. Figure 11 shows a modified version of the data file in Figure 7 with a plot of the new cross section where the circle is turned into an ellipse, and Figure 12 shows the same cylinder defined in the XZ plane.

```
100 XY
110 POINTS 4
120 1 -10. 20. 5.
130 2   0. 15. 5.
140 3  10. 20. 5.
150 4   0. 25. 5.
160 ELLI 1 2 10. 5.
170 ELLI 3 2 10. 5. RIGHT
180 ELLI 3 4 10. 5. LEFT
190 ELLI 4 1 10. 5.
200 BLOCK CYL4 0.15 40.
210 1. 1.
220 4 1 2 3 4
```

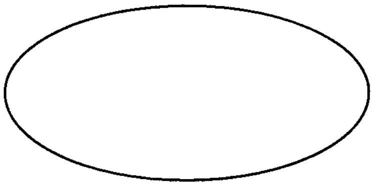


Figure 11. ELLIPTICAL command example for XY

```
100 XZ
110 POINTS 4
120 1 -10. 5. 20.
130 2   0. 5. 15.
140 3  10. 5. 20.
150 4   0. 5. 25.
160 ELLI 2 1 10. 5.
170 ELLI 2 3 10. 5. RIGHT
180 ELLI 4 3 10. 5. LEFT
190 ELLI 1 4 10. 5.
200 BLOCK CYL4 0.15 40.
210 1. 1.
220 4 4 3 2 1
```

Figure 12. ELLIPTICAL command example for XZ

QUADRATIC. The quadratic-line segment is provided for cases when the user needs a curved line segment that is not circular or elliptical. The command format is

"Quadratic" N1 N2 XQQ YQQ ZQQ [for XY, XZ, and YZ]
or
"Quadratic" N1 N2 RQQ THETAQQ ZQQ [for RTZ]

where

N1 = 1st point of quadratic arc

N2 = 2nd point of the quadratic arc

XQQ YQQ ZQQ = (x, y, z) interpolation point

RQQ THETAQQ ZQQ = (r, θ, z) interpolation point

N1 and N2 are the starting and ending point numbers, respectively, that the quadratic line goes through, and (XQQ, YQQ, ZQQ) is an intermediate interpolation point that the curve must also go through if XY, XZ, or YZ has been specified. If RTZ has been previously issued, (RQQ, THETAQQ, ZQQ) is the interpolation point in the polar coordinate system. Figure 13 shows an example data file and resulting cross section for the QUADRATIC command.

```
100 XY
110 POINTS 4
120 1 -5. 0.
130 2  0. -5.
140 3  5. 0.
150 4  0. 5.
160 QUAD 1 2 -4. -3.
170 QUAD 2 3  3. -4.
180 QUAD 3 4  4.  3.
190 QUAD 4 1 -3.  4.
200 BLOCK QU1 0.15 40.
210 1. 1.
220 4 1 2 3 4
```

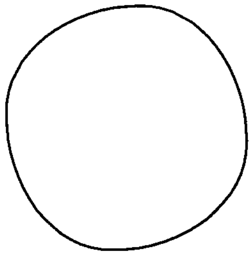


Figure 13. QUADRATIC command example

BLOCK. Perhaps the most useful way to define solids is the BLOCK command as provided in this program. A 2-D cross section defined in one of the principal planes using XY, XZ, YZ, or RTZ is allowed to grow in the third (perpendicular) direction. The format for this command is

"Block" NAME DENS DEPTH NHOLE [for XY, XZ, and YZ]
or
"Block" NAME DENS ANGLE NHOLE [for RTZ]
Do for the outer boundary and each hole,

SFX SFY XAPEX YAPEX HFX HFY [for XY]
or
SFX SFZ XAPEX ZAPEX HFX HFZ [for XZ]
or
SFY SFZ YAPEX ZAPEX HFY HFZ [for YZ]
or
SFX SFZ RAPEX ZAPEX HFR HFZ [for RTZ]

NPT N1 N2 N3 . . . NNPT

End Do

where

NAME = four-character name

DENS = density

DEPTH = how far cross section is extended for an XY, XZ, or YZ type block

ANGLE = angle in degrees cross section is rotated for a RTZ type block

NHOLE = number of holes in cross section

SFX = scale factor in x direction for far end of cross section

SFY = scale factor in y direction for far end of cross section

SFZ = scale factor in z direction for far end of cross section

SFR = scale factor in r direction for far end of cross section

HFX = scale factor in x direction for halfway point of cross section

HFY = scale factor in y direction for halfway point of cross section

HFZ = scale factor in z direction for halfway point of cross section

HFR = scale factor in r direction for halfway point of cross section

XAPEX = x apex value

YAPEX = y apex value

ZAPEX = z apex value

RAPEX = r apex value

NPT = number of points of outer boundary or hole

N1 = 1st point on outer boundary or hole

N2 = 2nd point on outer boundary or hole

N3 = 3rd point on outer boundary or hole

NNPT = NPTth point on outer boundary or hole

Figures 7-13 show examples of the BLOCK command. SFX, 5FY, SFZ, XAPEX, YAPEX, ZAPEX, RAPEX, HFX, HFY, HFZ, and HFR are parameters used to determine how the cross section is extruded and will be explained in detail below. These must be given for the outer boundary and every hole (such as a culvert). NPT is the number of points in the cross section; and N1, N2, N3, . . ., NNPT are the connectivity data for each cross section of the block. The outer boundary connectivity data are given in counterclockwise order when viewing an XY cross section in the -z direction, an XZ cross section in the -y direction, a YZ cross section in the -x direction, and an RTZ cross section in the -θ direction. The connectivity for each hole is done the same, except in clockwise order. Figure 14 shows Figure 7 expanded where the cylinder is converted to a hole.

```
100 XY
110 POINTS 8
120 1  -5. 20.
130 2   0. 15.
140 3   5. 20.
150 4   0. 25.
151 5 -10. 10.
152 6  10. 10.
153 7  10. 30.
154 8 -10. 30.
160 CIRC 1 2 5.
170 CIRC 2 3 5.
180 CIRC 3 4 5.
190 CIRC 4 1 5.
200 BLOCK CYL1 0.15 40. 1
201 1. 1.
202 4 5 6 7 8
210 1. 1.
220 4 4 3 2 1
```

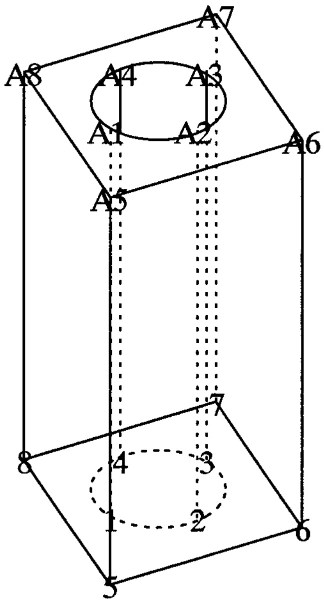


Figure 14. Example block with hole

Each original point of the XY cross section (numbered 1, 2, 3, etc.) above will have a corresponding point generated a distance DEPTH in the z direction (A1, A2, A3, etc.). The new (x, y, z) coordinates of these points are computed by

$$
\begin{aligned}
x_n &= (x_o - x_a)s_x + x_a \\
y_n &= (y_o - y_a)s_y + y_a \\
z_n &= z_o + d
\end{aligned}
\qquad (1)
$$

where

(x_o, y_o, z_o) = original point on cross section

(x_n, y_n, z_n) = new point

(x_a, y_a) = apex

s_x = scale factor in x direction

s_y = scale factor in y direction

d = depth

The other cross-section types are handled in a similar way. Note that if s_x and s_y are equal to one, then

$$\begin{aligned} x_n &= x_o \\ y_n &= y_o \\ z_b &= z_o + d \end{aligned} \qquad (2)$$

This allows (x_a, y_a) in the data files thus far given to default to zero and thus left off the data line. HFX and HFY are also left off the data line as the default linear growth extrusion is chosen. Figures 15-17 give examples of data files showing XZ blocks illustrating the use of SFX, SFZ, XAPEX, and ZAPEX.

HFX, HFY, HFZ, and HFR are scale factors for the halfway point of LENTH (d/2). In the examples shown thus far, they have been left out, defaulting to

$$\begin{aligned} h_x &= \frac{1}{2}(1 + s_x) \\ h_y &= \frac{1}{2}(1 + s_y) \end{aligned} \qquad (3)$$

```
100 XZ
110 POINTS 4
120 1  0. 0.  0.
130 2 10. 0.  0.
140 3 10. 0. 10.
150 4  0. 0. 10.
160 BLOCK BL1 0.15 20.
170 1. 1.
180 4 4 3 2 1
```

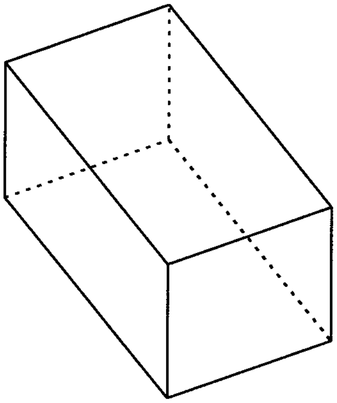


Figure 15. XZ block with no scaling

```
100 XZ
110 POINTS 4
120 1  0. 0. 0.
130 2 10. 0. 0.
140 3 10. 0. 10.
150 4  0. 0. 10.
160 BLOCK BL1 0.15 20.
170 1. 0.5
180 4 4 3 2 1
```

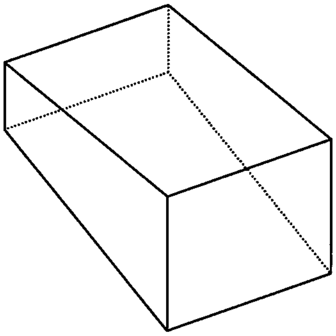


Figure 16. XZ block with z scaling and zero apex

```
100 XZ
110 POINTS 4
120 1  0. 0.  0.
130 2 10. 0.  0.
140 3 10. 0. 10.
150 4  0. 0. 10.
160 BLOCK BL1 0.15 20.
170 0.5 0.5 5. 5.
180 4 4 3 2 1
```

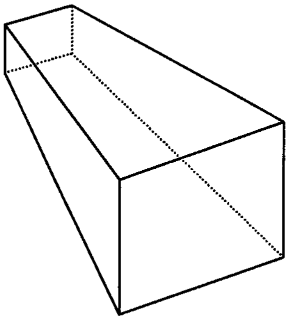


Figure 17. XZ block with x and z scaling and nonzero apex

This gives a linear variation in y in Figures 13-15. However, on input of different values than the default, the halfway point coordinates are computed from

$$
\begin{aligned}
x_h &= (x_o - x_a)h_x + x_a \\
y_h &= (y_o - y_a)h_y + y_a \\
z_h &= z_o + \frac{d}{2}
\end{aligned}
\tag{4}
$$

where (x_h, y_h, z_h) equals the new halfway point.

Then a quadratic variation in the tried dimension is accomplished as shown in the example in Figure 18.

```
100 XZ
110 POINTS 4
120 1  0. 0.  0.
130 2 10. 0.  0.
140 3 10. 0. 10.
150 4  0. 0. 10.
160 BLOCK BL1 0.15 20.
170 0.3 0.3 5. 5. 0.7 0.7
180 4 4 3 2 1
```

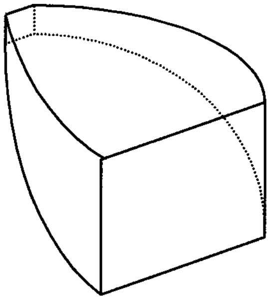


Figure 18. XZ block with quadratic variation

FACE. The FACE command is used to define a solid object by giving a boundary representation of its faces. Faces can consist of the following:

a. *Planar faces.* Straight or cubic sides.

b. *Bicubic patches.* Defined by 16 (x, y, z) points.

The format for this command is as follows:

```
“Face” NAME DENS NFACE

Do for each face,

   NPT N1 N2 N3 . . . NNPT [planar face]
                                   or
   “P” NPT N1 N2 N3 . . . NNPT [planar face]
                                   or
   “C” N1 N2 N3 . . . N16 [bicubic patch]

End Do
```

where

NAME = four character name

DENS = density

NFACE = number of faces

“P” = planar face

“C” = bicubic patch

NPT = number or points for planar face

N1 = 1st point

N2 = 2nd point

N3 = 3rd point

N16 = 16th point

NNPT = NPTth point

Notice that next comes the connectivity of each face with a P to designate a planar face and a C to designate a bicubic patch. If no letter is specified, P is the assumed default. The connectivity of a planar face consists of the number of points of the polygon followed by the point numbers. The order of the points must be counterclockwise if the outward normal to the face points out of the picture (-y direction). The connectivity of a bicubic patch consists of the 16 points given a row at a time from left to right and from bottom to top (assuming the outward normal of the patch is pointing toward the observer). Figure 19 shows an eighth of a sphere defined using the FACE definition capability. The sample problem therefore consists of one bicubic patch and three planar faces. As before, the faces must be numbered so that a right-hand screw advances toward the outward normal (holes can be produced by reversing this process) when turned in the direction of the numbering.

Planar Face. In an earlier version of the program, only straight-sided polygons were allowed. The cubic edges created from using bicubic patches can now be a part of a planar face. Note carefully however that in giving the connectivity data, the two intermediate points of a cubic-line segment are not given.

```
100 RTZ 50. 50. 50. 50. 50. 51.
110 POIN 14
120  1 10.    0.  0.
130  2 10.   30.  0.
140  3 10.   60.  0.
150  4 10.   90.  0.
160  5  8.66  0.  5.
170  6  8.66 30.  5.
180  7  8.66 60.  5.
190  8  8.66 90.  5.
200  9  5.    0.  8.66
210 10  5.   30.  8.66
220 11  5.   60.  8.66
230 12  5.   90.  8.66
240 13  0.    0. 10.
250 14  0.    0.  0.
260 FACE SPH1 0.15 4
270 C 1 2 3 4 5 6 7 8 9 10 11 12
271   13 13 13 13
280 P 3 14 4 1
290 P 3 14 1 13
300 P 3 14 13 4
```

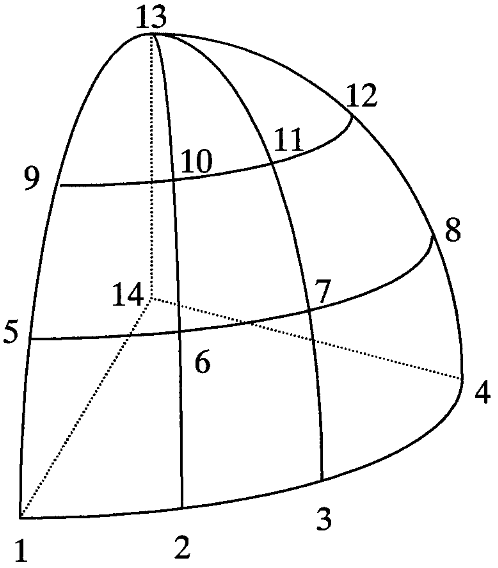


Figure 19. One-eighth sphere using the FACE command

Bicubic patch. The bicubic patch was chosen not only for its ability to model general shapes but also for its accuracy when modeling conic sections. Note that it has 16 points given by rows as shown. Four points can also coincide (as was needed in the sample) to form a triangular-shaped patch. If the patch is being used to model cones, cylinders, or spheres, it is important to place the points at equal angles apart. This rule was observed in the sample problem, and the volume is in error by 0.36 percent, which should be quite satisfactory. Care must be taken in this patch to observe the right-hand screw rule.

BR8. Another way to describe geometry is by the use of the eight-node brick element. Its format is

"BR8" NAME DENS
N1 N2 N3 N4 N5 N6 N7 N8

where

NAME = four-character name

DENS = density

N1 = 1st node of brick

N2 = 2nd node of brick

N3 = 3rd node of brick

N4 = 4th node of brick

N5 = 5th node of brick

N6 = 6th node of brick

N7 = 7th node of brick

N8 = 8th node of brick

Following the command, the user gives the eight nodes to define the element and connectivity. Care must be taken to number the nodes of the element, ensuring that they produce a positive volume. Figure 20 illustrates a typical example.

```
100 POIN 8
110 29  0.   0. 10.
120 30 10.   0. 10.
130 31 10. 10. 10.
140 32  0. 10. 10.
150 33  0.   0. 20.
160 34 10.   0. 20.
170 35 10. 10. 20.
180 36  0. 10. 20.
190 BR8 BR1 0.15
200 29 30 31 32 33 34 35 36
```

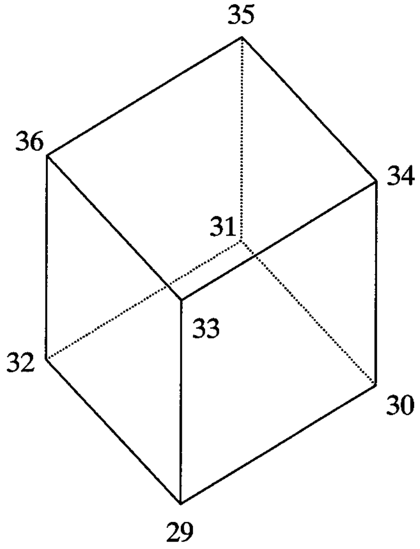


Figure 20. BR8 command example

TRANSLATE. Objects that have been defined can be moved or translated in space from one position to another using the TRANSLATE command. The possible options of this command are

"Translate"
"Translate" "POINts"
"Translate" "POINts" N1 N2
"Translate" "DENSity" DENS
"Translate" NAME

where

N1 = 1st point of group

N2 = 2nd point of group

DENS = density

NAME = four-character name

"POINts" = flag stating to translate points

"DENSity" = flag stating to translate by density

Note that points, items with the same density, and items with the same name can be translated. Figure 21 shows an example of the TRANSLATE command by moving the bottom four points of the brick -5 in the x direction.

ROTD. The ROTD command allows the user to permanently rotate a piece of geometry about a specified axis. This is different from the ROTP command, which only temporarily rotates the picture for easier viewing.

```
100 POIN 8
110 29  0.   0. 10.
120 30 10.   0. 10.
130 31 10.  10. 10.
140 32  0.  10. 10.
150 33  0.   0. 20.
160 34 10.   0. 20.
170 35 10.  10. 20.
180 36  0.  10. 20.
190 BR8 BR1 0.15
200 29 30 31 32 33 34 35 36
210 TRAN POIN 29 32
220 -5. 0. 0.
```

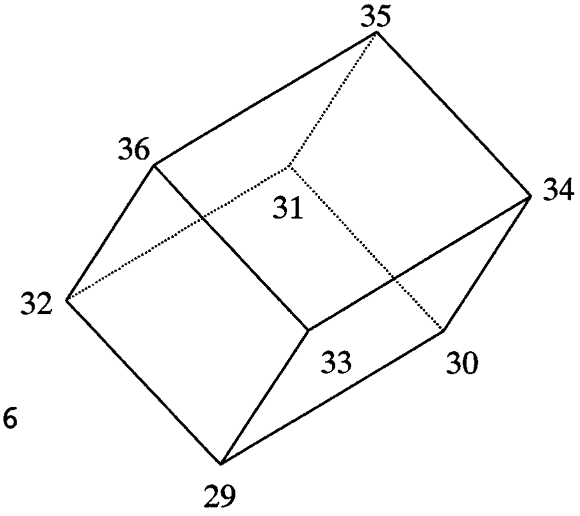


Figure 21. TRANSLATE command example

The specific format of the command is

"ROTD" "H" ANGLE NAME XO YO ZO
"ROTD" "V" ANGLE NAME XO YO ZO
"ROTD" "O" ANGLE NAME XO YO ZO

where

H = horizontal axis

V = vertical axis

O = outward axis

ANGLE = counterclockwise positive angle in degrees

NAME = four-character name

XO, YO, ZO = local origin of rotation coordinate system

H, V, and O are fixed axes around which rotations are made. ANGLE determines how much the piece is to be rotated about the given axis, and (XO, YO, ZO) is a point through which the given axes must go. Figure 22 shows an example of the ROTD and COPY commands.

```
100 XZ
110 POIN 3
120 1  0. 0. 0.
130 2 10. 0. 0.
140 3  5. 0. 5.
150 CIRC 2 1 7.072
160 BLOCK BL1 0.15 2.
170 1. 1.
180 3 3 2 1
190 COPY BL1 BL2
200 ROTD O 90. BL2 5. 0. 5.
```

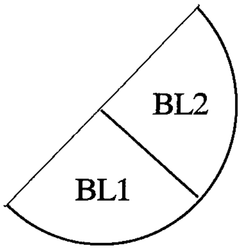


Figure 22. ROTD and COPY example

COPY. The COPY command copies or duplicates the geometry of a given name and puts it into a new name. The format of this command is

"Copy" NAMEl NAME2

where

NAMEl = geometry to be copied

NAME2 = name of resulting geometry

NAME2 can now be translated or rotated in space. Figure 22 also illustrates the COPY command.

REFLECT. The REFLECT command allows the user to reflect or mirror a piece of geometry about a plane parallel to the x-y, x-z, or y-z planes. The format for this command is

“REFlect” “X” XVAL NAME
“REFlect” “Y” YVAL NAME
“REFlect” “Z” ZVAL NAME

where

“X” XVAL = reflect about plane x = XVAL

“Y” YVAL = reflect about plane y = YVAL

“Z” XVAL = reflect about plane x = XVAL

NAME = four-character name

For example, to reflect an object identified by BL1 about the horizontal plane (parallel to the x-y plane), z = 100, use the command

```
REFLECT Z 100. BL1
```

Similar commands would be used for reflection about planes x = XVAL and y = YVAL. If “ALL” is given for NAME, the entire database of geometry is reflected. Figure 23 further illustrates the use of the REFLECT command.

Utility

There are utility commands that allow the user to input geometry, compute volume, etc. These will now be described.

INPUT. The INPUT command allows the user to input or read into memory a permanent data file saved on disc. Its format is

“INPut” FLNM1
“INPut” FLNM1 “P”

where

FLNM1 = file description (20 characters maximum)

"P" = flag requesting a detailed listing

If the P is typed, a detailed printout of the input file is also provided as if the commands had been done interactively.

```
100 POINTS 7
110 1  80.436 0. 740.000
120 2  88.250 0. 896.270
130 3 100.000 0. 901.500
140 4 169.370 0. 847.930
150 5 212.966 0. 785.650
160 6 244.976 0. 756.344
170 7 244.976 0. 740.000
180 ELLI 2 3 11.750 5.230
190 QUAD 3 4 134.685 0. 886.640
200 CIRC 6 5 100.000
210 BLOCK OVE1 0.155 49.000
220 1. 1.
230 7 1 2 3 4 5 6 7
240 COPY OVE1 OVE2
250 REFLECT X 0. OVE2
```

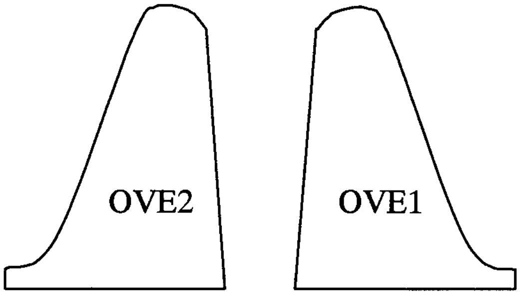


Figure 23. REFLECT data example

VOLUME. The VOLUME command allows the user to obtain volumetric data consisting of volume, weight, and centroid whenever it is typed. Its format is

"Volume"
"Volume" "ALL"
"Volume" NAME

where

NAME = four-character name

"ALL" = flag to do all geometric pieces

If VOLUME is typed, only the totals for the entire structure are given. If NAME is provided, only the volume data for geometry having the name are given. The ALL option will yield a detailed listing of all the data by name; for example, the result from the data in Figure 23 is

```
                               ---------
NO.  NAME    VOLUME         WEIGHT        XCG       YCG       ZCG

 1   OVE1   816462.50    126551.70     142.85    24.50    802.87
 2   OVE2   816462.60    126551.70    -142.85    24.50    802.87

    TOTAL  1632925.00    253103.40        .00    24.50    802.87
                               ---------
```

END. The END command is given to terminate running of the program. Its format is

"End"

GO. The GO command is issued when the program is being used for a specific structure such as a dam. Giving the GO command automatically causes the program to go on from the General Geometry Module to the General Loads Module. The format for this command is

"Go"

RETURN. The RETURN command is used to return to the *Structure or Module* Dialog Box so that the user can select another module. Typically, the next module is the General Loads Module. The format for this command is

"Return"

CLIP. The CLIP command allows the user to cut or clip the geometry by an arbitrary plane to produce a new structure for use as a free-body diagram or making new weight and centroid computations. The clipped data will be placed into a new data file specified by the user. Blocks, bricks, or faces not touched by the clipping plane will be placed untouched in the new file. The parts left over from a clip, however, will be converted to faces with the curved parts being modeled by bicubic patches and planar pieces having both straight and cubic sides. The specific format of the command is

"CLIp" "X" XVAL NAME
"CLIp" "+X" XVAL NAME
"CLIp" "-X" XVAL NAME
"CLIp" "Y" YVAL NAME
"CLIp" "+Y" YVAL NAME
"CLIp" "-Y" YVAL NAME
"CLIp" "Z" ZVAL NAME
"CLIp" "+Z" ZVAL NAME
"CLIp" "-Z" ZVAL NAME
"CLIp" N1 N2 N3 NAME

where

“X” XVAL = clip along plane x = XVAL and keep right part

“+X” XVAL = clip along plane x = XVAL and keep right part

“-X” XVAL = clip along plane x = XVAL and keep left part

“Y” XVAL = clip along plane y = YVAL and keep back part

“+Y” XVAL = clip along plane y = YVAL and keep back part

“-Y” YVAL = clip along plane y = YVAL and keep front part

“Z” ZVAL = clip along plane z = ZVAL and keep top part

“+Z” ZVAL = clip along plane z = ZVAL and keep top part

“-Z” ZVAL = clip along plane z = ZVAL and keep bottom part

NAME = four-character name

N1 = 1st point defining clipping plane

N2 = 2nd point defining clipping plane

N3 = 3rd point defining clipping plane

Note that you can clip parallel to the major axes or use three previously defined points in space to define a plane to do the clippings. N1, N2, and N3 are the labels of three previously defined points in space that determine the clipping plane. The part that is kept is pointed to as a right-hand screw and is advanced in the same way that the points are specified. NAME is optional and specifies a specific piece of structure to be clipped. All other pieces of geometry are left untouched and placed into the output file. If NAME is not specified, the entire geometry is clipped.

When the CLIP command is given, the program asks for two output data files where the new clipped data are to be placed. The first data file contains the solid geometry description (blocks, bricks, faces, etc.), and the second contains a definition of the resulting base or cross section of the intersection of the clipping plane and the original geometry. After the clip is complete, the program returns to the command level. Figure 24 shows a sample data file and its plot before and after the following interactive session:

```
COMMAND?
CLIP Z 6.

        ENTERING CLIPPING MODULE.
```

```
OUTPUT GEOMETRY DATA FILE?
GOUT

OUTPUT BASE DATA FILE?
BOUT

CLIPPING BL1

     EXITING CLIPPING MODULE.
```

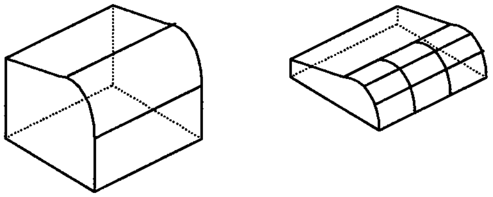
CLEAR. The CLEAR command is used to clear all definition of geometry from memory to begin a new problem. Its format is

"CLEar"

Plotting

There are several plotting commands to aid the user in visualizing the data. They will now be described in detail.

```
100 POINTS 5
110 1  0. 0.  0.
120 2 10. 0.  0.
130 3 10. 0.  5.
140 4  5. 0. 10.
150 5  0. 0.  8.
160 CIRC 4 3 5.
170 BLOC BL1 0.15
10.
180 1. 1.
190 5 5 4 3 2 1
```



Before clip

After clip
File GOUT

Figure 24. CLIP example

PLOT. The PLOT command allows part or all of the database to be plotted. Its format is

"Plot"
"Plot" "POINts"
"Plot" "POINts" N1 N2
"Plot" "DENSIty" DENS
"Plot" NAME

where

N1 = 1st point of group

N2 = 2nd point of group

DENS = density

NAME = four-character name

"POINts" = flag stating to plot points

"DENSity" = flag stating to plot by density

Giving the PLOT command without arguments causes all the lines to be plotted. Points only can also be plotted with a range between N1 and N2 or the entire set if the range is omitted. Objects with the same density DENS and the same name NAME can also be plotted.

WINDOW. The WINDOW command allows the user to pick a window, or portion of the plot on the screen, and plot just that portion. Its format is

"Window"

After typing WINDOW, the cross hairs will appear. Place them on the lower, left-hand corner or upper, right-hand corner of the desired window, hold the left mouse button and drag the mouse to define the desired box, and release. The new plot will then appear.

ZOOM. The ZOOM command allows the user to decrease or increase the size of the current picture on the screen. The format for this command is

"Zoom" FMAG

where FMAG equals a scale factor.

FMAG dictates whether the current picture is made bigger or smaller. If FMAG is less than one, the picture is decreased in size; if FMAG is greater than one, the picture is increased in size.

ROTP. The ROTP command allows the user to rotate a picture of the structure for viewing at different angles. This command is different from the ROTD command, which permanently rotates the geometry to a new position. The ROTP command changes only the picture on the screen, while the permanent storage of the geometry is left untouched. Its format is

"Rotp" "H" ANGLE
"Rotp" "V" ANGLE
"Rotp" "O" ANGLE

where

H = horizontal axis

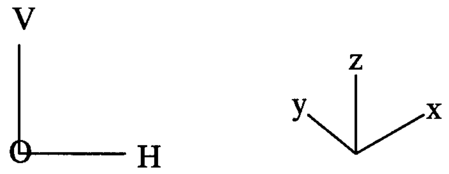
V = vertical axis

O = outward axis

ANGLE = counterclockwise positive angle in degrees

ANGLE determines how much the structure is to be rotated about the given H, V, or O axis. Note as shown in the Figure 25 the distinction between the coordinate system of the x, y, and z data and that of the rotation axes. Figure 25 shows a good set of rotations.

ROT V 30.
ROT H 30.



Rotation axes Coordinate axes

Figure 25. Set of rotations

ISOMETRIC. The ISOMETRIC command allows the user to specify a standard set of rotations rather than search for the desired plot. Its format is

"Isometric"

It is equivalent to the two rotations given in Figure 25 above.

LABEL. The LABEL command allows labels to be plotted along with line segments. Two types of labels are available: (a) point labels and (b) name labels. The format for this command is

"Label" "Points"
"Label" "Geometry"

where

"Points" = flag to turn on labeling of points

"Geometry" = flag to turn on labeling of geometry

Figures 19-21 illustrate the labeling of points, and Figures 22-23 show examples of labeling the geometry.

NOLABEL. The NOLABEL command turns off the label options of the LABEL command. Its format is

"Nolabel" "Points"
"Nolabel" "Geometry"

where

"Points" = flag to turn off labeling of points

"Geometry" = flag to turn off labeling of geometry

NOLABEL is the default over LABEL.

SOLID. The SOLID command causes all the lines to be solid rather than dashed or hidden. The format for this command is

"Solid"

Figure 7 is an example of all solid lines being drawn. SOLID is default over DASH and HIDE.

DASH. The DASH command causes all the hidden lines to be dashed rather than solid or hidden. The format for this command is

"Dash"

Figure 24 is an example of the DASH option being used.

HIDE. The HIDE command causes all the hidden lines to be hidden rather than dashed or solid. The format for this command is

"Hide"

Figure 8 is an example of the HIDE option being used.

SHADED. The SHADED command allows the user to plot his geometry using hidden surface routines with two shades of each color. Its format is

"SHAded"
"SHAded" "DENSity" DENS
"SHAded" NAME

where

DENS = density

NAME = four-character name

"DENSity" = flag stating to plot by density

As before, geometry with the same name or the same density may be plotted with the other geometry excluded. Figure 26 shows the geometry in Figure 24 shaded with a color of white and a dark blue background.

COLOR. The COLOR command allows the user to specify colors to different named pieces of geometry. Its format is

"COLor" COLOR NAME TRANSLUCENCY IBIT

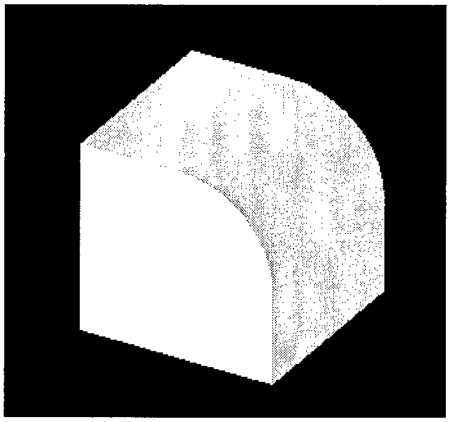


Figure 26. SHADED example

where

COLOR = color to apply to object

TRANSLUCENCY = variable to turn on translucency

IBIT = variable to designate whether even or odd bits are turned on when translucency is turned on

COLOR can be "WHITe", "BLUE", "GREEn", "CYAN", "RED", "MAGEnta", or "YELLow". TRANSLUCENCY, when supplied, has values "t" or "T" to turn on 50-percent translucency. IBIT is another optional variable with a value of 0 or 1. Fifty-percent translucency simply means every other dot is turned on, so IBIT = 0 says turn on the even bits, and IBIT = 1 says turn on the odd bits. This allows an object behind another to be seen. Figure 27 shows a similar plot to that of Figure 26, except that another block BL2 was added, and the first block BL1 was changed to translucent white.

BACKGROUND. The BACKGROUND command allows the user to set the background in a shaded or hidden line drawing. Its format is

"Background" COLOR

where COLOR equals one of the colors allowed in the color command.

ERASE. The ERASE command erases the screen. Its format is

"Erase"

```
100 POINTS 5
110 1  0. 0.  0.
120 2 10. 0.  0.
130 3 10. 0.  5.
140 4  5. 0. 10.
150 5  0. 0. 10.
160 CIRC 4 3 5.
170 BLOC BL1 0.15 10.
180 1. 1.
190 5 5 4 3 2 1
210 POINTS 2
220 6 -2. 0.  0.
230 7 -2. 0. 10.
240 BLOCK BL2 0.15 5.
250 1. 1.
260 4 1 6 7 5
270 COLOR WHIT BL1 T 0
280 COLOR YELL BL2
```

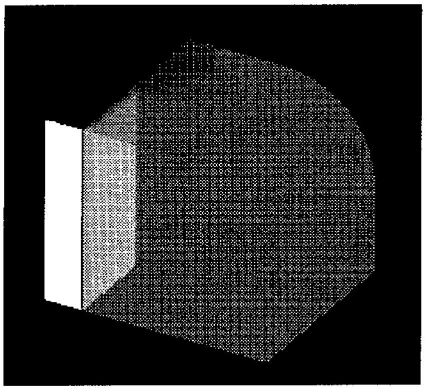


Figure 27. COLOR example with translucency

INITIALIZE. The INITIALIZE command initializes plot data back to the original values. Its format is

"INItialize"

Currently, the angles of rotation are reset to zero.

3 General Loads Module

Introduction

The General Loads Module uses three methods to construct loads.

- a. *Pressure volume.* Applying a density and direction to a volumetric piece.
- b. *Point load.* Applying a force at a point.
- c. *Simplified load commands.* Giving water and soil elevations and identifying where on the structure they are to be applied.

Pressure volumes and point loads can also be combined to form load cases.

The forces and moments about the global origin of each named load description and the sum total of each, respectively, can be computed by giving the FORCE command. As with doing the mass properties, most of the computations are done using exact line and surface integrals, making the results very accurate and the running time extremely small.

Pressure volume

A pressure volume is defined by assigning to any of the geometric solid pieces described above a density and a direction (+X, -X, +Y, -Y, etc.). The volume of the solid times the density gives the magnitude of the load, and the equivalent point of application of the load in the designated direction is the centroid of the geometric piece. An example of geometry and loads is given in Figures 28-30, which show two pressure volumes representing upstream water being applied to the nonoverflow example given in Figures 3 and 4. The upstream horizontal pressure volumes are given a direction of +X, and the downstream horizontal pressure volumes are given a direction of -X. The remaining geometries, excluding the monolith, represent vertical loading. Figure 28 is a front view; Figure 29 is a hidden line isometric view; and Figure 30 is a shaded isometric view. The use of color and translucency is a tool in visualizing both geometry and loads in the same plot.

Point load

A point load is simply a force with components (F_x, F_y, F_z) applied at a (x, y, z) point. One example where these are useful is in applying anchor loads in the CDAMS module.

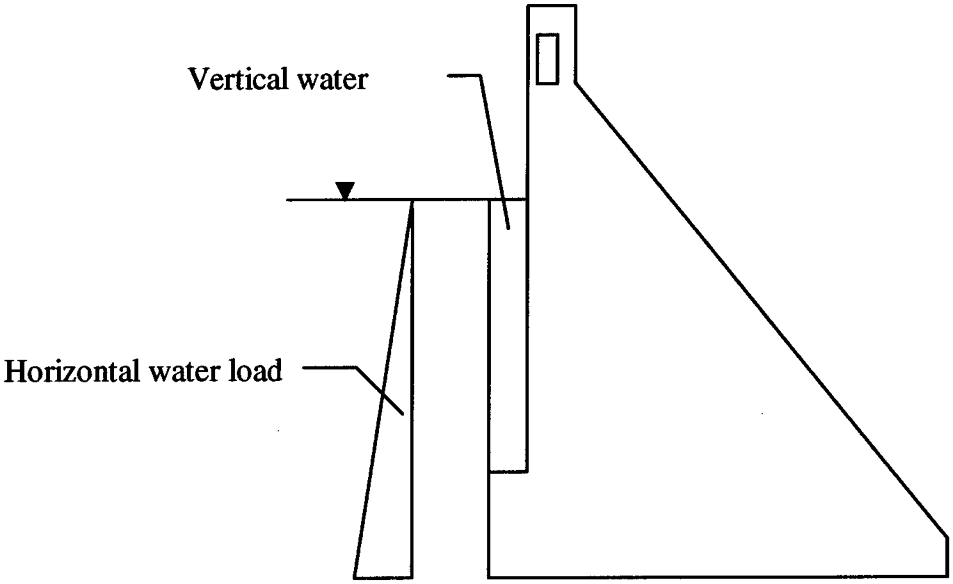


Figure 28. Front view (pressure volumes)

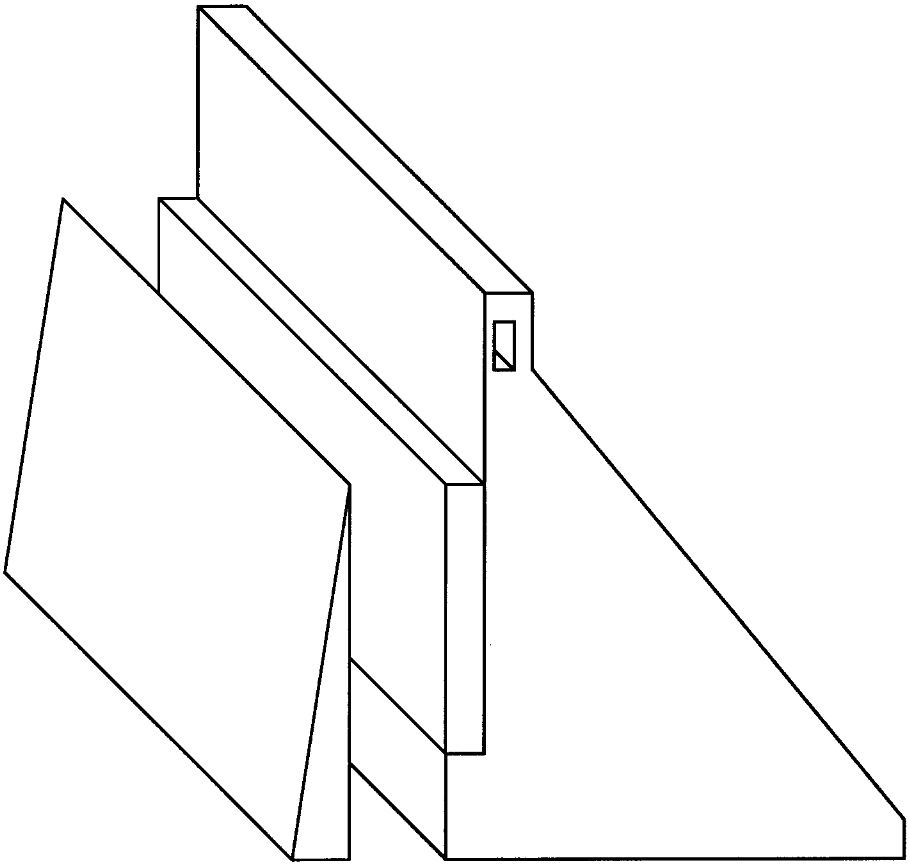


Figure 29. Hidden line view

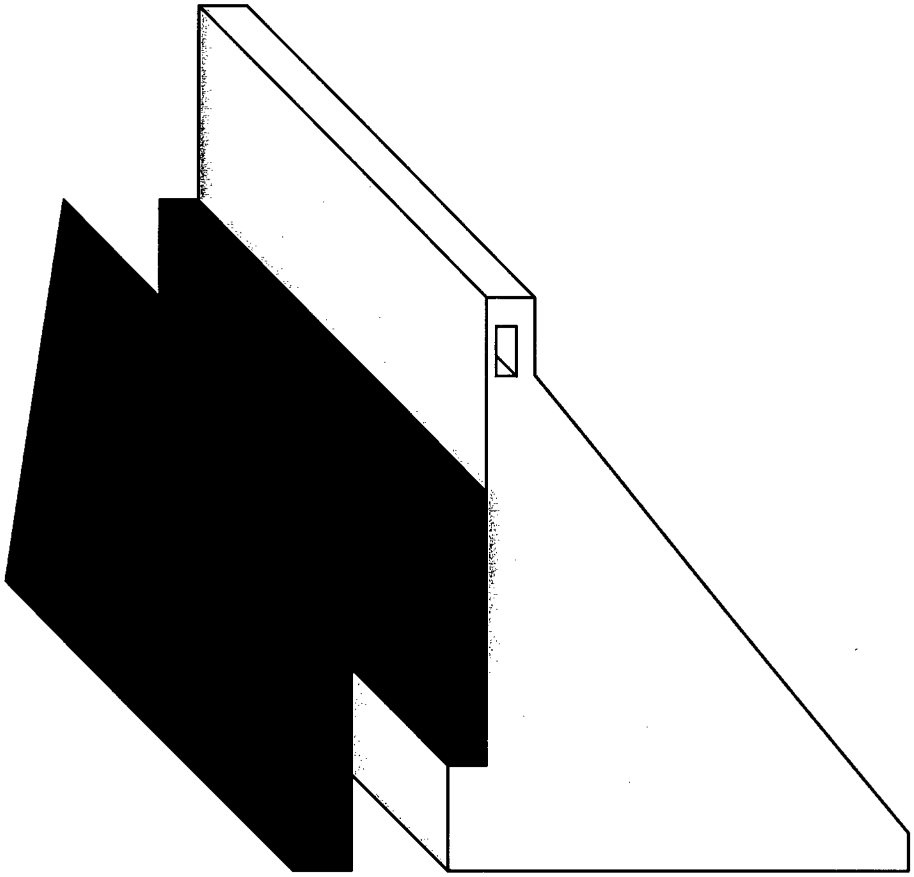


Figure 30. Shaded view

Simplified load commands

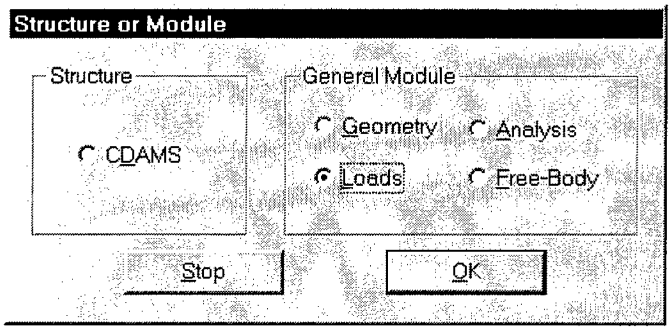
The loads on the dam monolith shown in Figures 28-30 are upstream water loads. Downstream water loads and upstream and downstream soil loads can also be done this way. Another way to define the loads is to provide the soil profile data and water levels and the data describing where on the structure these are applied. For those cases where this is possible, this is much easier than constructing the equivalent pressure volumes. This option is available in 3DSAD. The simplified load commands identify what surfaces are loaded and with what load, as compared with pressure volume data describing what solid piece of geometry properly represents the load.

All the loads are identified by name, and a table of the individual forces and moments and the total force and moment about the global origin are available using the FORCE command.

Running the Program

After the program is initiated, the following text appears on screen, and you are presented with the following dialog box from which you select which module to use:

```
*********************************
*  CASE PROGRAM    #X8100       *
*       VERSION    #1998/10/01  *
*********************************
```



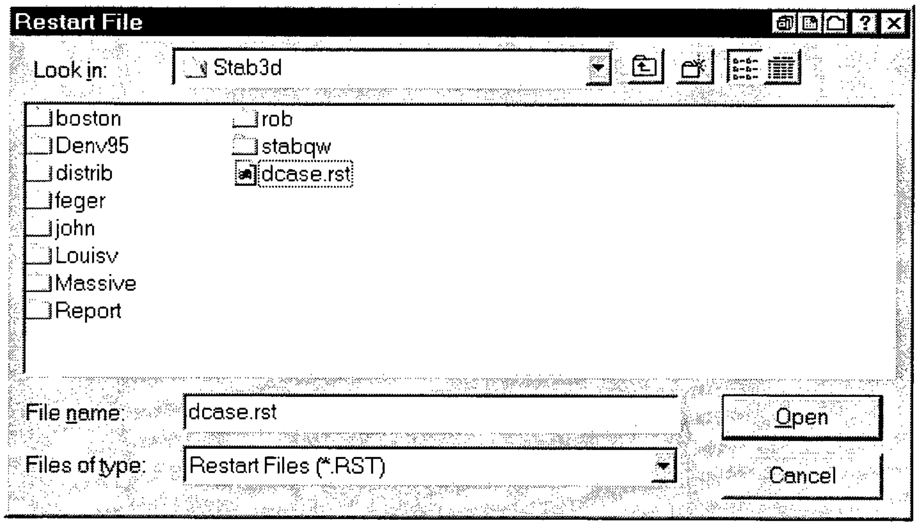
If you choose to save data in permanent files, click on the *Restart File* and/or the *Output File* check boxes, and then select the *OK* button. You can turn off a selected option by clicking on the check box a second time. Selecting the *Cancel* button has the same effect as clearing both of the check boxes. Once you select the *OK* button, the following line appears on screen:

```
ENTERING GENERAL LOADS MODULE.
```

If you elected to not save permanent files, you will be presented with the

```
COMMAND?
```

prompt; but if you chose to save data in permanent files, a dialog box will appear that allows you to choose a file name or enter a new one. The dialog box title bar identifies which type of file is being saved, and the default extension filter automatically shows only those files matching the proper file extension. If you chose to save both types of files, you are first prompted for the *Restart File* and then an *Output File*. The following example would appear if the *Restart File* option were selected:



Look in: Stab3d

File name: dcase.rst

Files of type: Restart Files (*.RST)

Selecting an existing file will cause the data in the existing file to be overwritten. Typing in a new file name will cause that file to be created and used until such time as a new one is entered.

The *Restart File* saves all data pertaining to defining loads. These include any data input from another data file. The *Output File* stores the computed forces and moments from any load case commands that are issued. This output file is used for input to the General Analysis Module.

Once a file name is selected or entered and the *Open* button selected, the dialog box disappears and you are presented with the `COMMAND?` prompt. Selecting the *Cancel* button will cause the program to generate a temporary file for use instead of a named permanent file.

The `COMMAND?` prompt is the point to which you are returned when the program has processed the previous command and is ready to perform additional tasks. Help is available for each valid command by typing the command name followed by a space and a question mark. The proper syntax and available options for the entered command are presented. If you type in just a question mark, all available commands for the General Loads Module are given:

```
                 ------
           PRESSURE VOLUMES
                 ------

             XY XZ YZ RTZ
                 POINT
       CIRCLE ELLIPSE QUADRATIC
            BLOCK FACE BR8
    TRANSLATE ROTD COPY REFLECT
          PTLD QUAKE UPLIFT
              CASE FORCE
```

```
            ------
           UTILITY
            ------

            INPUT
        END GO RETURN
          CLIP CLEAR

            ------
           PLOTTING
            ------

       PLOT WINDOW ZOOM
        ROTP ISOMETRIC
        LABEL NOLABEL
    SOLID DASH HIDE SHADED
       COLOR BACKGROUND
       ERASE INITIALIZE

            ------
       SIMPLIFIED LOADS
            ------

       DENSW WATER SOIL
         LOAD SLOADS
          SHOWLOADS
```

When doing the traditional pressure volume calculation, the basic command sequence is:

Command	Meaning
`INPUT FILENAME`	**Read data from file FILENAME.**
`PLOT`	**Plot pressure volume data.**
`FORCE`	**Compute force and moment for pressure volumes.**
`RETURN`	**Return to main menu.**

Likewise, when doing simplified loads commands, the sequence goes as follows:

Command	Meaning
`INPUT FILENAME`	**Read data from file FILENAME.**
`SHOWLOADS`	**Display simplified loads data.**
`SLOADS`	**Compute force and moment for simplified loads data.**
`RETURN`	**Return to main menu.**

Each command will now be described in detail.

Commands

When giving a command, only the minimum number of letters of a command need to be given. The user can, however, type the entire word if he prefers.

Commands and their accompanying data can be put into a data file or typed interactively while running the program. In giving the format for the commands, actual letters to be typed will be enclosed in the quotes to distinguish them from variable names. The quotes do not have to be typed when the user issues the command. The required letters are shown in all capitals; the optional letters are shown in lower case letters.

Pressure volumes

Blocks such as the ones shown in Figure 29 are not only used to define geometry but also for horizontal and vertical loads. What the user does is to build the geometry using the tools described in the General Geometry Module and apply a direction of +x, -x, +y, -y, +z, or -z to it. The centroid of the defined geometry represents the point of application of the force, and the magnitude of the force is determined by the volume of the geometry times the given density. The commands XY, XZ, YZ, RTZ, POINT, CIRCLE, ELLIPSE, QUADRATIC, TRANSLATE, ROTD, COPY, and REFLECT are the same as before. The commands BLOCK, FACE, and BR8 are the same, except DIR is the first variable after the command name and represents the direction of the applied force. Figure 31 shows an example of a horizontal water load (+x) on the left side of a wall 30.5 m (100 ft) high and extending 12.2 m (40 ft) in the y direction. Starting with a water density of 0.0625 kip/ft^3, the density given is five times greater or 0.3125 kip/ft^3, so the base of the triangle is reduced by a factor of 1.5 to 6.1 m (5 to 20 ft) instead of 30.5 m (100 ft). This gives the same value of force and moment, and it was done only for appearance when plotting.

```
100 POINTS 3
110 1  0. 0.   0.
120 2  0. 0. 100.
130 3 -20. 0.   0.
140 BLOCK +X WATH 0.3125 40.
150 1. 1.
160 3 3 2 1
```

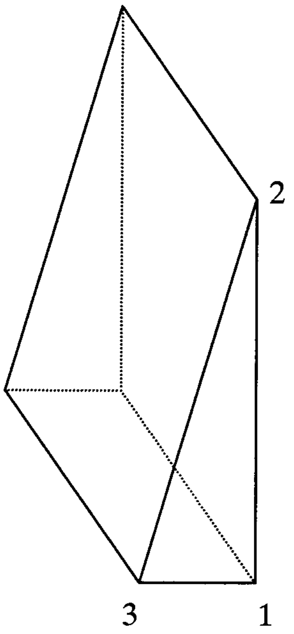


Figure 31. Horizontal water load

Four additional load building commands that exist in conjunction with the pressure volume capability are PTLD, QUAKE, UPLIFT, and CASE. To illustrate these four commands, consider the geometry file in Table 1 and the loads file in Table 2. Figure 32 shows a front view plot of the geometry and loads, which is the same geometry but a different load case than that shown in Figures 28-30.

PTLD. The PTLD command is used to describe a point load, and its format is

"PTld" NAME XX YY ZZ FX FY FZ

where

NAME = four-character name given to point load

XX, YY, ZZ = (x, y, z) coordinates where point load is to be applied

FX, FY, FZ = (x, y, z) components of point load

Table 1. Geometry File

```
100 POINTS  18
110  1  0.    0.  95.5
120  2  0.    0. 109.
130  3  3.    0. 109.
140  4  3.    0. 109.
150  5  3.    0. 109.
160  6  3.    0. 109.
170  7  3.    0. 193.5
180  8 13.    0. 193.5
190  9 13.    0. 193.5
200 10 13.    0. 193.5
210 11 13.    0. 178.5
220 12 72.28 0. 100.5
230 13 72.28 0. 100.5
240 14 72.28 0.  95.5
250 15  5.    0. 180.
260 16  5.    0. 187.
270 17  9.    0. 187.
280 18  9.    0. 180.
290 BLOCK NON1 0.15 10. 1
300 1. 1.
310 14 1 2 3 4 5 6 7 8 9 10 11 12 13 14
320 1. 1.
330 4 18 17 16 15
```

Table 2. Loads File

```
100 PTLD WT 26.68 5. 128.34 0. 0. -51101.23
110 POINTS 3
120 1 -10.    0. 186.5
130 2 -10.    0.  95.5
140 3 -19.282 0.  95.5
150 QUAD 3 1 -14.641 0. 163.75
160 BLOCK +X EQ10 0.05 10.
170 1. 1.
180 3 1 2 3
190 POINTS 3
200 4 10.    0. 122.9
210 5 10.    0.  95.5
220 6 12.795 0.  95.5
230 QUAD 4 6 11.397 0. 116.05
240 BLOCK +X EQ50 0.05 10.
250 1. 1.
260 3 6 5 4
270 POINTS 8
280  7 0. 0.  95.5
290  8 0. 0. 109.
300  9 3. 0. 109.
310 10 3. 0. 109.
320 11 3. 0. 109.
330 12 3. 0. 109.
340 13 3. 0. 186.5
350 14 0. 0. 186.5
360 BLOCK -Z V210 0.0625 10.
370 1. 1.
380 8 14 13 12 11 10 9 8 7
390 POINTS 4
400 15 72.28  0. 122.9
410 16 55.256 0. 122.9
420 17 72.28  0. 100.5
430 18 72.28  0. 100.5
440 BLOCK -Z V250 0.0625 10.
450 1. 1.
460 4 18 17 16 15
470 POINTS 3
480 19 -29.282 0. 186.5
490 20 -29.282 0.  95.5
500 21 -47.482 0.  95.5
510 BLOCK +X WH10 0.3125 10.
520 1. 1.
530 3 19 20 21
540 POINTS 3
550 22 22.795 0. 122.9
560 23 22.795 0.  95.5
570 24 28.275 0.  95.5
```

(Continued)

Table 2. (Concluded)

```
580 BLOCK -X WH50 0.3125 10.
590 1. 1.
600 3 24 23 22
610 TRAN EQ50
620 72.28 0. 0.
630 TRAN WH50
640 72.28 0. 0.
650 UPLIFT 4
660 A 5.6875
670 B 1.7125
680 C 1.7125
690 D 5.6875
700 QUAKE EQN +X 0.1 1
710 WT
720 CASE VI 3 8
730 WT V210 V250 WH10 WH50
740 EQ10 EQ50 EQN
```

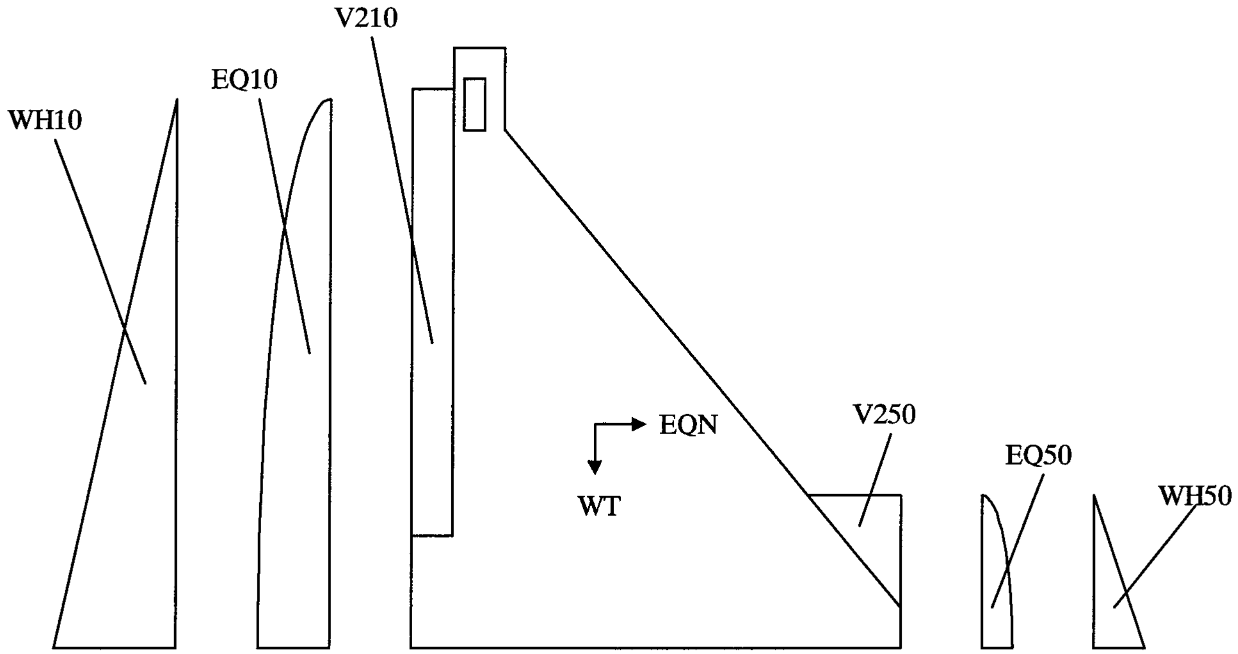


Figure 32. Geometry and loads

The load WT in Figure 32 and on Line 100 of Table 1 is a point load representing the geometry of Table 1.

QUAKE. The QUAKE command allows the user to apply a seismic coefficient to a given load when computing earthquake loads, and a new point load is generated in the specified direction representing the earthquake load. The format for the command is

```
"QUAKe" NAME DIR COEF NPT
N1 N2 . . . NNPT
```

where

NAME = four-character name of new generated point load

DIR = direction of new point load

COEF = seismic coefficient

NPT = number of loads where seismic coefficient is to be applied

N1 = 1st load where seismic coefficient is applied

N2 = 2nd load where seismic coefficient is applied

NNPT = NPTth load where seismic coefficient is applied

DIR can be "X", "+X", "-X", "Y", "+Y", "-Y", "Z", "+Z", or "-Z". EQN in Figure 32 is defined by Lines 700-710, and it represents a horizontal earthquake load resulting from the weight of the structure.

UPLIFT. The UPLIFT command is used if uplift loads are to be computed later by the General Analysis Module. It gives the uplift values for points on the base of the foundation where overturning and sliding stability are computed. Uplift data are linked to case data described below. The format of the command is

```
"Uplift" NPT
N1 UP1
N2 UP2
  .
  .
  .
NNPT UPNPT
```

where

NPT = number of base points that require uplift to be specified

N1 = point label for 1st base point

N2 = point label for 2nd base point

NNPT = point label for NPTth base point

UP1 = uplift value for base point N1

UP2 = uplift value for base point N2

UPNPT = uplift value for base point NNPT

An example of this command is shown in Lines 650-690 of Table 2.

CASE. The CASE command allows the user to combine several load names into a load case. Its format is

```
"Case" CNAME LDTYPE NPT
N1 N2 . . . NNPT
```

where

CNAME = four-character name of load case

LDTYPE = load type

NPT = number of load names

N1 = point label for 1st load name

N2 = point label for 2nd load name

NNPT = point label for NPTth load name

LDTYPE is a flag used in the General Analysis Module and has the following values:

1 - Short term.
2 - Long term.
3 - Instantaneous.

Lines 720-740 of Table 2 illustrate the use of this command.

FORCE. The FORCE command allows the user to obtain force and moment information, and it applies to everything except the simplified load commands described later in this report. Its possible options are:

```
"FOrce"
"FOrce" "ALL"
"FOrce" NAME
```

where

NAME = four-character name

"ALL" = flag to do all load pieces

If FORCE is typed, only the totals for the entire structure are given. If NAME is provided, only the force and moment data for loads having the name are given. The ALL option will yield a detailed listing of all the data by name. Table 3 gives an example of this option using the data in Table 2 with the earthquake data removed.

Table 3. Force and Moment Calculations

```
                              ---------
 NAME               FX                    FY                    FZ
                    MX                    MY                    MZ


 WT                    .00                   .00             -51101.23
                -255506.20            1363381.00                   .00
 V210                  .00                   .00               -145.31
                   -726.56                217.97                   .00
 V250                  .00                   .00               -119.17
                   -595.84               7937.22                   .00
 WH10              2587.81                   .00                   .00
                       .00             325633.00             -12939.07
 WH50              -234.61                   .00                   .00
                       .00             -24548.32               1173.06

TOTAL              2353.20                   .00             -51365.71
                -256828.60            1672621.00             -11766.00
                              ---------
```

Utility

The utility commands of INPUT, END, RETURN, CLIP, and CLEAR are the same as in the General Geometry Module. Giving the command GO while running under the Dams Input Module sends you to the General Analysis Module.

Plotting

The commands PLOT, WINDOW, ZOOM, ROTP, ISOMETRIC, SOLID, DASH, HIDE, SHADED, COLOR, BACKGROUND, ERASE, and INITIALIZE are the same as in the General Geometry Module. The commands LABEL and NOLABEL are slightly different and will be described now.

LABEL. The LABEL command allows labels to be plotted along with line segments. Two types of labels are available: (a) point labels and (b) name labels. The format for this command is

"Label" "Points"
"Label" "Loads"

Figures 32 is an example of labeling the loads.

NOLABEL. The NOLABEL command turns off the label options of the LABEL command. Its format is

"Nolabel" "Points"
"Nolabel" "Loads"

NOLABEL is the default over LABEL.

Simplified loads

A set of commands separate from the pressure volume capability are the simplified load commands that provide an alternative to point loads and pressure volumes used to compute general loads. An example of these commands is illustrated in Table 4 where the geometry is plotted in Figure 33. Figure 34 shows a display of the headwater defined in the data file. These commands will now be described in detail.

DENSW. The DENSW command sets the density of water, and its format is

"Densw" DENSW

where DENSW equals the density of water.

The default value is 0.0625 kip/ft^3, and an example of this command is given in Line 310 of Table 4.

WATER. The WATER command allows the user to define and name a water level, and its format is

"Water" LOAD_NAME ELEVATION

where

LOAD_NAME = name applied to load

ELEVATION = elevation of pool of water

Table 4. Simplified Loads Data File

```
100 POINTS 9
110 1  0.    0. 268.
120 2  1.5   0. 283.
130 3 20.7   0. 283.
140 4 20.7   0. 288.94
150 5 24.23  0. 291.
160 6 40.02  0. 282.56
170 7 54.23  0. 275.
180 8 54.23  0. 268.
190 9 26.369 0. 300.
200 QUAD 4 5 22.465 0. 290.485
210 QUAD 5 6 32.125 0. 288.658
220 CIRC 7 6 28. LEFT
230 BLOCK OVE1 0.15 20.
240 1. 1.
250 8 1 2 3 4 5 6 7 8
260 CIRC 5 9 20. LEFT
270 BLOCK GATE 0.0625 20.
280 1. 1.
290 4 5 9 9 5
300 COLOR RED GATE
310 DENSW 0.0625
320 WATER HEAD 296.
330 WATER TAIL 270.
340 LOAD BLOCK OVE1 SIDE 1 5 HEAD
350 LOAD BLOCK OVE1 SIDE 5 8 TAIL
360 LOAD BLOCK GATE SIDE 5 9 HEAD
370 SOIL 1
380 S1 268. 278. 0.075 0.35 0.35 1.
390 LOAD BLOCK OVE1 SIDE 1 5 S1
```

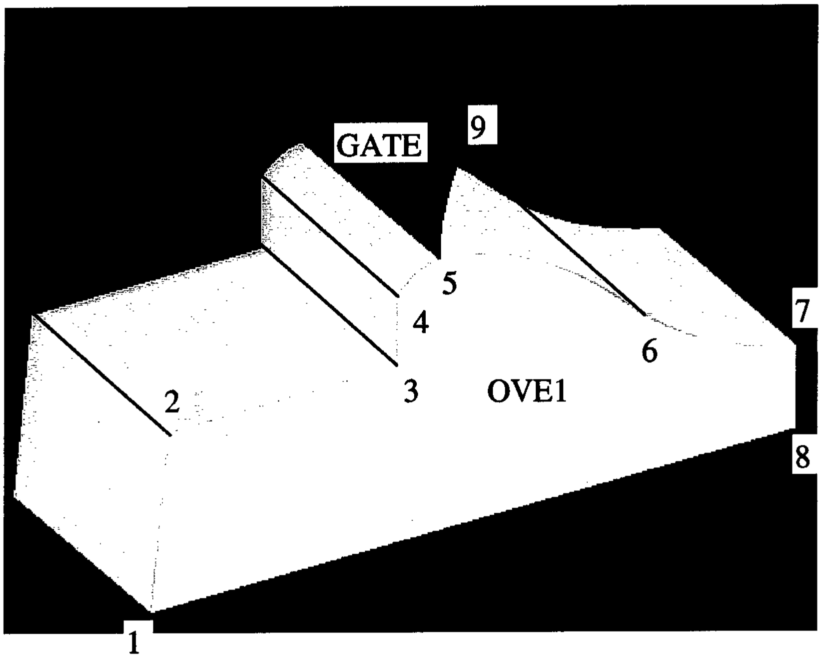


Figure 33. Overflow cross section with gate

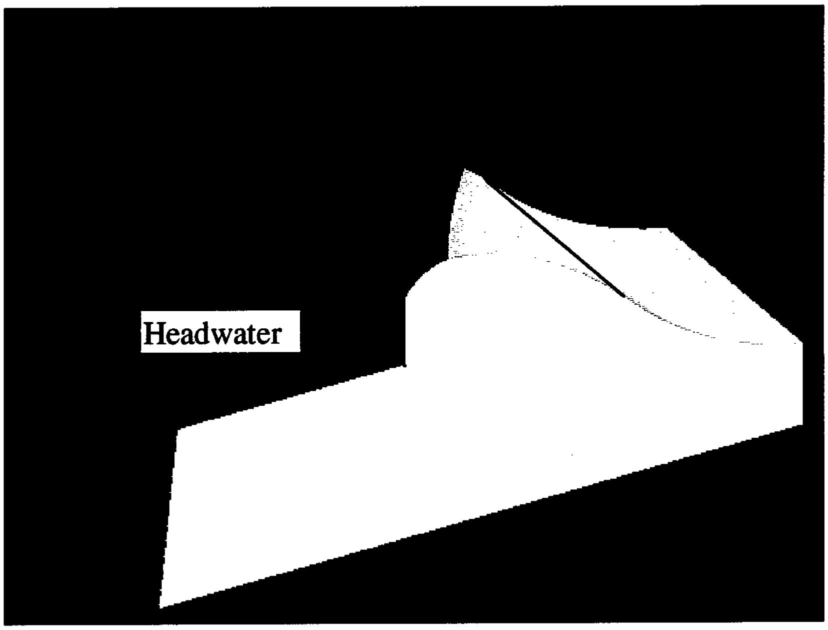


Figure 34. Display of headwater

An example establishing headwater and tailwater is given in Lines 320-330 of Table 4.

SOIL. The SOIL command, similar to the WATER command, is used to establish horizontal soil layers. The format of the command is:

“SOII” NUMBER_OF_LAYERS

Do for each layer from top to bottom

LAYER_NAME EL_BOTTOM EL_TOP EFFECTIVE_UNIT_WEIGHT KX KY KZ

End Do

where

NUMBER_OF_LAYERS = number of soil layers

LAYER_NAME = name of soil layer

EL_BOTTOM = elevation of bottom of soil layer

EL_TOP = elevation of top of soil layer

EFFECTIVE_UNIT_WEIGHT = effective unit weight of soil (typically, buoyant unit weight for soil in water)

KX = soil coefficient in x direction (varies depending on active, passive, or at rest type conditions)

KY = soil coefficient in y direction

KZ = soil coefficient in z direction

Lines 370-380 in Table 4 illustrate the use of this command.

LOAD. The LOAD command allows the user to connect the water and soil levels to the geometry. Its format differs depending upon the type of geometry being loaded, and these formats are as follows:

BLOCKS. “LOAD” “Block” BLOCK_NAME “Side” FIRST_POINT SECOND_POINT LOAD_NAME

or
“LOAD” “Block” BLOCK_NAME “Side” “ALL” LOAD_NAME
or
“LOAD” “Block” BLOCK_NAME “Front” LOAD NAME
or
“LOAD” “Block” BLOCK_NAME “Back” LOAD NAME

where

“Block” = flag stating to load a block

“Side” = flag stating to load side

“Front” = flag stating to load front

“Back” = a flag stating to load the back

BLOCK_NAME = name of a block

FIRST_POINT = first point defining where on block load is to be applied

SECOND_POINT = second point defining where on block load is to be applied

“ALL” = flag stating to load all side faces

LOAD_NAME = name of load to be applied

Blocks can be loaded on the two ends (front or back), an entire side, or part of a side. Care must be taken to give the point numbers of a block in the same order that the block was originally defined. Lines 340-360 and 390 in Table 4 show the loading of the sides of the overflow and gate cross sections by the headwater, tailwater, and soil loads. Figure 34 displays the headwater loading.

FACES. “LOAD” “Face” FACE_NAME FIRST_FACE LAST_FACE LOAD_NAME

or
“LOAD” “Face” FACE_NAME “ALL” LOAD_NAME

where

“Face” = flag stating to load faces

FACE_NAME = name of a cluster of faces

FIRST_FACE = first face defining where load is to applied

SECOND_FACE = second face where load is to applied

LOAD_NAME = name of load to be applied

“ALL” = flag stating that all faces in cluster are loaded

BRICKS. “LOAD” “Brick” BRICK_NAME FIRST_FACE LAST_FACE LOAD_NAME

or
“LOAD” “Brick” BRICK_NAME “ALL” LOAD_NAME

where

"Brick" = flag stating to load a brick

BRICK_NAME = name of a cluster of faces

FIRST_FACE = first face of brick where load is to be applied

SECOND_FACE = second face of brick where load is to be applied

LOAD_NAME = name of load to be applied

"ALL" = flag stating that all faces of brick are loaded

The faces of a brick element are numbered in a set way (Figure 35), and they will be described in terms of the first node, second node, etc., of the brick as given in Table 5 below.

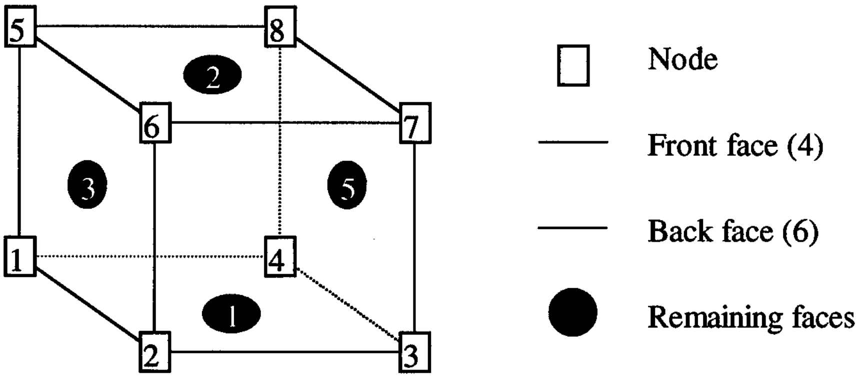


Figure 35. Face numbers

Table 5. Face Nodes for a Brick Element

Face Number	Face Nodes			
1	**4**	**3**	**2**	**1**
2	**5**	**6**	**7**	**8**
3	**1**	**2**	**6**	**5**
4	**2**	**3**	**7**	**6**
5	**3**	**4**	**8**	**7**
6	**4**	**1**	**5**	**8**

SLOADS. The SLOADS command allows the user to compute the values of the simplified loads. The possible options for this command are:

"SLoads"
"SLoads" "ALL"
"SLoads" NAME

where

NAME = name of water or soil layer to be evaluated

"ALL" = flag stating to compute all loads

SLOADS is used to give the sum total, whereas the "ALL" option will print a detailed listing of each load and then the total. Specifying NAME will print the results for just that particular name. For the sample problem given in Table 4, the command

```
SLOADS ALL
```

produces the results in Table 6.

Table 6. SLOADS Results

```
                              ---------
  NAME                  FX                    FY                  FZ
                        MX                    MY                  MZ


HEAD-OVEL            474.38                   .00             -375.53
                   -3755.30             135370.00            -4743.75
TAIL-OVEL             -2.50                   .00                 .00
                        .00               -671.67               25.00
HEAD-GATE             15.63                   .00               -1.32
                     -13.20               4605.14             -156.25
S1   -OVEL            26.25                   .00               -7.50
                     -75.00               7125.00             -262.50

 TOTAL               513.75                   .00             -384.35
                   -3843.50             146428.40            -5137.50
                              ---------
```

SHOWLOADS. The SHOWLOADS command is used to display the simplified loads described thus far, and its format is

"SHowload" NAME

where NAME equals the name of a simplified load to be displayed.

If the display option SOLID is turned on, a shaded solid plot is produced; whereas if HIDE had previously been issued, a hidden line plot is generated. A water load will be plotted in light blue and a soil load in brown. Figure 34 was drawn by first inputting the file given in Table 4, then giving an ISOMETRIC command, and finally issuing the command

```
SHOWLOADS HEAD
```

which shows the faces where the headwater is applied.

4 General Analysis Module

Introduction

Most programs for stability use a 2-D analysis with a rectangular base. However, the General Analysis Module does a general 3-D analysis and allows for a definition of a general planar or near-planar base oriented in any way in space. The analysis uses the general flexure formula (limit equilibrium analysis) for computing base pressures from a resultant force and uplift. When a base is found to be in noncompression, an iterative process is used with the uplift being recomputed at each iteration and then added to the input to obtain the total resultant. When convergence is achieved, the results are printed.

Input

Input consists of the following:

a. *Surface of investigation.* The area representing the base (generally the base of the structure) defined by points, any curves connecting the points, and the connectivity data showing how the points and line segments are joined.

b. *Resultant without uplift.* The force with components (F_x, F_y, F_z) and moment with components (M_x, M_y, M_z), excluding uplift, as computed from all the loads of a given load case.

c. *Uplift.* An uplift pressure at each point on the base.

d. *Foundation data.* Shear strength and phi angle for computing sliding stability.

Analysis

An analysis is done by the following steps:

a. *Plane of analysis.* The plane of analysis is computed from a least-squares fit of the data describing the surface of investigation. If the surface is already a plane, it will be used as is.

b. Base pressure computation. The base pressures for each input point of the base and at intermediate points of a curve are computed using the general flexure formula.

c. Iteration. If any of the base pressures are negative, a new effective base, associated uplift pressures, and total resultant are computed. Steps *b* and *c* are repeated until convergence is achieved.

d. Sliding factor of safety. A sliding factor of safety is computed for a single block analysis (the same as shear friction factor of safety for a horizontal base).

Output

Output consists of the following information. Except for the input data, all results are available for the initial base and the new effective base after iteration.

a. Input data. An optional summary of input data.

b. Area properties. The area, centroid, etc., of the defined base.

c. Resultant. The total force and moment components, including uplift.

d. Base pressures. (x, y, z) coordinate and base pressure for each point on the base.

e. Design information. The percentage of effective base and sliding factor of safety.

f. Kern plot. A plot of the base (solid lines), kern (dashed lines), centroid of base (circle), and resultant (+).

Figure 36 gives an example of the kern plot for the base of a power house (analysis done by Mr. Bill Kling, Mobile District Corps of Engineers).

Running the Program

After the program is initiated, the following text appears on screen; you are presented the following dialog box from which you select which module to use:

```
********************************
*  CASE PROGRAM   #X8100       *
*       VERSION   #1998/10/01  *
********************************
```

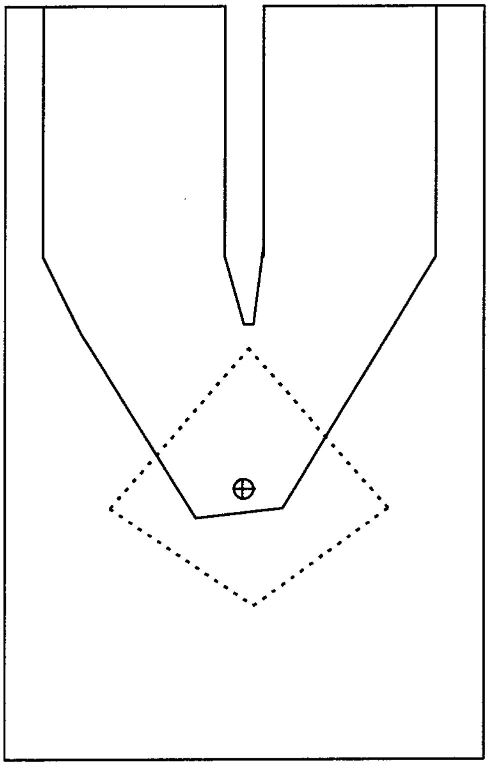
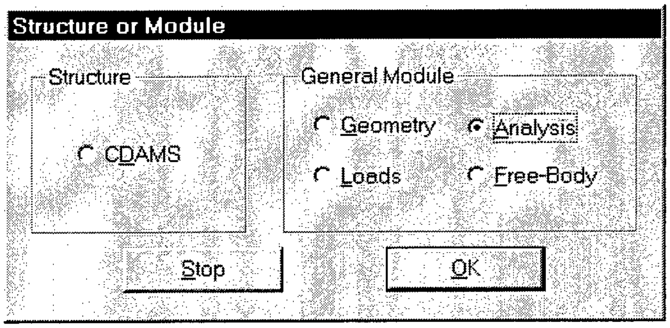
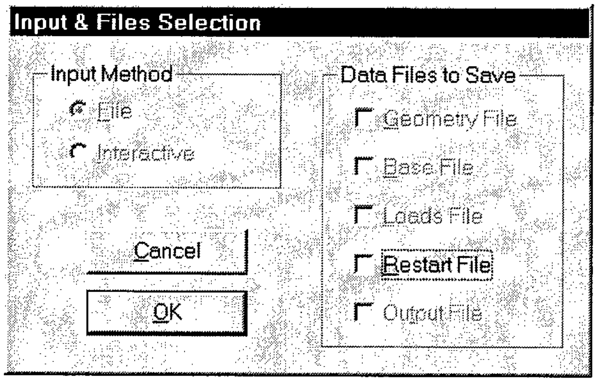


Figure 36. Kern plot



Select the option button marked *Analysis* and then press the *OK* button (pressing *Stop* will end the program). You are then presented with the following dialog box, with which you identify whether or not you want to save as permanent output a restart file. If you choose not to save data in a permanent file, the program will generate a temporary file for use during the session.


Input & Files Selection

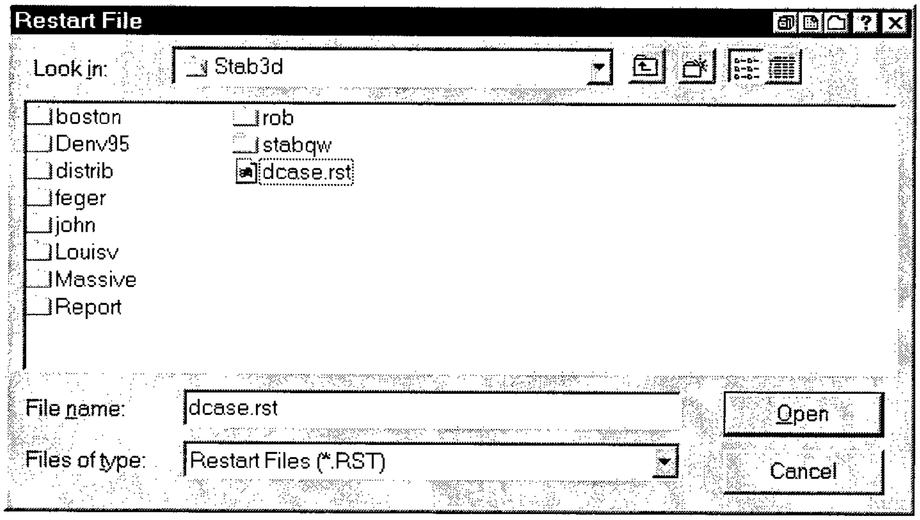
Input Method
● File
○ Interactive

Data Files to Save
☐ Geometry File
☐ Base File
☐ Loads File
☐ Restart File
☐ Output File

If you choose to save data in a permanent file, click on the *Restart File* check box, and then press the *OK* button. You can turn off the selection clicking on the check box a second time. Pressing the *Cancel* button has the same effect as leaving the restart file check box blank. Once you press the *OK* button, the following line appears on screen:

```
ENTERING GENERAL ANALYSIS MODULE.
```

If you elected to not save permanent files, you will be presented with the `COMMAND?` prompt; but if you chose to save restart data in a permanent file, a dialog box will appear that allows you to choose a file name or enter a new one. The default extension filter automatically shows only those files matching the restart file extension. Below is an example that would appear if the *Restart File* option were selected:


Restart File

Look in: Stab3d

boston
Denv95
distrib
feger
john
Louisv
Massive
Report
rob
stabqw
dcase.rst

File name: dcase.rst
Files of type: Restart Files (*.RST)

Selecting an existing file will cause the data in the existing file to be overwritten. Typing in a new file name will cause that file to be created and used until such time as a new one is entered.

The *Restart File* option saves all data that the user has thus far input either from another data file or by typing interactively. Once a file name is selected or entered and the *Open* button pressed, the dialog box disappears and you are presented with the `COMMAND?` prompt. Pressing the *Cancel* button will cause the program to generate a temporary file for use instead of a named permanent file.

The `COMMAND?` prompt is the point to which you are returned when the program has processed the previous command and is ready to perform additional tasks. Help is available for each valid command by typing the command name followed by a space and a question mark. The proper syntax and available options for the entered command are presented. If you type in just a question mark, all available commands for the General Analysis Module are given as follows:

```
             ------
         DATA BUILDING
             ------

             POINTS
CIRCULAR ELLIPTICAL QUADRATIC
           PHI SHRSTR
          SANGLE DENSW
        BASE UPLIFT CASE

             ------
            UTILITY
             ------

             INPUT
         END GO RETURN
             CLEAR
```

When doing an analysis, the basic command sequence is given in Table 7 below. The base data and case date are often placed in the same data file. However, two files are created when using the Dams Input Module. Each command will now be described in detail.

Table 7. Summary of the Procedure

Command	Meaning
INPUT BASE_FILENAME	Read base data from file BASE_FILENAME.
INPUT CASE_FILENAME	Read case data from file CASE_FILENAME.
INPUT DATA SUMMARY?	Get summary of input data.
INTERMEDIATE RESULTS?	Get intermediate results.
KERN PLOT?	Plot kern.
FINAL RESULTS?	Get final results.
RETURN	Return to main menu.

Commands

When giving a command, only the minimum number of letters of a command need to be given. The user can, however, type the entire word if he prefers. Commands and their accompanying data can be put into a data file or typed interactively while running the program. In giving the format for the commands, actual letters to be typed will be enclosed in the quotes to distinguish them from variable names. The quotes do not have to be typed when the user issues the command. The required letters are shown in all capitals; the optional letters are shown in lower case letters.

Data building

The POINTS, CIRCULAR, ELLIPTICAL, QUADRATIC, DENSW, and UPLIFT commands are the same as in the General Geometry and General Loads Modules with the restriction that circular and elliptical arcs can only be defined in the x-y coordinate system. The remaining data-building commands will now be described in more detail. The data file in Table 8 illustrates most of the commands.

Table 8. Example Data File

```
100 POINTS 4
110 A  0.   0. 268.
120 B 54.   0. 268.
130 C 54. 32. 268.
140 D  0. 32. 268.
150 UPLIFT 4
160 A 2.
170 B 0.125
180 C 0.125
190 D 2.
200 PHI 19.6
210 SHRSTR 0.22
220 BASE 1
230 4 A B C D
240 CASE NORM 1
250 1100. 0. -5800. -100000. 470000. 0.
```

PHI. The resistance to sliding is computed using

$$R = N \tan \phi + sA \tag{5}$$

where

R = resistance to sliding

N = normal component of force applied to base

ϕ = angle of internal friction of foundation material

s = shear strength or cohesion of foundation material

A = effective area of base

The PHI command is used to specify the angle ϕ. Its format is

"Phi" ANGLE

where ANGLE equals the angle ϕ specified in degrees.

Line 200 in Table 8 is an example of the PHI command.

SHRSTR. The SHRSTR command is used to specify the shear strength in Equation 5. Consistent units are used. Its format is

"SHrstr" S

where S equals shear strength.

Line 210 in Table 8 is an example of the SHRSTR command.

SANGLE. The SANGLE command allows the user to specify in what direction the shear friction factor of safety is to be computed. Its format is

"Sangle" "Default"
"Sangle" SANG

where

SANG = angle in horizontal plane measured from global x axis for which sliding stability is to be evaluated

"Default" = flag stating default angle

The default angle is the angle formed by the horizontal component of the resultant load and the global x axis. Note, however, that sliding is always computed tangent to the plane of analysis.

BASE. The user describes the order in which the points and curved line segments are connected by giving the BASE command. The format for this command is

"Base" NHOLE

Do for outer boundary and each hole

NPT N1 N2 . . .NNPT

End Do

where

NHOLE = number of holes in base

NPT = number of points of boundary

N1 = 1st point of boundary

N2 = 2nd point of boundary

NNPT = NPTth point of boundary

The outer boundary is given in counterclockwise order, and all connectivity data for holes are given in clockwise order. Lines 220-230 in Table 8 is an example of the BASE command.

UPLIFT. When one or more of the base pressures are negative on the first iteration, a new effective base and, possibly, a new value for uplift must be computed. Thus, the uplift data must be specified separately from the other forces and moments of the load case. These data are provided by giving the uplift pressure at each of the defined points on the base as previously described in the General Loads Module.

CASE. After the user has specified points and any curves, defined the connectivity for the base, specified any uplift values, and defined ϕ, s, and the density of water when different from the default of 0.0625 kip/ft^3, he must give the CASE command to define the other applied forces and moments. Its format is

"Case" CNAME, LDTYPE
FX FY FZ MX MY MZ

where

CNAME = four-character identifier

LDTYPE = load type

FX = applied force in x direction

FY = applied force in y direction

FZ = applied force in z direction

MX = applied moment in x direction

MY = applied moment in y direction

MZ = applied moment in z direction

LDTYPE can have the following values:

1 - Short term.
2 - Long term.
3 - Instantaneous.

Specifying an instantaneous load type prevents the uplift from being modified when the effective base is modified. FX, FY, FZ, MX, MY, and MZ are specified about the global coordinate system and contain all the loads except the contribution from uplift. Lines 240-250 in Table 8 give an example of the CASE command.

After the data for the CASE command are given, the program performs the computations and begins output. A detailed discussion of the output is given in the next section.

Utility

The commands INPUT, END, GO, RETURN, and CLEAR have the same function as in the General Geometry and General Loads Modules.

Output

After a CASE command is issued, various output options are interactively made available. They will now be discussed.

Printout of input

The user is first asked

```
DO YOU WISH TO SEE A SUMMARY OF THE ANALYSIS INPUT DATA?
```

If YES is typed, a summary table is printed. Table 9 gives this table for the file in Table 8. A carriage return then sends the program to the next question.

Table 9. Summary of Input Data

```
                LOAD CASE NORM CATEGORY = 1

         INPUT FORCES AND MOMENTS EXCLUDING UPLIFT

FX =   1100.000    FY =      0.000    FZ = -5800.000
MX = -100000.0     MY =     0000.0    MZ =        0.0

            INPUT COORDINATES AND UPLIFT VALUES

  NAME       X          Y          Z         UPLIFT

    A      0.000      0.000    268.000       2.000
    B     54.000      0.000    268.000       0.125
    C     54.000     32.000    268.000       0.125
    D      0.000     32.000    268.000       2.000

 PHI = 19.60    SHRSTR = 0.22    SANGLE = DEFAULT

                    DENSITY = 0.0625
```

Intermediate kern plot

If any of the computed base pressures are negative, the user is next asked the question

```
DO YOU WISH TO SEE THE INTERMEDIATE KERN PLOT?
```

If YES is given, the following are plotted:

a. *Outline of the original base.* Solid lines.

b. *Kern.* Dashed lines.

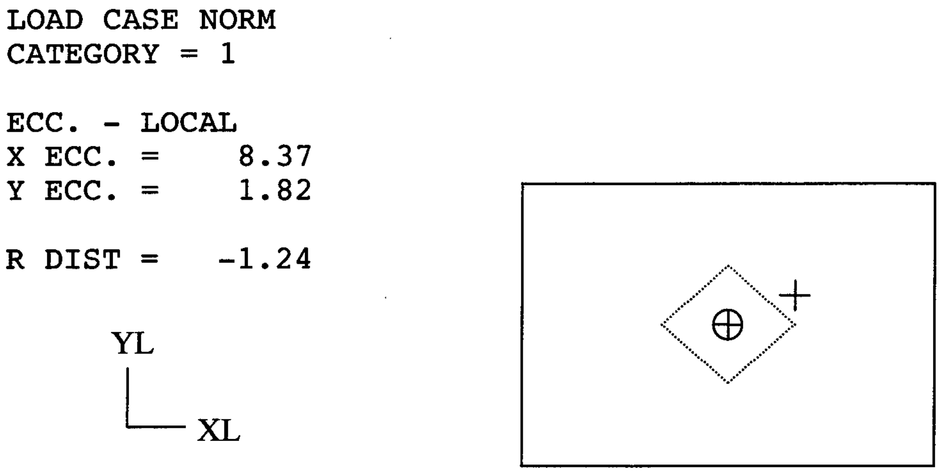
c. *Centroid of the base.* Circled +.

d. *Position of the load resultant.* +.

e. *Eccentricity.* Printout of x and y values in the local coordinate system.

f. *⊥ distance from load resultant to kern.* Printout of positive value for inside and negative value for outside.

Figure 37 shows the intermediate kern plot for the data file given in Table 8.



```
LOAD CASE NORM
CATEGORY = 1

ECC. - LOCAL
X ECC. =    8.37
Y ECC. =    1.82

R DIST =   -1.24
```

Figure 37. Intermediate kern plot

When this plot is completed, the program will pause. A carriage return sends the program to print the intermediate results.

Intermediate results

The intermediate results for the data file in Table 8 are given in Table 10. The description of the variables for the intermediate and final results are given in Table 11.

Final kern plot

The user is next asked the question

```
DO YOU WISH TO SEE THE FINAL KERN PLOT?
```

If YES is given, the plot shown in Figure 39 is given.

Final results

Finally, the final results are printed. The final results for the data file in Table 8 are given in Table 12. A carriage return sends the program to the `COMMAND?` question.

Table 10. Intermediate Results

```
                    LOAD CASE NORM CATEGORY = 1

                   COMPUTED BASE AREA PROPERTIES

  AREA = 1728.000      IXP = 147456.0     IYP = 410904.0
  XBAR =   27.000     YBAR =   16.000    ZBAR =    268.0
 XYANG =    0.000    ZNANG =    0.000   PXANG =    0.000


                   SUMMARY OF FORCES AND MOMENTS

                             --INPUT--

    FX =  1100.000    FY =     0.000    FZ = -5800.000
    MX = -100000.0    MY =    0000.0    MZ =       0.0

                        --COMPUTED UPLIFT--

    FX =     0.000    FY =     0.000    FZ =  1836.000
    MX =   29376.0    MY = -34492.0     MZ =       0.0

                             --TOTAL--

    FX =  1100.000    FY =     0.000    FZ = -9964.000
    MX =  -70624.0    MY = 435008.0     MZ =       0.0

    COMPUTED IN PLANE COORDINATES AND BASE PRESSURES

      NAME       X          Y          Z      PRESSURE

       A        .000       .000    268.000     -0.621
       B      54.000       .000    268.000      3.646
       C      54.000     32.000    268.000      5.209
       D        .000     32.000    268.000      0.942

          COMPUTED SHEAR FRICTION FACTOR OF SAFETY

        PHI = 19.60    SHRSTR = 0.22    SANGLE = 0.

                    FACTOR OF SAFETY = 1.63
```

Table 11. Description of Variables

Variable	Description
`CATEGORY`	1 – long term, 2 – short term, 3 – instantaneous
`AREA`	Area of the base in the plane of analysis
`IXP`	x principal moment of area in the local coordinate system
`IYP`	y principal moment of area in the local coordinate system
`XBAR`	x centroid in global coordinates
`YBAR`	y centroid in global coordinates
`ZBAR`	z centroid in global coordinates
`XYANG`	Angle the line of greatest slope in the plane of analysis makes with the global x axis (θ_{xy} in Figure 38)
`ZNANG`	Angle the plane of analysis makes with the horizontal line (θ_z in Figure 38)
`PXANG`	Angle between the local x axis and the principal x axis associated with the moment of area in the local coordinate system
`FX`	Force in the x direction
`FY`	Force in the y direction
`FZ`	Force in the z direction
`MX`	Moment in the x direction
`MY`	Moment in the y direction
`MZ`	Moment in the z direction
`NAME`	Point label
`(X, Y, Z)`	Global (x, y, z) coordinates of the in-plane point
`PRESSURE`	Computed bearing or base pressure
`FACTOR OF SAFETY`	Shear friction factor of safety
`EFFECTIVE BASE`	Percentage of base in compression

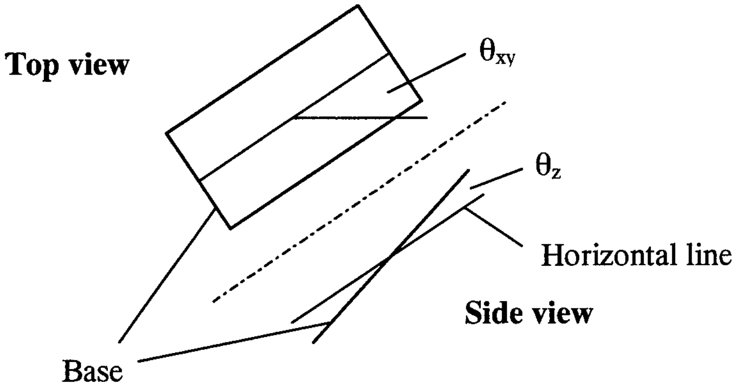
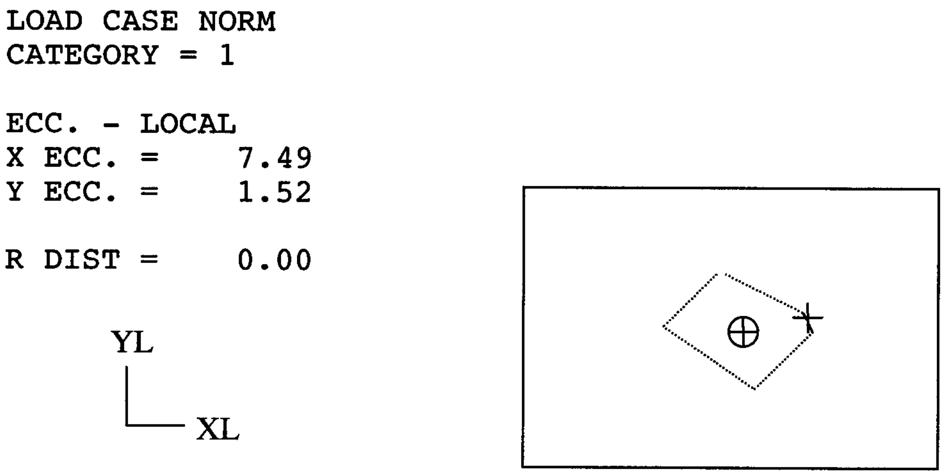


Figure 38. Angle definitions



```
LOAD CASE NORM
CATEGORY = 1

ECC. - LOCAL
X ECC. =    7.49
Y ECC. =    1.52

R DIST =    0.00
```

Figure 39. Final kern plot

Table 12. Final Results

```
               LOAD CASE NORM CATEGORY = 1

              COMPUTED BASE AREA PROPERTIES

  AREA = 1645.519      IXP = 134187.1     IYP = 373770.5
  XBAR =   28.175     YBAR =   16.544    ZBAR =    268.0
 XYANG =    0.000    ZNANG =    0.000   PXANG =   -5.208


              SUMMARY OF FORCES AND MOMENTS

                        --INPUT--

    FX =  1100.000   FY =     0.000   FZ = -5800.000
    MX = -100000.0   MY =    0000.0   MZ =       0.0

                   --COMPUTED UPLIFT--

    FX =     0.000   FY =     0.000   FZ =  1913.326
    MX =   29774.0   MY = -36567.5    MZ =       0.0

                        --TOTAL--

    FX =  1100.000   FY =     0.000   FZ = -9964.000
    MX =  -70226.0   MY = 433432.6    MZ =       0.0

   COMPUTED IN PLANE COORDINATES AND BASE PRESSURES

     NAME      X          Y          Z      PRESSURE

     B-A    10.684       .000    268.000      0.000
       B    54.000       .000    268.000      3.535
       C    54.000     32.000    268.000      5.343
       D      .000     32.000    268.000      0.935
     D-A      .000     15.440    268.000      0.000

        COMPUTED SHEAR FRICTION FACTOR OF SAFETY

      PHI = 19.60   SHRSTR = 0.22   SANGLE = 0.

   FACTOR OF SAFETY = 1.59     EFFECTIVE BASE = 95.2
```

5 Free-Body Module

Introduction

The practicing engineer not only needs to perform an analysis at the base of the structure but also at other elevations and cross sections. Therefore, the ability to "clip" the structure with a single or multiple planes is needed to produce a free body containing a new definition of geometry and loads. The Free-Body Module is a utility written to facilitate this process. An example is given in Figures 40 and 41. Figure 40 shows the clipping plane in the front view of Figure 28, and Figure 41 shows the result of the clip for the shaded view of Figure 30.

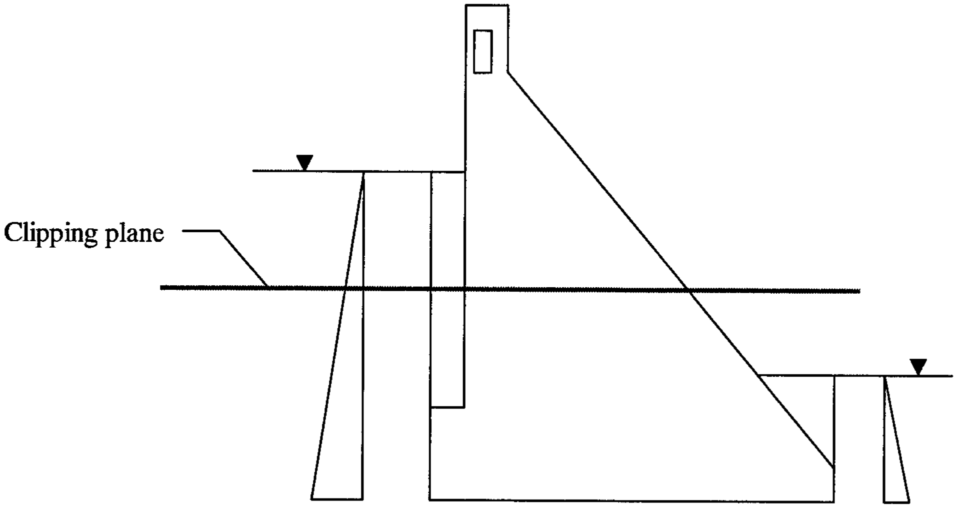


Figure 40. Front view with clipping plane

Input consists of the following:

a. *Data file names.* The name of the input data file to be clipped and the names of the output data files.

b. *Clip commands.* A group of commands identical to those available in the General Geometry and General Loads Modules that will produce the correct clipped data files.

c. *Reference point.* The (x, y, z) point that behaves like a local origin and is the reference point about which moments are computed.

Any number of input data files and clip commands can be given.

Output consists of a data file containing the clipped geometry or loads data to be input into the General Geometry or General Loads Module, respectively, and a base file for the General Analysis Module.

This rigid body type analysis is good for a coarse approximation of the stresses within the structure. If a more detailed analysis is required, the finite element method should be used.

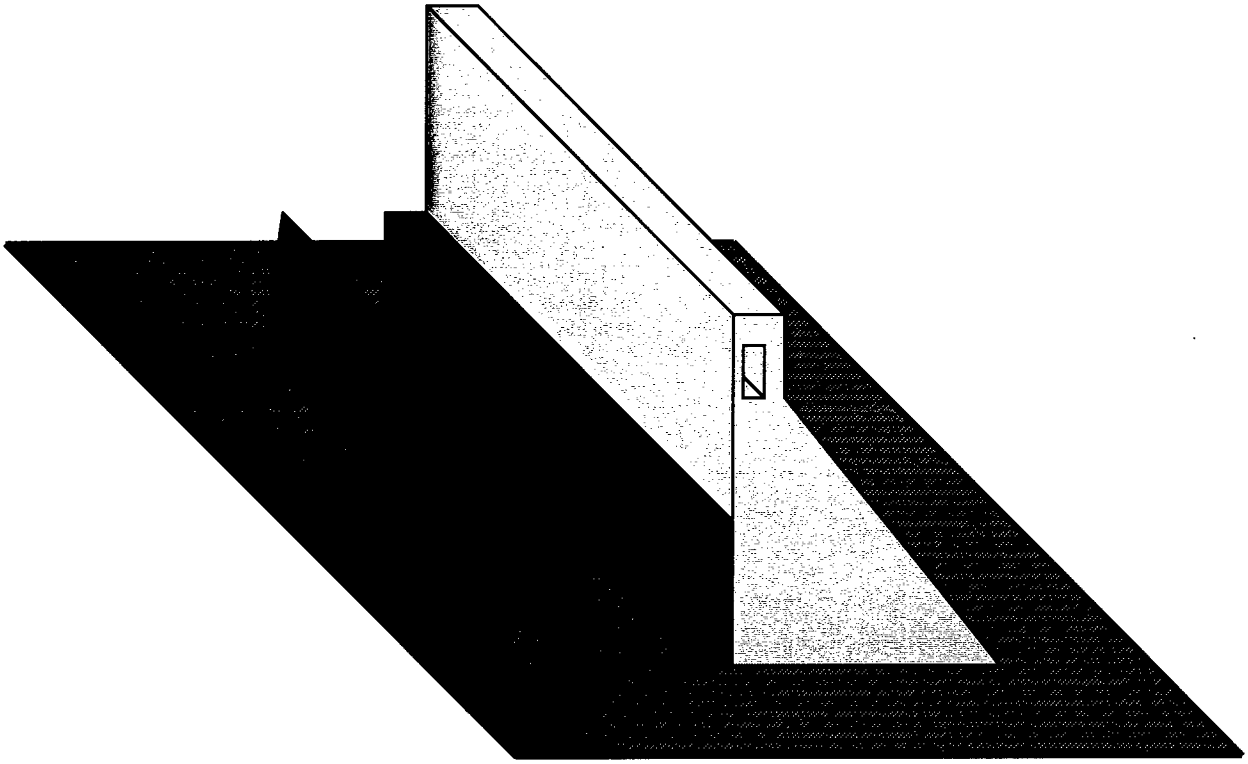
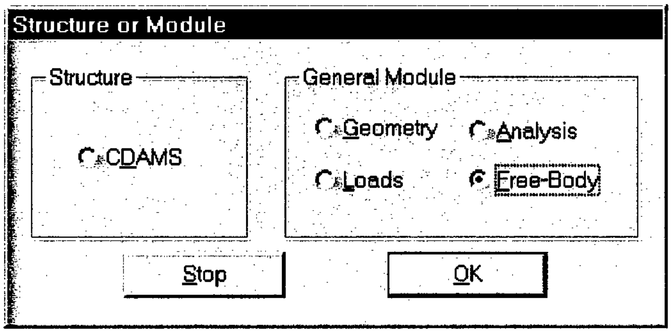


Figure 41. Shaded view with clipped data

Running the Program

After the program is initiated, the following text appears on screen; you are presented the following dialog box from which you select which module to use:

```
**********************************
*  CASE PROGRAM   #X8100        *
*       VERSION   #1997/10/01   *
**********************************
```



Select the option button marked *Free-Body* and then press the *OK* button (pressing *Stop* will end the program). You are then ready to do the question-and-answer sequence described next.

Before running the Free-Body Module, the user must save his general geometry and general loads in one or more files. The first question the Free-Body Module asks is

```
INPUT DATA FILE NAME?
```

Here the user gives the name of the first of the total number of files to be clipped. The next question is

```
NUMBER OF CLIPS?
```

At least one clip must be performed. After this question, any of the same clip commands available in the General Geometry and General Loads Modules are given in response to the question

```
CLIP COMMAND?
```

The format of the CLIP command is found in Chapter 2.

So that more than one data file can be clipped, the next question is

```
NEXT DATA FILE NAME (OR TYPE NONE)?
```

If the user has no more data files, he should answer NONE at this point.

For loads computations, the forces and moments will be computed about a global origin unless another point is specified. The following question allows the user to choose this point.

```
POINT WHERE FORCES AND MOMENTS ARE TO BE COMPUTED CX, Y, Z)?
```

The default coordinates are (0, 0, 0).

New geometry and loads data resulting from the various clips can be put into a data file for further use. Therefore, the next question to be answered is

```
FILE NAME FOR CLIPPED GEOMETRY AND LOADS DATA?
```

If a carriage return or enter is typed, the data file is not saved. With a near horizontal clip, it is also appropriate to save a new base for an analysis using the General Analysis Module. The last question is then

```
FILE NAME FOR NEW BASE DATA?
```

As before, if a carriage return or enter is typed, the file is not saved. If file names are assigned, these two files are saved when the Free-Body Module is exited.

Example Problems

Two examples illustrating the Free-Body Module are given in the following paragraphs.

Horizontal clip

Consider first the simple example of the nonoverflow monolith shown in Figures 40 and 41 with more detail given in Figures 42 and 43 and accompanying data files FREEG and FREEL given in Tables 13 and 14, respectively. The problem consists of headwater at 56.8 m (186.5 ft) and tailwater at 37.46 m (122.9 ft). Figure 42 shows a front view of the geometry and pressure volume loads used to model the problem, and Figure 43 shows an isometric view. Table 13 contains the geometric data, and Table 14 contains the loads data. A clip at z = 45.7 m (150 ft) will be accomplished with forces and moments to be computed at the point (3, 0, 150).

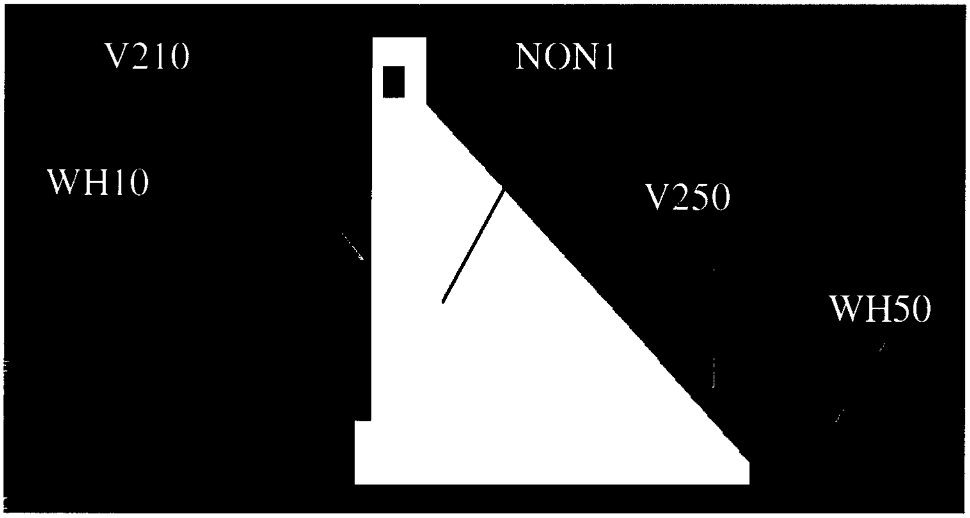


Figure 42. Front view (horizontal clip)

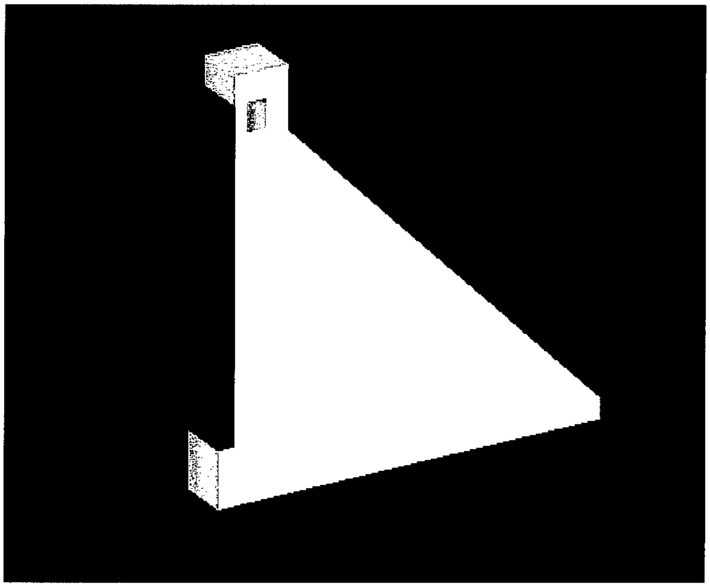


Figure 43. Isometric view (horizontal clip)

Table 13. File FREEG

```
20000 POINTS   12
20010     1      0.          0.         95.500
20020     2      0.          0.        109.000
20030     3      3.000       0.        109.000
20070     4      3.000       0.        193.500
20080     5     13.000       0.        193.500
20110     6     13.000       0.        178.500
20120     7     72.280       0.        100.500
20140     8     72.280       0.         95.500
20150     9      5.000       0.        180.000
20160    10      5.000       0.        187.000
20170    11      9.000       0.        187.000
20180    12      9.000       0.        180.000
20190 BLOCK NON1    0.15000     10.000     1
20200       1.000       1.000
20210  8  1  2  3  4  5  6  7  8
20220       1.000       1.000
20230   4 12 11 10  9
```

The computer run to complete this is as follows:

Table 14. File FREEL

```
20000 POINTS     4
20020      1      0.          0.        109.000
20030      2      3.000       0.        109.000
20070      3      3.000       0.        186.500
20080      4      0.          0.        186.500
20090 BLOCK  -Z  V210     0.06250     10.000
20100        1.000       1.000
20110      4    4    3    2    1
20120 POINTS     3
20130      9     72.280       0.        122.900
20140     10     55.256       0.        122.900
20150     11     72.280       0.        100.500
20170 BLOCK  -Z  V250     0.06250     10.000
20180        1.000       1.000
20190      3   11   10    9
20200 POINTS     3
20210     13    -10.000       0.        186.500
20220     14    -10.000       0.         95.500
20230     15    -28.200       0.         95.500
20240 BLOCK  +X  WH10     0.31250     10.000
20250        1.000       1.000
20260      3   13   14   15
20270 POINTS     3
20280     16     10.000       0.        122.900
20290     17     10.000       0.         95.500
20300     18     15.480       0.         95.500
20310 BLOCK  -X  WH50     0.31250     10.000
20320        1.000       1.000
20330      3   18   17   16
20360 TRAN WH50
20370           72.280 0. 0.
20380 COLOR       RED      V210
20390 COLOR       RED      V250
20400 COLOR      CYAN      WH10
20410 COLOR      CYAN      WH50
```

```
ENTERING FREE-BODY MODULE.

INPUT DATA FILE NAME?
FREEG

NUMBER OF CLIPS?
1
```

```
CLIP COMMAND?
CLIP Z 150

ENTERING CLIPPING MODULE.

CLIPPING NON1

EXITING CLIPPING MODULE.

NEXT DATA FILE NAME (OR TYPE NONE)?
FREEL

NUMBER OF CLIPS?
2

CLIP COMMAND?
CLIP Z 150

ENTERING CLIPPING MODULE.

CLIPPING V210
CLIPPING V250
CLIPPING WH10
CLIPPING WH50

EXITING CLIPPING MODULE.

CLIP COMMAND?
CLIP X 3 V210

ENTERING CLIPPING MODULE.

CLIPPING V210
CLIPPING WH10

EXITING CLIPPING MODULE.

NEXT DATA FILE NAME (OR TYPE NONE)?
NONE

POINT WHERE FORCES AND MOMENTS ARE TO BE COMPUTED
(X, Y, Z)?
3 0 150

FILE NAME FOR CLIPPED GEOMETRY AND LOADS DATA?
FREEC
```

```
FILE NAME FOR NEW BASE DATA?
FREEB

EXITING FREE-BODY MODULE.
```

Two clips are needed on the loads file, FREEL, because the heel supporting the vertical load on the upstream side was removed by the first clip, leaving a piece of vertical water load that was discarded by the second clip. The clipped data file FREEC is given in Table 15, and FREEB is given in Table 16. Figure 44 shows a plot of the resulting geometry and loads.

Table 15. FREEC Data File

```
20000 POIN   18
20000    1      3.00       .00    150.00
20000    2      3.00       .00    193.50
20000    3      3.00     10.00    193.50
20000    4      3.00     10.00    150.00
20000    5     13.00       .00    193.50
20000    6     13.00     10.00    193.50
20000    7     13.00       .00    178.50
20000    8     13.00     10.00    178.50
20000    9     34.66       .00    150.00
20000   10     34.66     10.00    150.00
20000   11      5.00       .00    180.00
20000   12      9.00       .00    180.00
20000   13      9.00     10.00    180.00
20000   14      5.00     10.00    180.00
20000   15      9.00       .00    187.00
20000   16      9.00     10.00    187.00
20000   17      5.00       .00    187.00
20000   18      5.00     10.00    187.00
20000 FACE NON1       .15   13
20000    4    1    2    3    4
20000    4    2    5    6    3
20000    4    5    7    8    6
20000    4    7    9   10    8
20000    5    9    7    5    2    1
20000    5    4    3    6    8   10
20000    4   11   12   13   14
20000    4   12   15   16   13
20000    4   15   17   18   16
20000    4   17   11   14   18
20000    4   17   15   12   11
20000    4   13   16   18   14
20000    4    4   10    9    1
```

(Continued)

Table 15. (Concluded)

```
20000 POIN    6
20000   19   -10.00        .00    186.50
20000   20   -10.00      10.00    186.50
20000   21   -17.30      10.00    150.00
20000   22   -17.30        .00    150.00
20000   23   -10.00        .00    150.00
20000   24   -10.00      10.00    150.00
20000 COLO CYAN WH10
20000 FACE   +X WH10      .3125     5
20000    4   19   20   21   22
20000    4   23   24   20   19
20000    3   19   22   23
20000    3   20   24   21
20000    4   24   23   22   21
20000 TRAN
20000     -3.00      0.00   -150.00
```

Table 16. FREEB Data File

```
20000 POIN    4
20000    1     3.00        .00    150.00
20000    9    34.66        .00    150.00
20000   10    34.66      10.00    150.00
20000    4     3.00      10.00    150.00
20000 BASE
20000    4    1    9   10    4
```

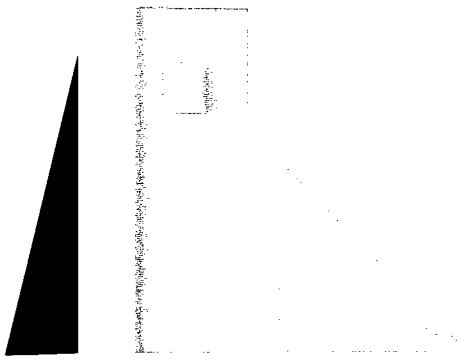


Figure 44. Plot of data from clip

FREEC and FREEB can now be used in further calculations using the other general modules.

Vertical clip

The user may desire to perform an analysis on a 0.3048-m (l-ft) cross section of his geometry and loads. Data used to accomplish this task can be generated by using the vertical clip option of the Free-Body Module. To illustrate, consider the data file (called FREEGL) in Table 17 containing a nonoverflow cross section, two gates, a pier, a horizontal water pressure volume, and a vertical water pressure volume. A front and isometric view of these data are shown in Figures 45 and 46. Suppose we wish to compute the forces and moments on a 0.3048-m (l-ft) strip in the very center of the structure (y = 14.9 m (6 ft)). The following execution of the Free-Body Module consisting of clips at 4.7 m (15.5 ft) and 5.0 m (16.5 ft) will accomplish this task:

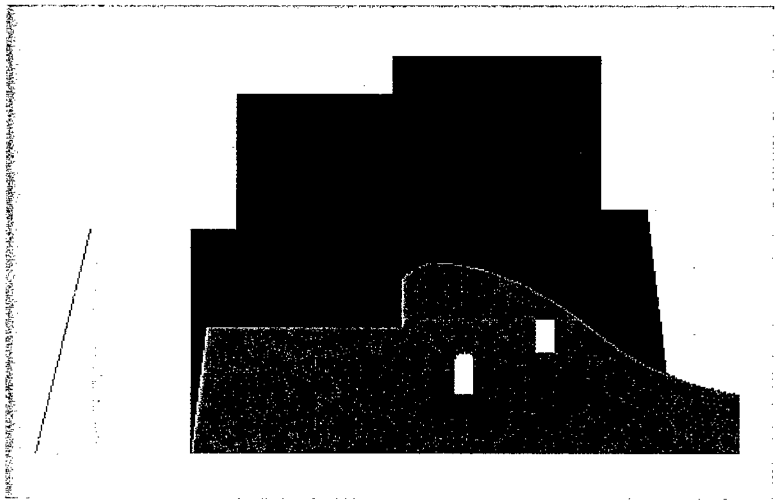


Figure 45. Front view (vertical clip)

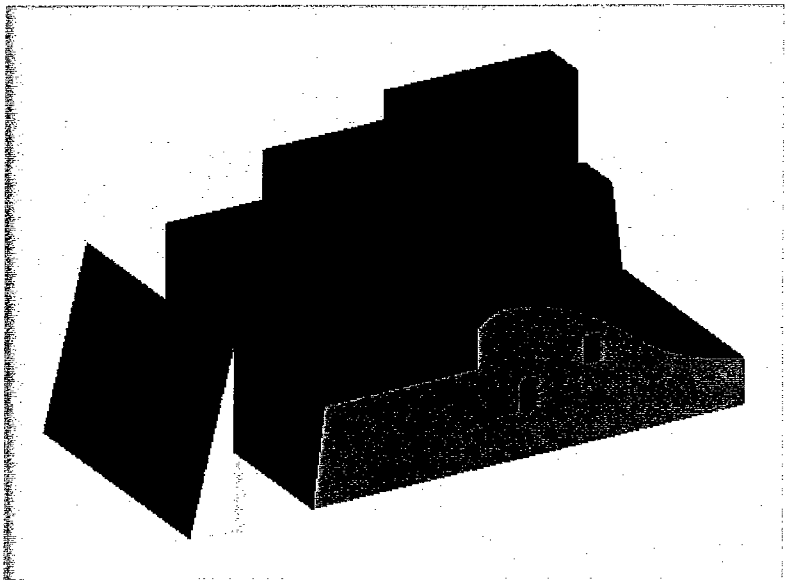


Figure 46. Isometric view (vertical clip)

Table 17. FREEGL Data File

```
20000 POIN   16
20010    1        0.        0.   268.000
20020    2     1.500        0.   283.000
20030    3    20.700        0.   283.000
20050    4    20.700        0.   288.940
20060    5    24.230        0.   291.000
20070    6    40.020        0.   282.560
20080    7    54.230        0.   275.000
20890    8    54.230        0.   268.000
20100    9    26.000        0.   275.000
20110   10    26.000        0.   279.000
20120   11    28.000        0.   279.000
20130   12    28.000        0.   275.000
20140   13    34.000        0.   280.000
20150   14    34.000        0.   284.000
20160   15    36.000        0.   284.000
20170   16    36.000        0.   280.000
20180 QUAD    4    5   22.465        0.   290.485
20190 QUAD    5    6   32.125        0.   288.658
20200 CIRC    7    6   28.000 LEFT
20210 CIRC   11   10    1.000 RIGH
20220 BLOC OVE1     0.150    32.000    2
20230     1.000     1.000
20240    8    1    2    3    4    5    6    7    8
20250     1.000     1.000
20260    4   12   11   10    9
20270     1.000     1.000
20280    4   16   15   14   13
20290 POIN   14
20300   17    20.700    13.000   288.940
20310   18    24.230    13.000   291.000
20320   19    40.020    13.000   282.560
20330   20    47.025    13.000   277.500
20340   21    45.010    13.000   297.500
20350   22    40.590    13.000   297.500
20360   23    40.590    13.000   315.670
20370   24    19.920    13.000   315.670
20380   25    19.920    13.000   311.220
20390   26     4.500    13.000   311.220
20400   27     4.500    13.000   291.000
20410   28     1.500    13.000   291.000
20420   29     1.500    13.000   283.000
20430   30    20.700    13.000   283.000
```

(Sheet 1 of 3)

Table 17. (Continued)

```
20440 CIRC   20   19    28.000
20450 QUAD   18   19    32.125    13.000   288.658
20460 QUAD   18   17    22.465    13.000   290.485
20470 BLOC PIE1     0.150     6.000
20480     1.000     1.000
20490   14   30   29   28   27   26   25   24   23
22   21   20
20500   19   18   17
20510 POINT   3
20520   31    24.230        0.   291.000
20540   32    26.369        0.   300.000
20550   33    24.230        0.   291.000
20560 CIRC   32   31    20.000 RIGH
20570 CIRC   32   33    20.000 RIGH
20580 BLOC GAT1    0.0625    13.000
20590     1.000     1.000
20600    3   33   32   31
20610 POIN    3
20620   34    24.230       19.   291.000
20630   35    26.369       19.   300.000
20640   36    24.230       19.   291.000
20650 CIRC   35   34    20.000 RIGH
20660 CIRC   35   36    20.000 RIGH
20670 BLOC GAT2    0.0625    13.000
20680     1.000     1.000
20690    3   34   35   36
20700 COLO  RED GAT1
20710 COLO  RED GAT2
20720 COLO MAGE PIE1
20730 POIN    7
20740   37      .000        0.   268.000
20750   38     1.500        0.   283.000
20760   39    20.700        0.   283.000
20770   40    20.700        0.   288.940
20780   41    24.230        0.   291.000
20790   42    24.634        0.   295.000
20800   43      .000        0.   295.000
20810 QUAD   40   41    22.465      .000   290.485
20820 CIRC   42   41    20.000 RIGH
20830 BLOC   -z V210     .0625    13.000
20840     1.000     1.000
20850    7   43   42   41   40   39   38   37
```

(Sheet 2 of 3)

Table 17. (Concluded)

```
20860 POIN    7
20870   44       .000     19.000    268.000
20880   45      1.500     19.000    283.000
20890   46     20.700     19.000    283.000
20900   47     20.700     19.000    288.940
20910   48     24.230     19.000    291.000
20920   49     24.634     19.000    295.000
20930   50       .000     19.000    295.000
20940 QUAD   47   48     22.465     19.000    290.485
20950 CIRC   49   48     20.000 RIGH
20960 BLOC   -Z V212      .0625     13.000
20970      1.000     1.000
20980    7   50   49   48   47   46   45   44
20990 POIN    6
21000   51       .000     13.000    268.000
21010   52      1.500     13.000    283.000
21020   53      1.500     13.000    291.000
21030   54      4.500     13.000    291.000
21040   55      4.500     13.000    295.000
21050   56       .000     13.000    295.000
21060 BLOC   -Z V211      .0625      6.000
21070      1.000     1.000
21080    6   56   55   54   53   52   51
21090 POIN    3
21100   57   -10.000       .000    295.000
21110   58   -10.000       .000    268.000
21120   59   -15.400       .000    268.000
21130 BLOC   +X WH10      .3125     32.000
21140      1.000     1.000
21150    3   57   58   59
21160 COLO CYAN V210
21170 COLO BLUE V211
21180 COLO CYAN V212
21190 COLO YELL WH10
21200 COLO BLAC OVE1
21210 BACK WHIT
```

(Sheet 3 of 3)

```
ENTERING FREE-BODY MODULE.

INPUT DATA FILE NAME?
FREEGL

NUMBER OF CLIPS?
2
```

```
CLIP COMMAND?
CLIP Y 15.5

ENTERING CLIPPING MODULE.

CLIPPING OVE1
CLIPPING PIE1
CLIPPING GAT1
CLIPPING GAT2
CLIPPING V210
CLIPPING V212
CLIPPING V211
CLIPPING WH10

EXITING CLIPPING MODULE.

CLIP COMMAND?
CLIP -Y 16.5

ENTERING CLIPPING MODULE.

CLIPPING OVE1
CLIPPING PIE1
CLIPPING GAT1
CLIPPING GAT2
CLIPPING V210
CLIPPING V212
CLIPPING V211
CLIPPING WH10

EXITING CLIPPING MODULE.

NEXT DATA FILE NAME (OR TYPE NONE) ?
NONE

POINT WHERE FORCES AND MOMENTS ARE TO BE COMPUTED
(X, Y, Z)?
0. 16. 0.

FILE NAME FOR CLIPPED GEOMETRY AND LOADS DATA?
FREECC

FILE NAME FOR NEW BASE DATA?
<CR>

EXITING FREE-BODY MODULE.
```

The output file FREEC can be read into the General Loads Module, plotted, and forces and moments computed. Figure 47 shows an isometric view of these data.

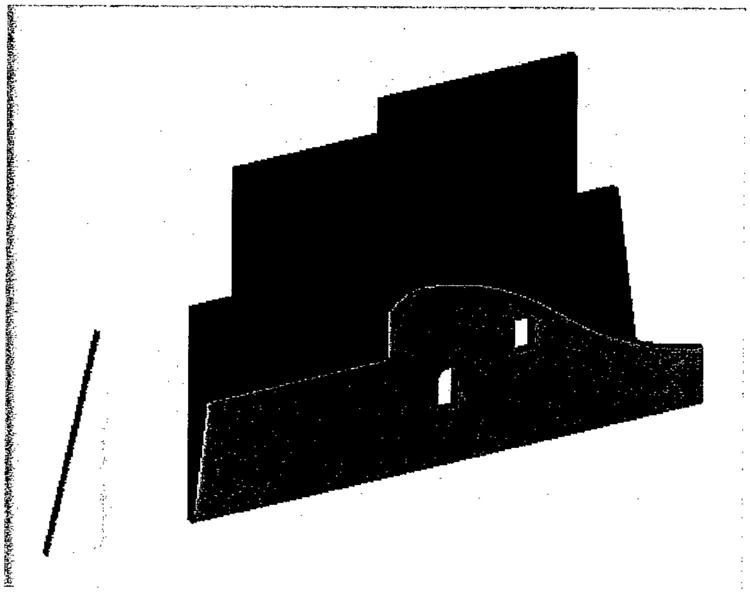


Figure 47. Isometric view of file FREECC

6 CDAMS

Introduction

CDAMS is a set of specific structure modules for dams. An overflow with optional pier and nonoverflow cross section is available through the Dams Input Module. Figure 48 shows the overflow cross section; Figure 49 shows the pier; and Figure 50 shows the nonoverflow cross section. More than one cross section can be used to describe the dam. As long as the given dam can be constructed by using the variables given, then CDAMS can be used to perform the stability computations. Six standard load cases as outlined in Engineer Manual 1110-2-2200 are available. The Criteria Check Module automatically checks sliding, maximum bearing, and percentage of effective base criteria for each load case requested.

An analysis consists of the following:

a. Generate data for general modules. The Dam Input Module converts its data for the geometry and water and soil levels into data files for the General Geometry, Loads, and Analysis Modules.

b. Automatic movement through the general modules. CDAMS automatically moves the user through the general modules to get the desired results. A stop is made in the General Geometry, Loads, and Analysis Modules to obtain geometry, loads, or kern plot, or get volume, weight, force, moment, base pressure, etc., information.

c. Criteria check. The Criteria Check Module is called to test the results for suitability.

Running the Program

After the program is initiated, the following text appears on screen, and you are presented a dialog box from which you select which module to use:

```
*********************************
*  CASE PROGRAM   #X8100        *
*       VERSION   #1998/10/01   *
*********************************
```

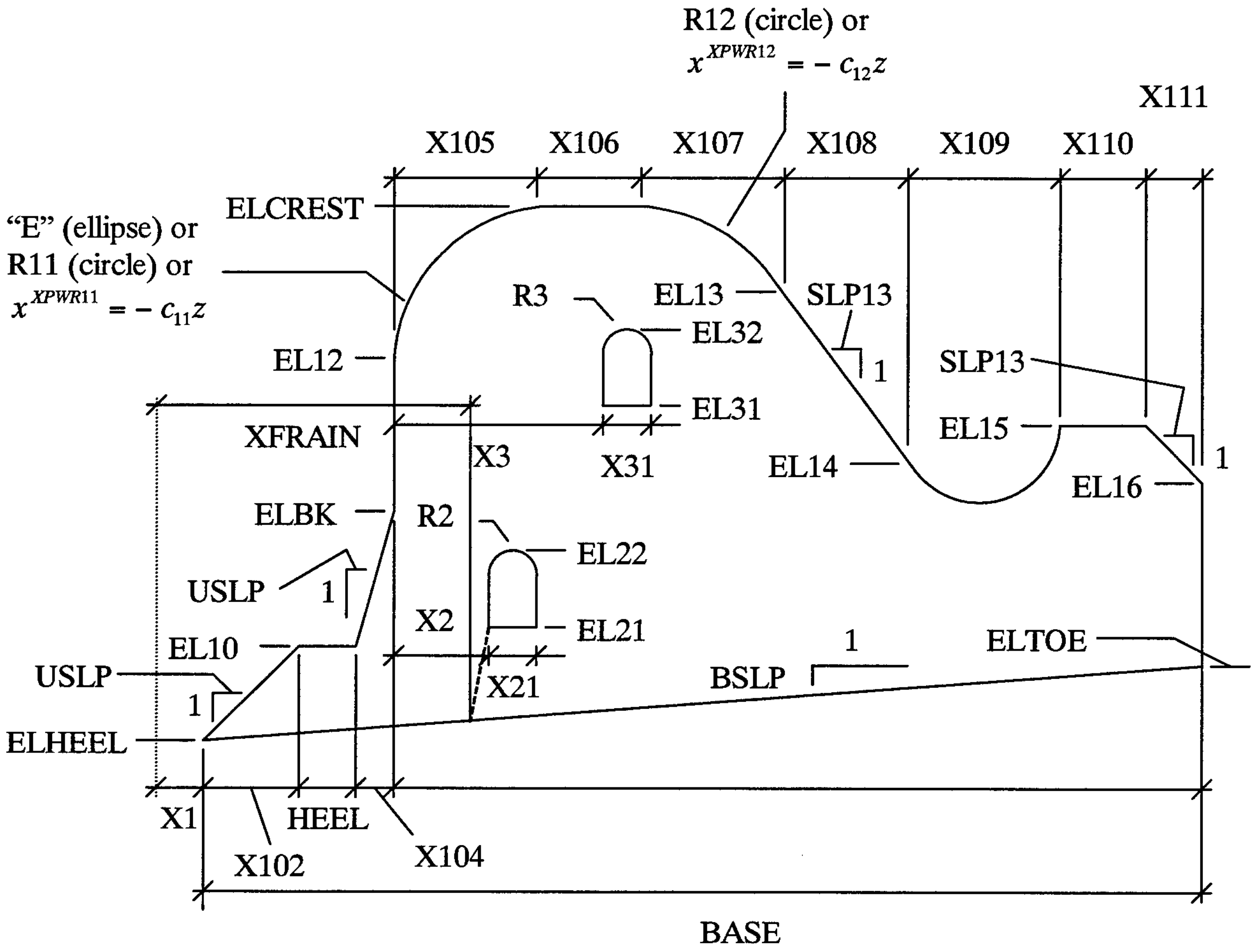
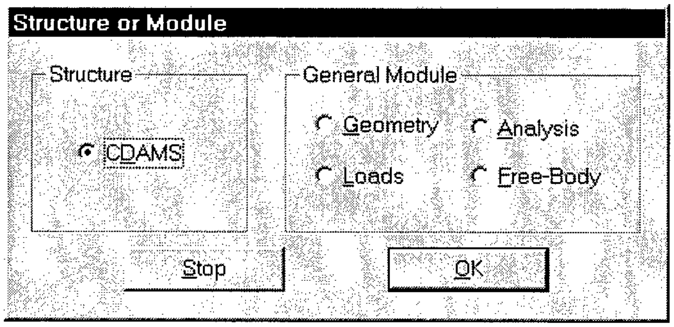


Figure 48. Overflow cross section



Select the option button marked *CDAMS* and then select the *OK* button (pressing *Stop* will end the program) to produce the following panel:

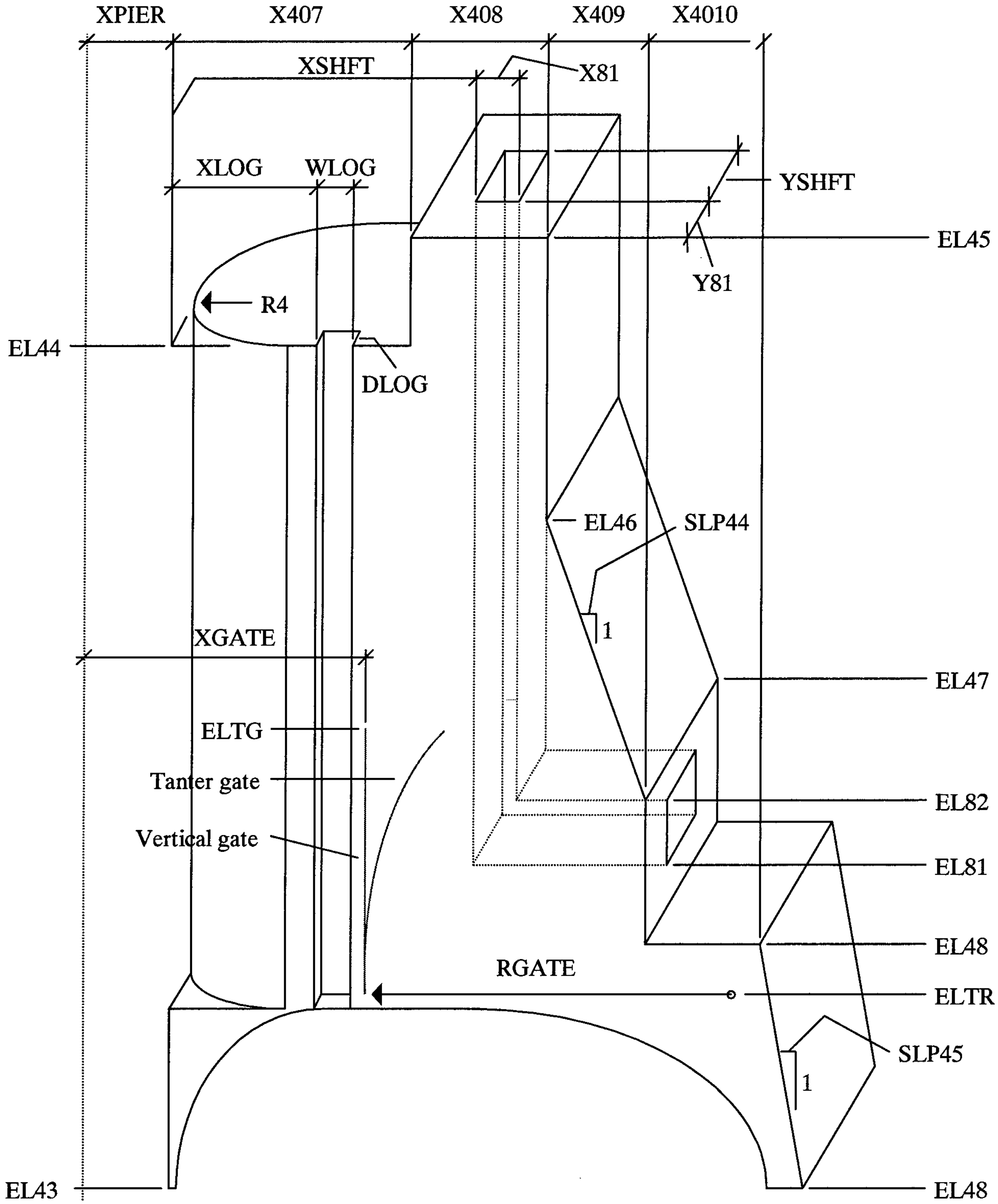


Figure 49. Pier section

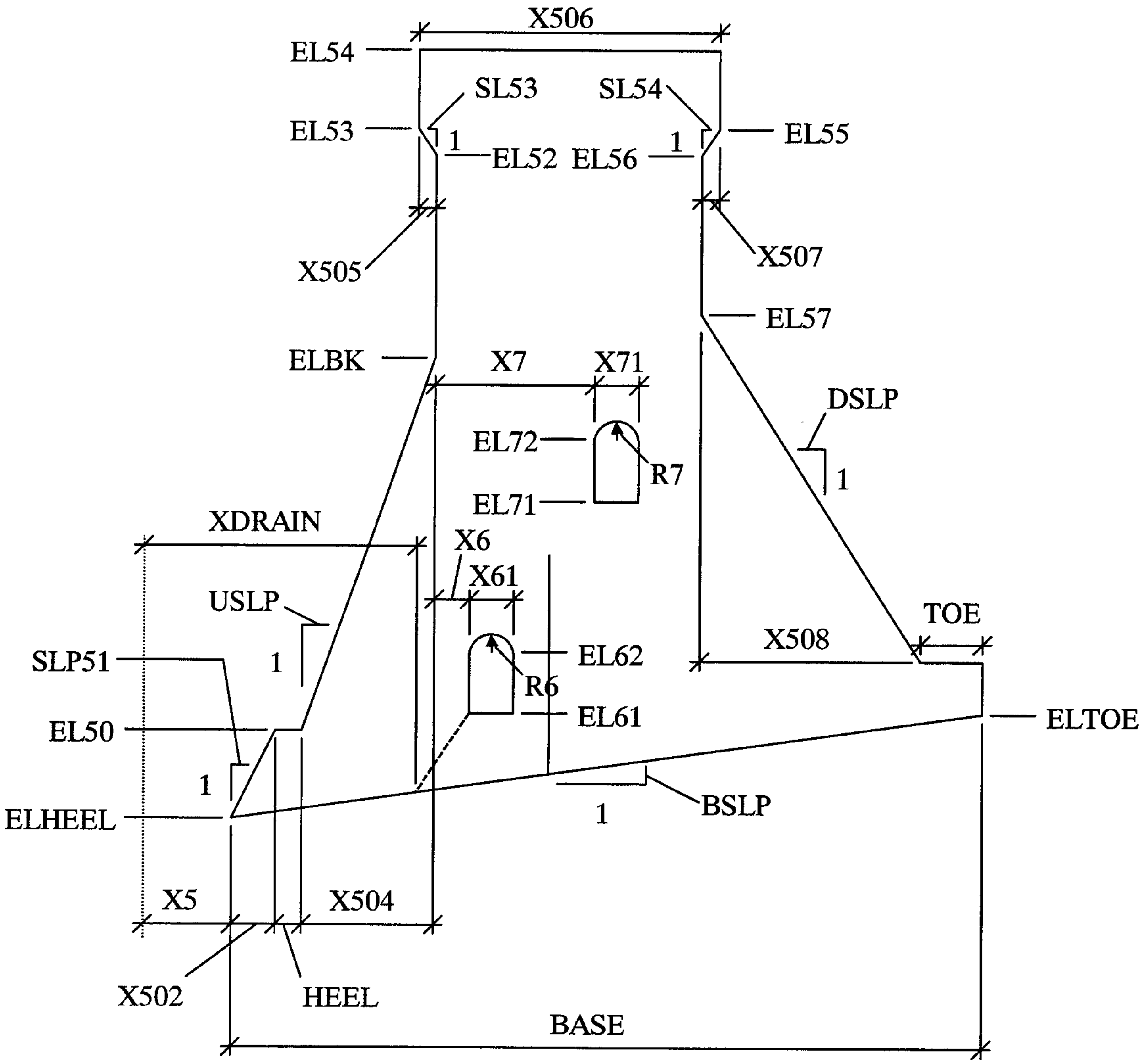
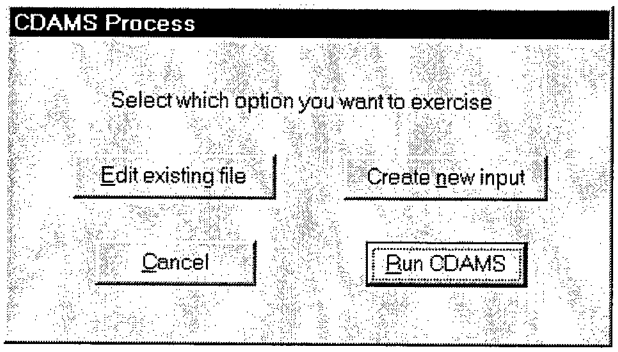


Figure 50. Nonoverflow cross section


CDAMS Process

Select which option you want to exercise

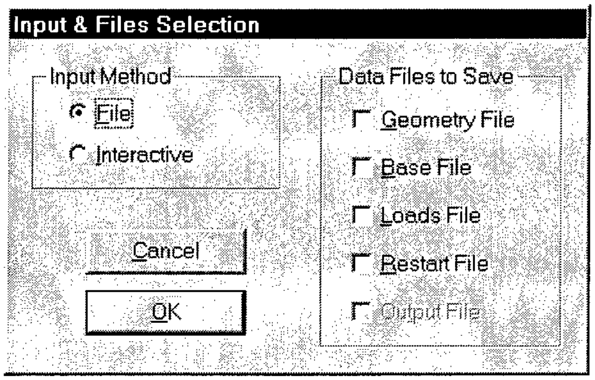
The different options will now be discussed.

Run CDAMS option

Select the *Run CDAMS* button, and the following line appears on screen:

```
ENTERING CDAMS MODULE.
```

You are then presented with the following dialog box, with which you identify how you want to input your data and whether or not you want to save as permanent output, files capturing various types of data and/or a *Restart File*. If you choose not to save data in permanent files, the program will generate temporary files as needed for use during the session.



Input & Files Selection

Input Method
● File
○ Interactive

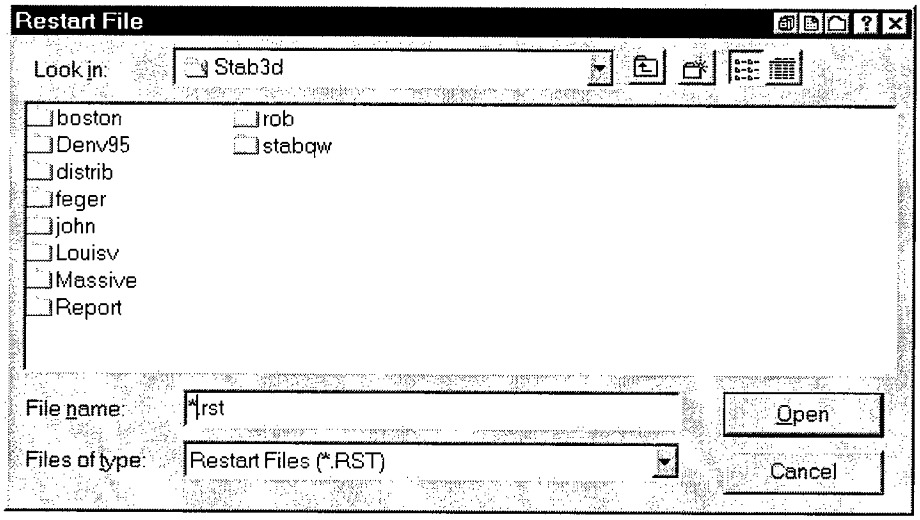
Data Files to Save
☐ Geometry File
☐ Base File
☐ Loads File
☐ Restart File
☐ Output File

First, choose your type of input, either from an existing input *File* or by an *Interactive* session. If working from an existing file, you will always have the opportunity to edit the geometry data of the structures defined in the file, but not all the other load data in the file. You can interactively edit most all the data in an existing file by first choosing to read the input file, proceed through the program, perform an analysis, and then return to this dialog box and then select *Interactive*. Then when you proceed, with a few exceptions, all values in the input file will be displayed in the appropriate dialog boxes for you to change as you see fit.

CAUTION: During an *Interactive* entry session, the resulting restart file (if saved) will **not** contain the altered data in a format suitable to use as an input file in the future. No means is available to save the altered data, to "back up" during the interactive session, or to rerun the program with the newly entered data. The program will however process the data entered and/or altered as if it were original input. Data displayed in the "Other Common Loads" and "Section Definition" dialog boxes during an interactive input session will only show the *last* data read, thus may not reflect the data in the original input file that was "paired" with the section as defined in the input file. The recommended method to interactively build a data set is to modify an existing data file or generate a new one by using the preprocessor file building utility and then read that file into the program.

If you choose to save data in permanent files, click on the appropriate check box(s). Once you have chosen your input type and which file(s) to save, press the *OK* button. You can uncheck selected boxes by clicking on the checked box a second time. Pressing the *Cancel* button will clear all the file check boxes and return you to the "Structure or Module" dialog box.

If you elected to not save permanent files, the program will generate temporary files as needed for it to continue; but if you chose to save data in permanent files, a dialog box will appear that allows you to choose a file name or enter a new one for each of the different file types you selected. The dialog box title bar identifies which type of file is being saved, and the default extension filter automatically shows only those files matching the proper file extension. Files will be asked for in the same order as they are in the dialog box, followed lastly by the *Input* file if appropriate. The following example would appear if the *Restart File* option were selected:



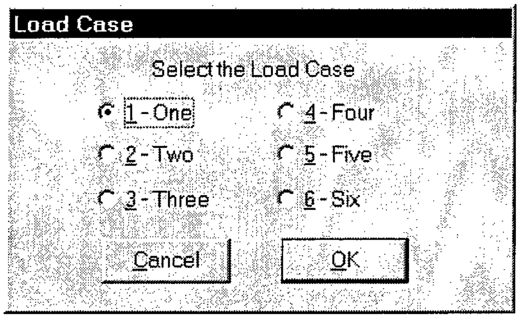
Look in: Stab3d

File name: *.rst

Files of type: Restart Files (*.RST)

For output files, selecting an existing file will cause the data in the existing file to be overwritten. Typing in a new file name will cause that file to be created and used until such time as a new one is entered. Pressing the *Cancel* button when an output file name is asked for will cause the program to generate a temporary file for internal use instead of a named permanent file. Pressing *Cancel* when an input file is asked for will cause the program to back up to the "Input & Files Selection" dialog box. Each permanent data file chosen stores either geometry, base, or loads data. The *Restart File* saves all data entered into the program, including data read in from other data files. When "stepping through" the 3DSAD modules, the *Geometry File* is used as input data for the General Geometry Module. The *Loads File* is used as partial input for the General Loads Module, and the *Base File* is used as partial input for the General Analysis Module.

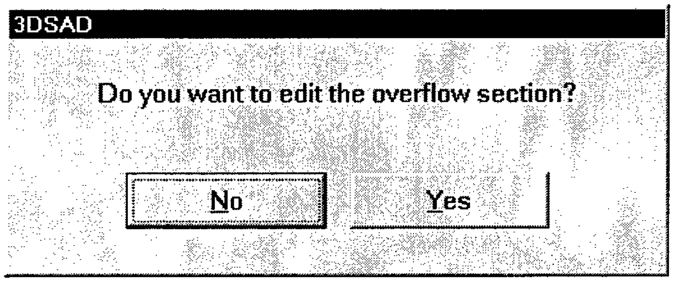
Once all the required file names are obtained, the dialog box disappears, and you are presented with the following dialog box in which you choose the load case:



Select which load case you wish to analyze and press the *OK* button. Selecting the *Cancel* button will return you to the "Structure or Module" Dialog box.

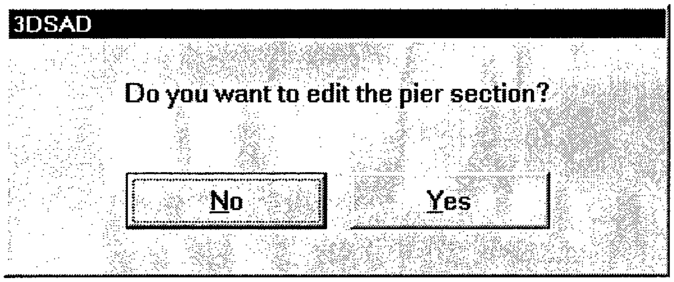
From this point on, the progress of the program is dependent on whether you elected to input data from an *Input File* or to *Interactive*ly input the data. The procedure as if input data were read from a file is presented here first, followed by the sequence of events as if an interactive session were conducted. Both input procedures culminate with a common procedure of either a design or an analysis. Those steps follow the interactive input sequence.

Input by an existing input file. Based on the structure defined in the file, one or more of the following dialog boxes will appear. They will appear in the same sequence as the structure is defined in the file:



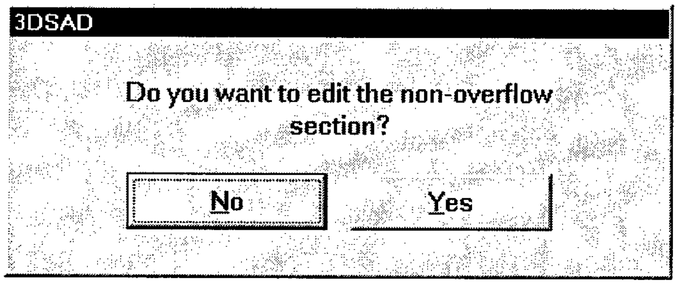
Do you want to edit the overflow section?

-or-



Do you want to edit the pier section?

-or-



Do you want to edit the non-overflow section?

Answering *No* will cause the program to continue to the next portion of the structure defined in the input file. If you select *Yes*, a graphic will appear that displays a "stylistic" representation of the structure, the variable names, and the current values for the structure's geometry. Each structure has been subdivided into three portions, with each portion having its own screen to keep the amount of information on each screen to a manageable level.

The three screens are as follows:

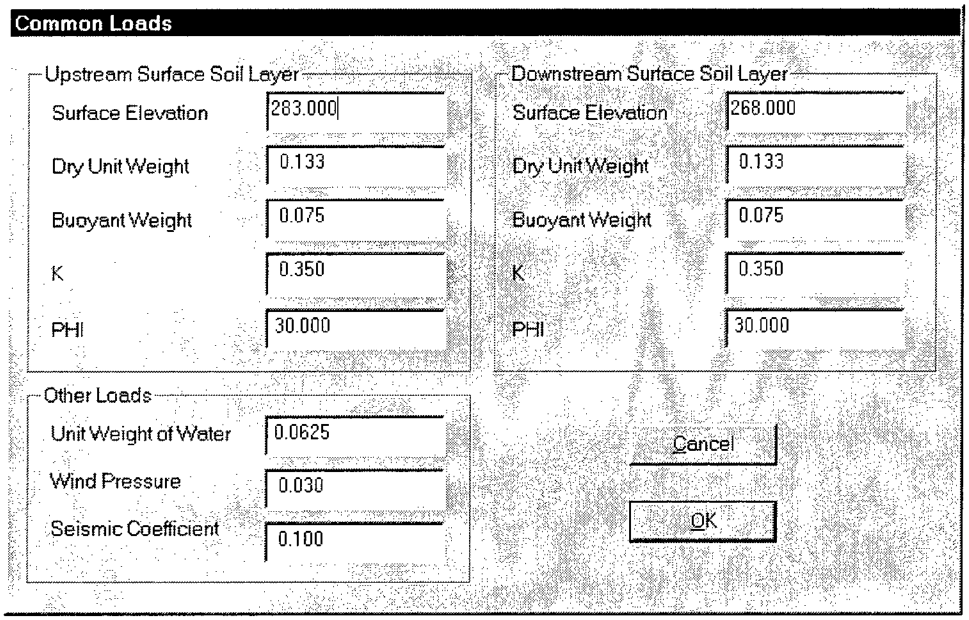
- Input of horizontal distance values.
- Input of vertical distance (elevation) values.
- Input of slope, curve, and radius values.

See Appendix A for a picture of the nine input screens. For each input screen, move the mouse cursor over a variable's name or value and press the left mouse button. A dialog box will appear that has the variable's name and a data entry field that displays its current value and allows you to change it. Typing in a new value and pressing the *OK* button will place the new value into the program. Pressing the *Cancel* button will cause the previous value to be retained. The dialog box will disappear, and the current value will be displayed on the graphic. You "toggle" between the three input screens for the structure type by clicking on one of the buttons located on the left side of the screen. Selecting the "EXIT" button will cause the program to continue on and process the next portion of the input file.

Once all structures defined in the input file are processed, a dialog box appears telling you that all input is complete. This is also the point where you end up after making all your input during an interactive input session. See the instructions that follow the interactive input procedures on how to proceed from that point.

Performing an interactive input session. CAUTION: Performing an interactive input session will **NOT** create a valid restart file. Although the values entered during the interactive session will be used during the program's design and/or analysis phase, no means are available to correct an incorrect entry or to rerun the program with newly entered values. The recommended method to interactively build a data set is to modify an existing data file or generate a new one by using the preprocessor file-building utility. If you desire to run the program in an interactive input mode, follow the procedures outlined below.

For the remaining dialog boxes, all have a button marked *Cancel.* Pressing the *Cancel* button will return the program flow to the "Structure or Module" dialog box and disregard any changes made to the values in that particular dialog box. After selecting your permanent data files to save (if any) and which load case to process, the following series of dialog boxes is displayed. The values displayed here are those that appear after reading in the example file 'X8100D1.DAT' and then performing an interactive entry session. (Read the CAUTION paragraph above and about the "Input and Files Selection" dialog box in the preceding section).

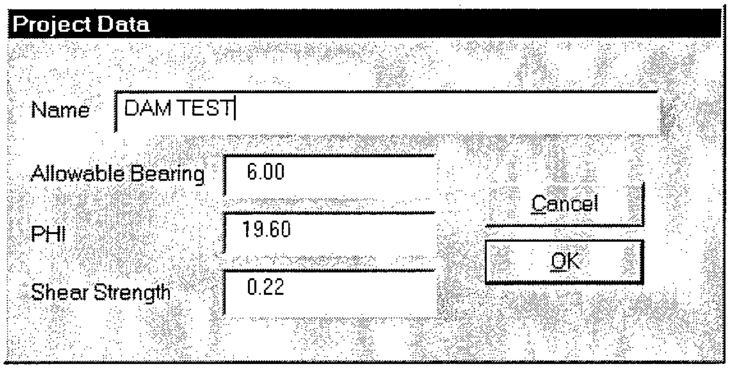


Common Loads

Upstream Surface Soil Layer
Surface Elevation 283.000
Dry Unit Weight 0.133
Buoyant Weight 0.075
K 0.350
PHI 30.000

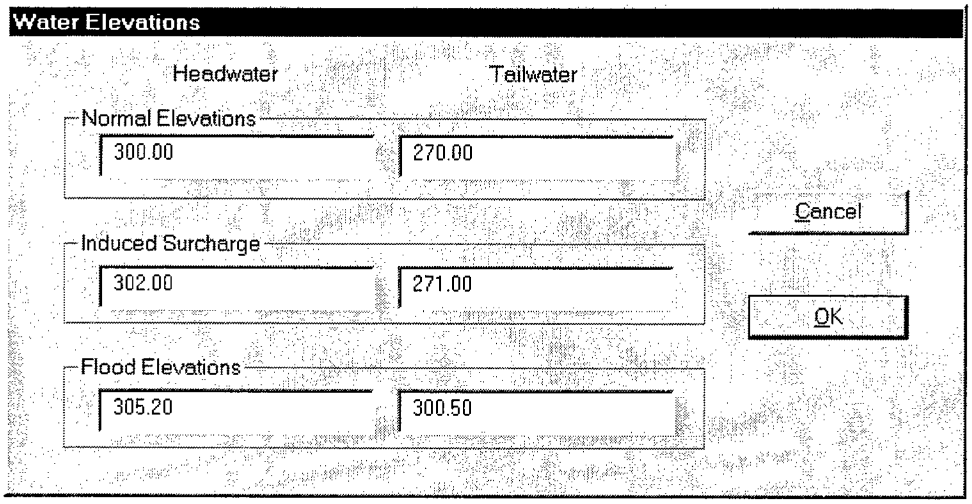
Downstream Surface Soil Layer
Surface Elevation 268.000
Dry Unit Weight 0.133
Buoyant Weight 0.075
K 0.350
PHI 30.000

Other Loads
Unit Weight of Water 0.0625
Wind Pressure 0.030
Seismic Coefficient 0.100



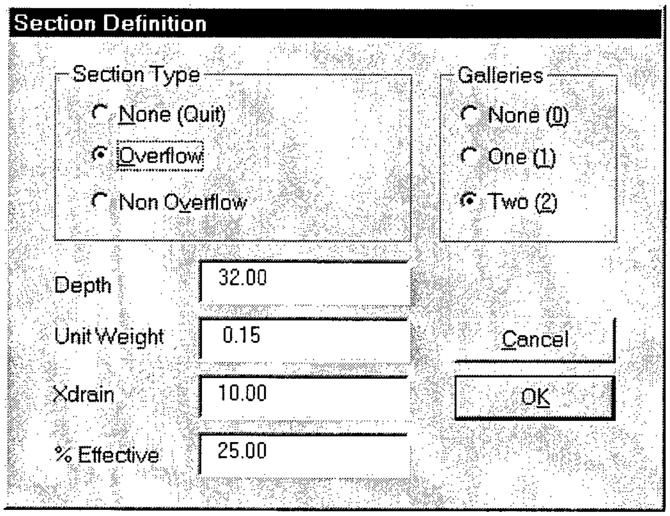
Project Data

Name DAM TEST
Allowable Bearing 6.00
PHI 19.60
Shear Strength 0.22



	Headwater	Tailwater
Normal Elevations	300.00	270.00
Induced Surcharge	302.00	271.00
Flood Elevations	305.20	300.50

This next dialog box, the "Section Definition" dialog, is the return point after data for the selection is complete. That is, after choosing to define an Overflow Section (for example) and making all the appropriate input for it, you are returned here. The CDAMS Module allows for the input of up to two overflow sections and two nonoverflow sections. When done making all of your sectional input, select the *None* option button, and the program will continue to the "Input Complete" dialog box, which is also the common "joining" point in the program where a program run using data from an input file will resume.



Section Type
○ None (Quit)
● Overflow
○ Non Overflow

Galleries
○ None (0)
○ One (1)
● Two (2)

Depth 32.00
Unit Weight 0.15
Xdrain 10.00
% Effective 25.00

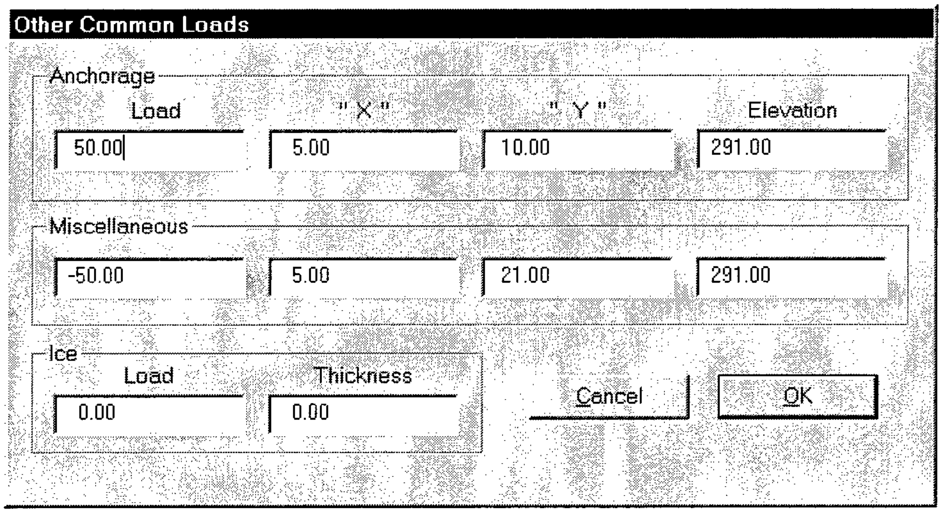
CAUTION: When the "Section Definition" dialog box appears, it will display the information about the **last structure defined** in the file that was read in **or the previously defined** structure. If you are inputting data from "scratch" and building a new input file, this is not a problem as you are defining the structure "on the fly," and data are written to the restart file (if you identified one) sequentially. But, if you are editing an existing data file, remember that the data displayed pertain to the last one entered. You will need to know ahead of time the sequence in which the structures are defined in the file and the values for each one for this dialog box and the next one.

Now, based on which “Section Type” was selected, a “stylized” graphic will appear for you to use to input geometry values. Each structure has been subdivided into three portions, with each portion having its own screen to keep the amount of information on each screen to a manageable level. The three screens are as follows:

- Input of horizontal distance values.
- Input of vertical distance (elevation) values.
- Input of slope, curve, and radius values.

See Appendix A for pictures of the nine input screens.

For each input screen, move the mouse cursor over a variable’s name or value and press the left mouse button. A dialog box will appear that has the variable’s name and a data entry field that displays its current value and allows you to change it. Typing in a new value and pressing the *OK* button will place the new value into the program. Pressing the *Cancel* button will cause the previous value to be retained. The dialog box will disappear and the current value will be displayed on the graphic. You “toggle” between the three input screens for the structure type by clicking on one of the buttons on the left of the screen. Selecting the “EXIT” button will cause the program to display this “Other Common Loads” dialog.



Anchorage

Load	" X "	" Y "	Elevation
50.00	5.00	10.00	291.00

Miscellaneous

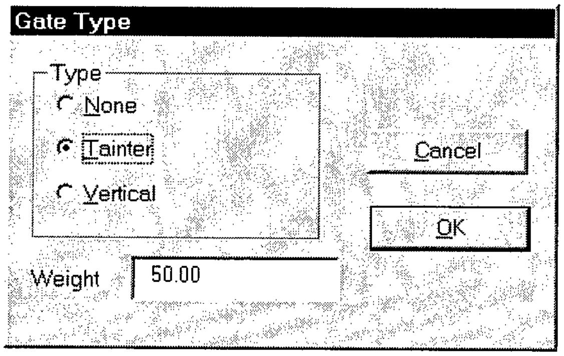
-50.00	5.00	21.00	291.00

Ice

Load	Thickness
0.00	0.00

CAUTION: Like the “Section Definition” dialog box, the “Other Common Loads” dialog displays the **last** data entered, whether read from an input file or from an interactive edit session. For each section being defined, load data are uniquely associated with it. When editing is complete, the values entered into the dialog are written to a file. And when the program resumes, the values used for the design and/or analysis come from these files generated at run time based on what is read initially from the input file. If you selected the Nonoverflow Section, you will now be returned to the “Section Definition” dialog to either enter another section, or select “None”, in which case you will be shown the

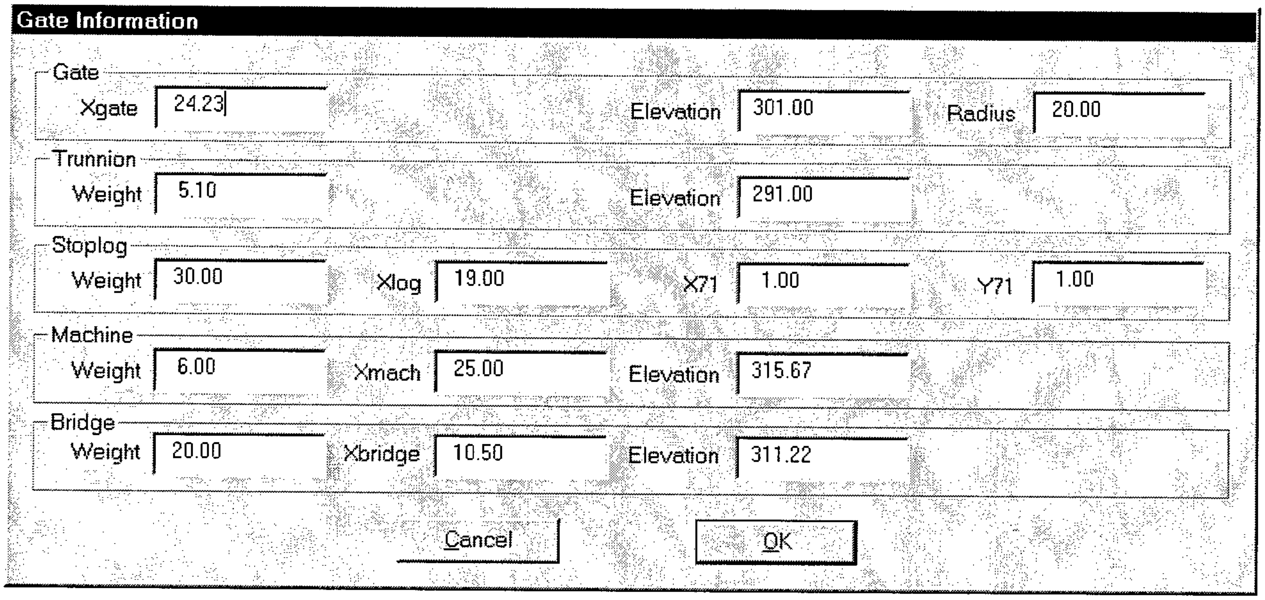
"Input Complete" dialog. The remaining steps you would perform are described after the procedures for an Overflow Section data entry.



Type
○ None
● Tainter
○ Vertical

Weight 50.00

If you are working on an overflow section definition, after the "Other Common Loads" dialog, you must select a Gate Type in this next dialog:



Gate
Xgate 24.23
Elevation 301.00
Radius 20.00

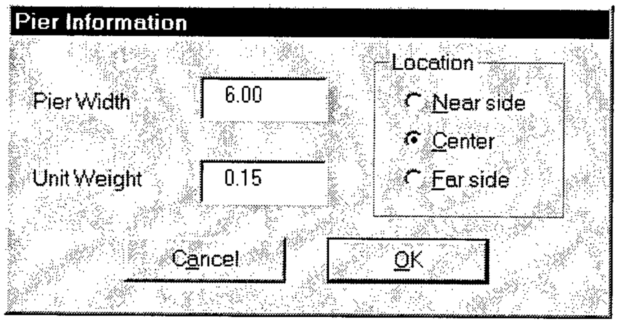
Trunnion
Weight 5.10
Elevation 291.00

Stoplog
Weight 30.00
Xlog 19.00
X71 1.00
Y71 1.00

Machine
Weight 6.00
Xmach 25.00
Elevation 315.67

Bridge
Weight 20.00
Xbridge 10.50
Elevation 311.22

If no gate type is selected, the next screen will show the "Input Complete" dialog. But if a gate type is chosen, dialogs are presented to obtain additional information: first, about the gate itself as shown above, and then about the pier:

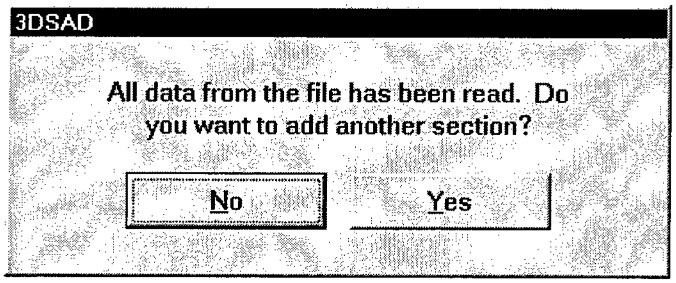


Pier Width 6.00
Unit Weight 0.15

Location
○ Near side
● Center
○ Far side

Once this dialog is completed, a graphic will appear enabling you to input geometry values about the pier, just like you could with the overflow section. Exiting the pier data entry graphic will return you to the "Section Definition" dialog.

After all sectional data are made and the "*None*" option button is selected in the "Section Definition" dialog, the following dialog is displayed. This is also the "joining" place in the program where program flow from a run using data input from an input file matches backup with that of a run using interactive input.



3DSAD

All data from the file has been read. Do you want to add another section?

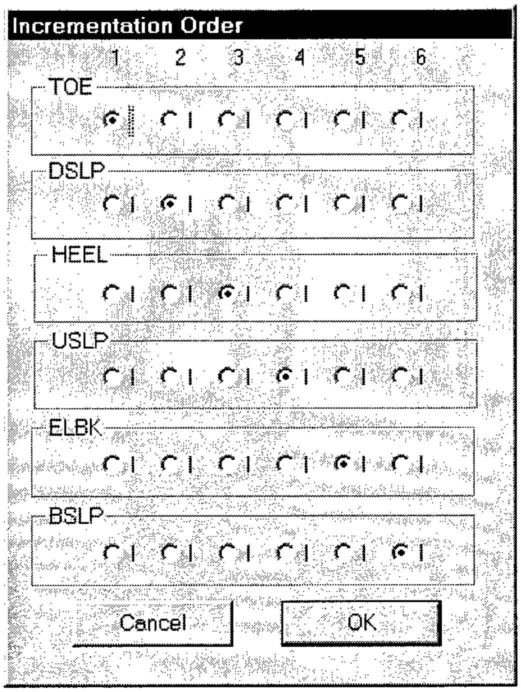
Analysis

If you choose to *Analyze* the data, you are sent to the General Geometry Module and presented with the "COMMAND" prompt. You can perform any of the commands available in the General Geometry Module, such as VOLUME, PLOT, ISOMETRIC, COLOR, ROTP, etc. Entering the GO command will automatically take you to the General Loads Module. Once in the General Loads Module, the "COMMAND" prompt is displayed; you can perform any of the commands available in the General Loads Module, such as FORCE, PLOT, ISOMETRIC, COLOR, ROTATE, etc. Entering the GO command will automatically take you to the General Analysis Module, and you are asked whether or not you want to see a summary of the analysis input data. If you enter a "Yes" answer, a table of Input Forces and Moments Excluding Uplift is displayed, followed by a table of Input Coordinates and Uplift Values. You are then asked whether or not you want to see the Final Kern Plot. If you answer "Yes," the plot will display. Then a table of Base Area Properties, Final Forces and Moments, and In-Plane coordinates and Base Pressures is displayed.

Once all the data are displayed, you will be returned to the "Load Case Dialog," where you may choose to examine another load case or select *Cancel* to return to the "Structure or Module" dialog box.

Design

If you chose the *Design* option from the above dialog box, three more sets of data are necessary. On each of the next three dialog boxes, pressing the *Cancel* button will return you to the "Input complete, Analyze or Design" dialog. First you will be asked to arrange the order of incrementation for section variables used during the design process. You do this by choosing the order sequence of the matrix of option buttons.

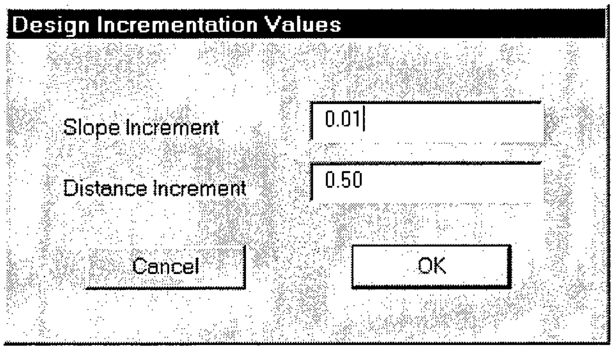


Incrementation Order

	1	2	3	4	5	6
TOE	●	○	○	○	○	○
DSLP	○	●	○	○	○	○
HEEL	○	○	●	○	○	○
USLP	○	○	○	●	○	○
ELBK	○	○	○	○	●	○
BSLP	○	○	○	○	○	●

Changing the displayed sequence order will cause the button under the same number to “swap places” with the one being changed. For example, if you clicked on the “4” button in the “TOE” group, the “TOE” variable would become “4”, and the “USLP” variable would assume the value of 1 (TOE’s previous value). The default order is displayed above.

Once you have chosen the sequence you want, press the *OK* button to define the incrementation values:

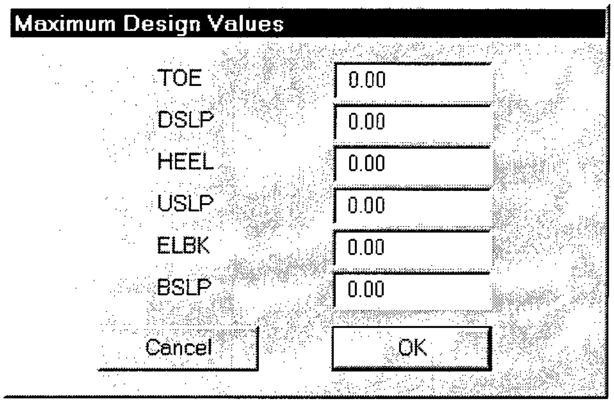


Design Incrementation Values

Slope Increment 0.01

Distance Increment 0.50

Input your desired values and press the *OK* button to go to the Maximum Design Values dialog:



Maximum Design Values

TOE 0.00
DSLP 0.00
HEEL 0.00
USLP 0.00
ELBK 0.00
BSLP 0.00

Input your desired values and select the *OK* button to step through the design process and display values pertaining to the design. Once stability has been achieved, you will be sent to the General Geometry Module and presented the "COMMAND" prompt from which you can enter any General Geometry input command.

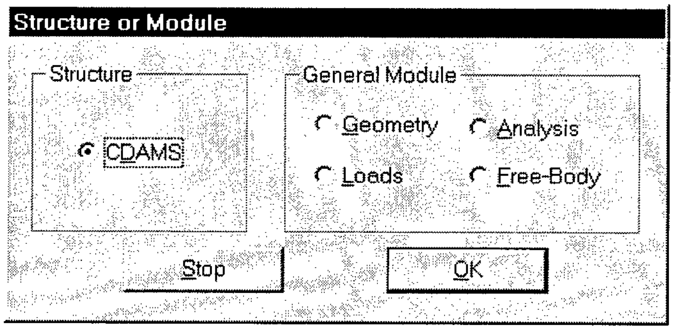
Creating or editing an input file

These procedures outline how to edit or create a new input file for use with the CDAMS Module. The steps taken are essentially the same. They differ in that if you edit a file, you provide an existing input file, and the values in that file are presented in the appropriate dialog boxes instead of being initialized to zero. As the system is reviewed/edited/added to, up to two overflow and/or two nonoverflow sections can be included in the file. When editing a file, the structures are presented for review and/or modification in the sequence they are defined in the file. You may go forward or backward through the file to alter values by pressing the *Cancel* button in a dialog box. After all defined structures are reviewed, additional ones can be added. Once you begin adding new data, you **cannot** back up to the structures defined in the file. If during an edit session, you elect to change the **type** of structure in the file, all data pertaining to that defined structure will be deleted. For this reason, it is best not to try and "insert" a different type of structure between two existing structures in the system. Adding the new structure to the end of the file is a better approach unless your intention is to delete an existing structure. During a creation or edit session, structures may be defined/added in any sequence up to the limit of two structures of each type. The new values are written to an output file that can be used later as input into the CDAMS Module. The file being edited is **not** altered.

CAUTION: Some earlier input files used with 3DSAD do not have values of zero on lines that end with zeros. Input files intended to be edited with this preprocessor MUST have all positions filled. The files created by this preprocessor will have the zero values included. (See Appendix B for proper file formats.)

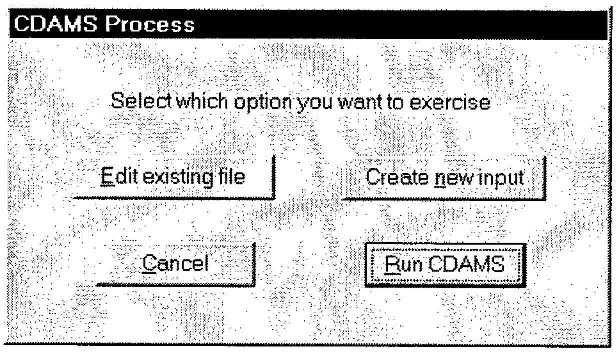
After the 3DSAD program is initiated, the following text appears on screen; you are presented a dialog box from which you select which module to use:

```
********************************
*  CASE PROGRAM    #X8100      *
*        VERSION   #1998/10/01 *
********************************
```



● CDAMS

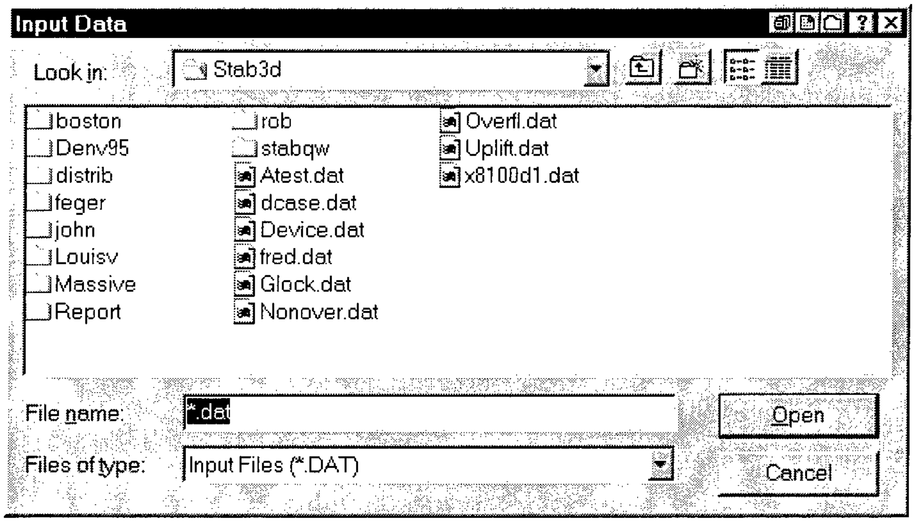
Select the option button marked *CDAMS* and then press the *OK* button (pressing *Stop* will end the program). You are then presented with the following dialog box, with which you choose whether to edit an existing file or create a new one from scratch. Pressing *Cancel* will return you to the “Structure or Module” dialog box.



Select which option you want to exercise

NOTE: The remainder of this section assumes that you are editing an existing file. The values shown in the example dialog boxes are those that were read in from the file X8100D1.DAT.

If you will be editing an existing file, you will be prompted for the file to edit. An example of the dialog box that prompts you for the file name is shown below. Select a file or type in the name of an existing file and press the *Open* button. Pressing the *Cancel* button will return you to the “CDAMS Process” dialog box.



Look in: Stab3d

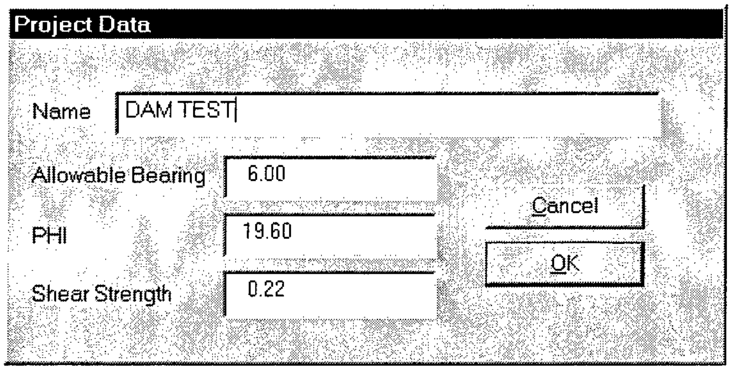
boston
Denv95
distrib
feger
john
Louisv
Massive
Report
rob
stabqw
Atest.dat
dcase.dat
Device.dat
fred.dat
Glock.dat
Nonover.dat
Overfl.dat
Uplift.dat
x8100d1.dat

File name: *.dat

Files of type: Input Files (*.DAT)

Regardless of whether you are editing an existing file or just creating a new one, you will be prompted for an output file name in a dialog box similar to the one above. Provide an output file name and press the *Open* button. Selecting or typing in an existing file name will cause that existing file to be overwritten with new values. Pressing the *Cancel* button will return you to the "CDAMS Process" dialog box.

The following sequence of dialog boxes for you to fill in will be presented. First, data about the project:



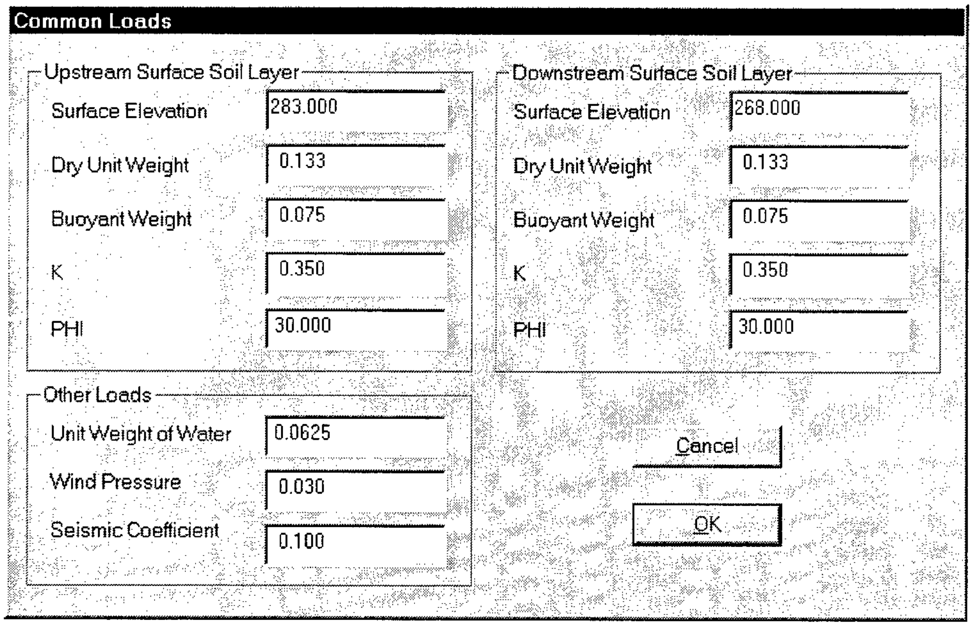
Name: DAM TEST

Allowable Bearing: 6.00

PHI: 19.60

Shear Strength: 0.22

Next, some "Common Loads" values:



Common Loads

Upstream Surface Soil Layer

Surface Elevation	283.000
Dry Unit Weight	0.133
Buoyant Weight	0.075
K	0.350
PHI	30.000

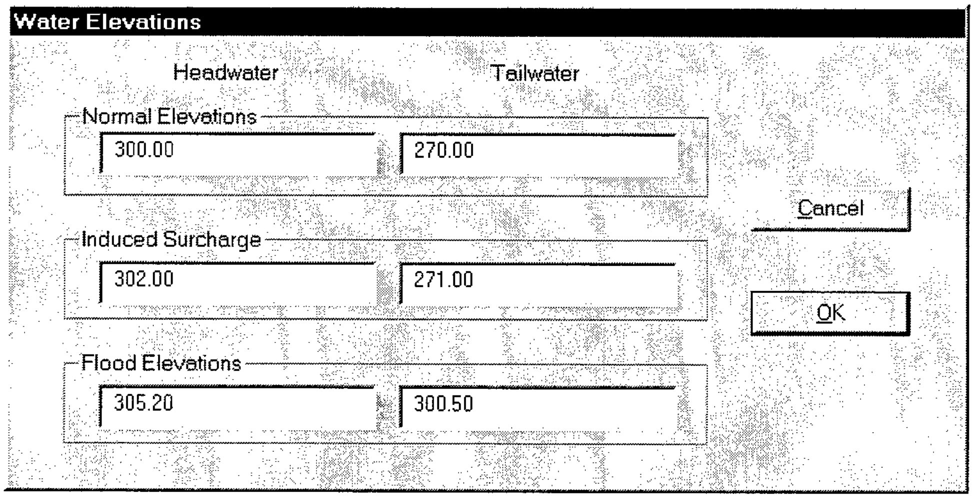
Downstream Surface Soil Layer

Surface Elevation	268.000
Dry Unit Weight	0.133
Buoyant Weight	0.075
K	0.350
PHI	30.000

Other Loads

Unit Weight of Water	0.0625
Wind Pressure	0.030
Seismic Coefficient	0.100

Followed with the "Water Elevations" dialog box.



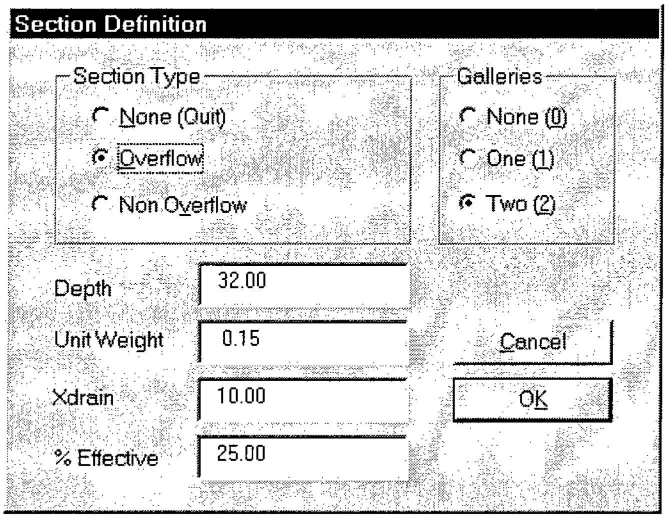
Water Elevations

	Headwater	Tailwater
Normal Elevations	300.00	270.00
Induced Surcharge	302.00	271.00
Flood Elevations	305.20	300.50

Then you begin to define the structures that make up the project. This next dialog box is the "Return Point" to which you are returned after completing all data input about a given section. If you are editing an existing structure, the sections are presented in the same sequence they appear in the input file.

NOTE: If, while editing a file, you change the *Section Type* from that which is being read in, the data about that section will be lost.

After all defined sections are processed, you will be given the opportunity to add more sections to the structure. Once you begin to define a new section, you **cannot** back up to the information in the original input file (if in an edit session) or back up to the previously defined section. You may enter the section types in any sequence, and you are limited to two overflow sections and/or two nonoverflow sections in any given file.


Section Definition

Section Type
○ None (Quit)
● Overflow
○ Non Overflow

Galleries
○ None (0)
○ One (1)
● Two (2)

Depth 32.00
Unit Weight 0.15
Xdrain 10.00
% Effective 25.00

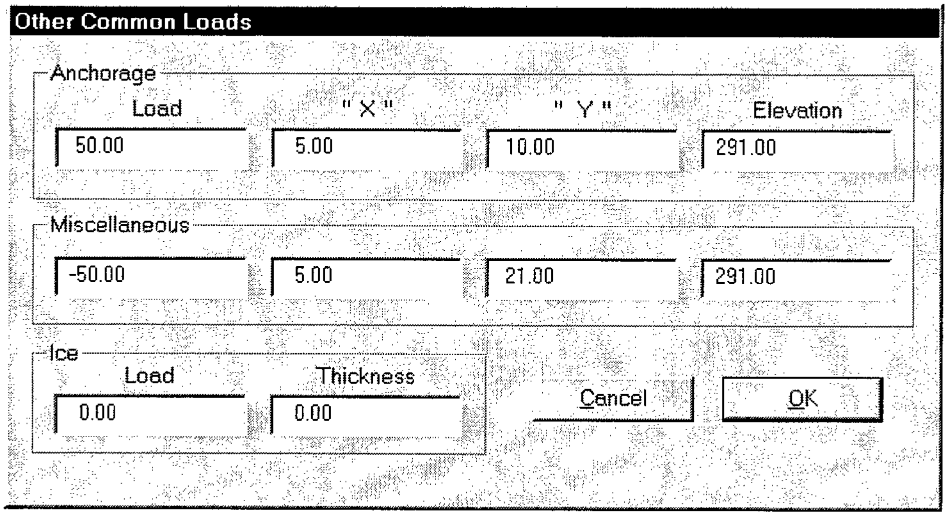
Depending on what *Section Type* is defined, a graphic will appear that displays a stylistic representation of the section along with the variable names and the current values that define the section. Each *Section Type* is broken down into three input screens to keep the number of input variables on any given screen to a manageable number. The three screens are as follows:

- Input of horizontal distance values.
- Input of vertical distance (elevation) values.
- Input of slope, curve, and radius values.

See Appendix A for pictures of the input screens.

For each input screen, move the mouse cursor over a variable's name or value and press the left mouse button. A dialog box will appear that has the variable's name and a data entry field that displays its current value and allows you to change it. Typing in a new value and pressing the *OK* button will place the new value into the program. Pressing the *Cancel* button will cause the previous value to be retained. The dialog box will disappear and the current value will be displayed on the graphic. You "toggle" between the three input screens for the structure type by clicking on one of the buttons on the left of the screen.

Selecting the "EXIT" button will cause the program to display this "Other Common Loads" dialog.


Other Common Loads

Anchorage

Load	"X"	"Y"	Elevation
50.00	5.00	10.00	291.00

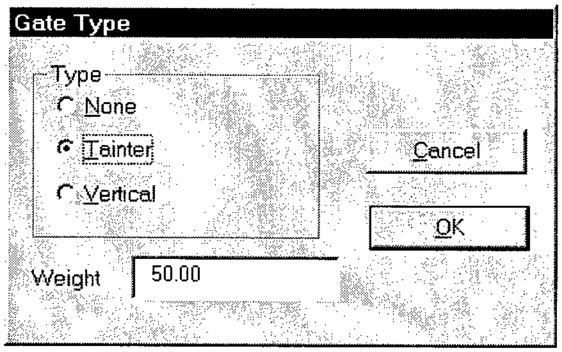
Miscellaneous

-50.00	5.00	21.00	291.00

Ice

Load	Thickness
0.00	0.00

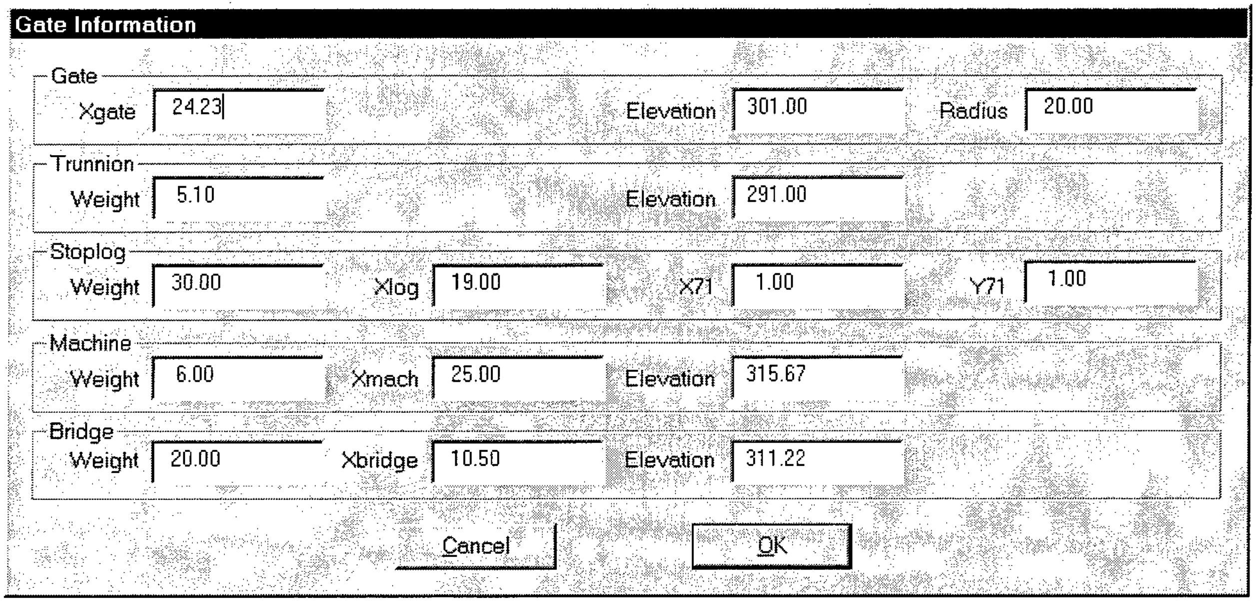
If the section being defined is a nonoverflow section, pressing the *OK* button will either return you to the "Section Definition" dialog or ask you if you want to add another section, based on the data in the input file being processed. If the section being defined is an overflow section, next you will be asked about a gate type:


Gate Type

Type
- ○ None
- ● Tainter
- ○ Vertical

Weight 50.00

If a gate type is selected, then information about the gate needs to be provided. If no gate is in the structure, the next two dialogs are skipped, and you will be returned to the "Section Definition" dialog box.


Gate Information

Gate
Xgate 24.23
Elevation 301.00
Radius 20.00

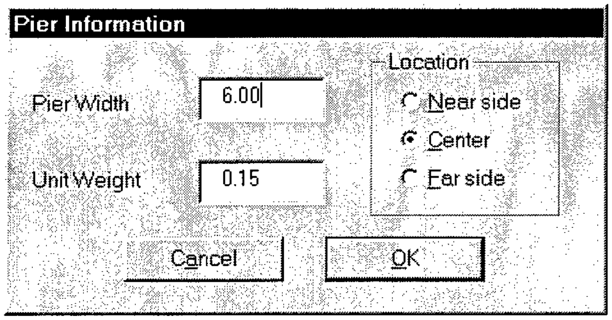
Trunnion
Weight 5.10
Elevation 291.00

Stoplog
Weight 30.00
Xlog 19.00
X71 1.00
Y71 1.00

Machine
Weight 6.00
Xmach 25.00
Elevation 315.67

Bridge
Weight 20.00
Xbridge 10.50
Elevation 311.22

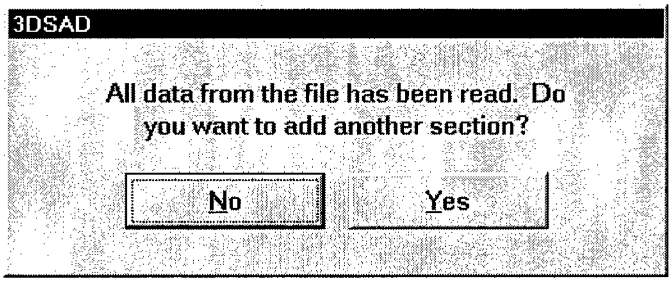
And then the following information will be requested about the pier section:


Pier Information

Pier Width 6.00
Unit Weight 0.15

Location
○ Near side
● Center
○ Far side

When the *OK* button is pressed, another graphic will appear that allows you to change geometry values just like you did for the overflow section. When you exit from that graphic, you will either be returned to the "Section Definition" dialog box or asked if you want to add another section, based on the data in the input file being processed. If there is another section defined in the input file, the above process repeats until all sections defined have been processed or you select the *None (Quit)* option button from that dialog box. If you continue with and reach the end of the information in the file, you will be asked whether or not to add another section to it with the following dialog box:


3DSAD

All data from the file has been read. Do you want to add another section?

If you choose to add another section (up to the limit of two of each type), you will be returned to the "Section Definition" dialog box. From this point, you **cannot** back up to the previously entered data. If you select the *No* button, you are returned to the "CDAMS Process" dialog box where you can create or edit another file, run the CDAMS Module, or return to the program entry point, the "Structure or Module" dialog.

7 Locks

Introduction

CDAMS capability of 3DSAD has been well developed for dams, but not for locks. Rather than develop a separate locks module, existing CDAMS modules will be used to generate as much as possible, and then the resulting data files will be modified for use in the general modules. This chapter contains several examples of how 3DSAD was used to model locks. They are all from actual Corps projects and are done with the help of the practicing engineers on the respective project. A section is also provided at the end to introduce the advanced topic of downdrag on the backs of rock-founded concrete gravity retaining walls.

Culvert Valve Monolith

This example is a typical culvert valve monolith for a conventional lock (data and assistance provided by Ms. Monica Greenwell, Louisville District), and its dimensions are given in Figure 51 (front view) and Figure 52 (top view). The lock sits on rock and has rock at EL 367 ft on the lock chamber side and at El 371 ft on the land side. Water is at EL 383 ft in the lock and at EL 395 ft on the land side. Backfill from the rock to EL 443 ft on the land side has a moist density of 0.126 kip/ft^3, a saturated density of 0.13 kip/ft^3, and a drained internal friction angle of 32 deg. The rock has a saturated density of 0.165 kip/ft^3, a drained cohesion of 50 psi, and a drained internal friction angle of 53 deg. The concrete has a density of 0.15 kip/ft^3. A 6.1- by 7.9-m (20- by 26-ft) culvert valve recess is placed in the middle in the longitudinal direction of the 16.76-m (55-ft) monolith. The culvert valve is closed with the water level on the front (upstream face) at 128 m (420 ft) and on the back (downstream face) at 116.7 m (383 ft). Water in the culvert valve recess is at the same height as the water in the lock chamber.

Use of 3DSAD

This problem is used to show how geometry and loads are computed using 3DSAD. The rigid body limit equilibrium approach is taken for this problem, so the analysis given in 3DSAD is also applicable. The nonoverflow cross section of CDAMS is used as a template to generate most of the geometry and loads. Figure 53 shows a front view of the generated geometry and loads, and Figure 54

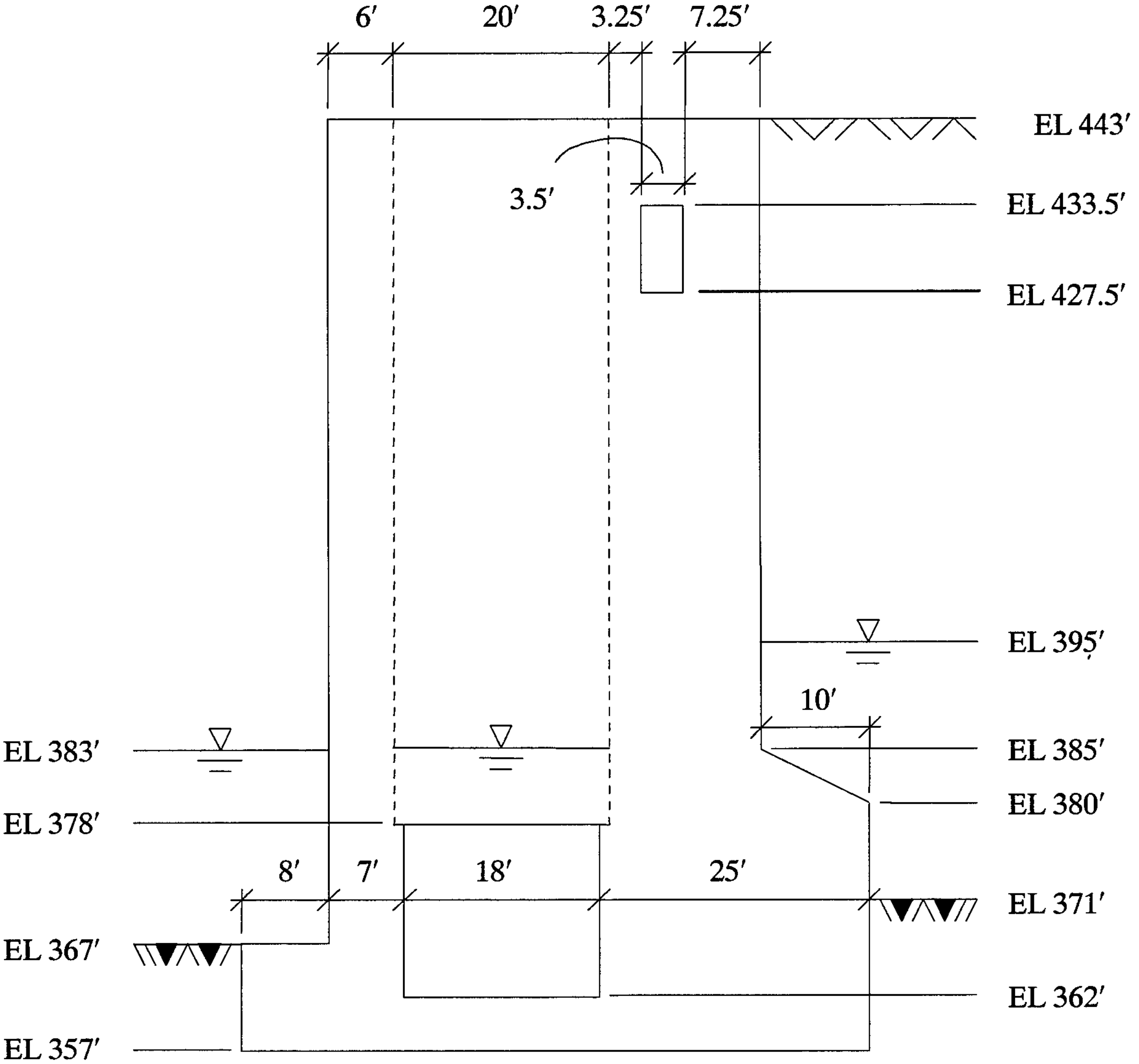


Figure 51. Front view (typical culvert valve monolith)

shows an isometric view. Here, NON1 is the nonoverflow monolith geometry; EH10 is the upstream horizontal soil load; WH10 is the upstream horizontal water load; V210 is the upstream vertical water load; EH50 is the downstream horizontal soil load; WH50 is the downstream horizontal water load; V150 is the downstream vertical buoyant saturated soil load; and V250 is the downstream vertical moist soil load. The upstream side (left) of the dam corresponds to the lock chamber side, and the downstream side (right) of the dam corresponds to the land side for this problem. Although this seems awkward because the upstream water level in CDAMS is lower than the downstream water level, this will generate the correct loads.

Geometry

The generated geometry as given in Table 18 is correct except for the addition of the culvert valve recess. This is accomplished by either adding a hole as given in Table 19

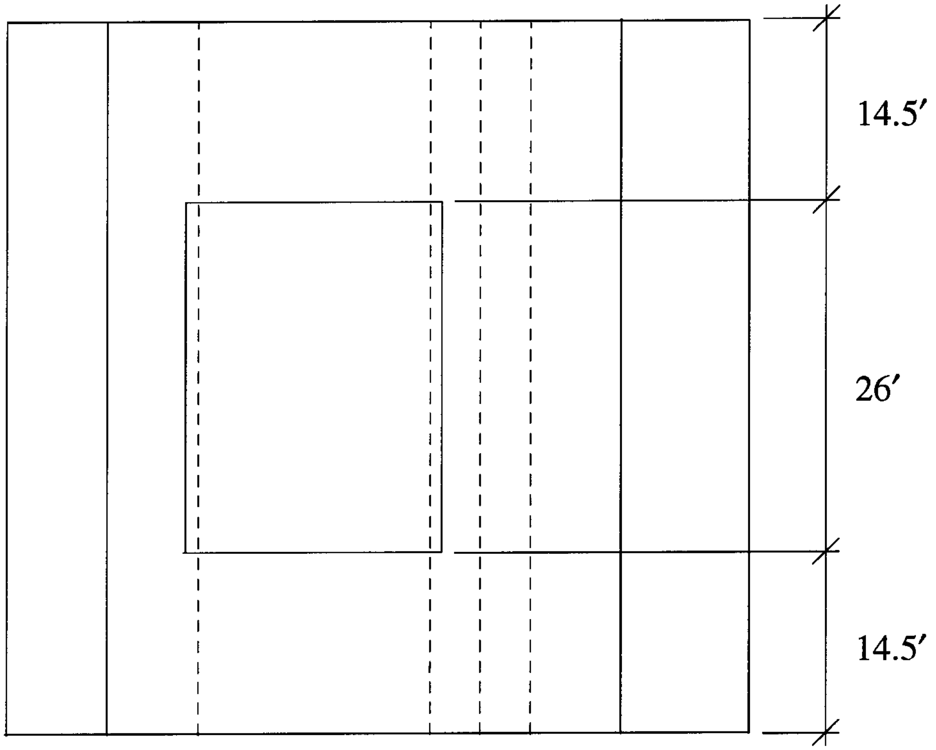


Figure 52. Top view

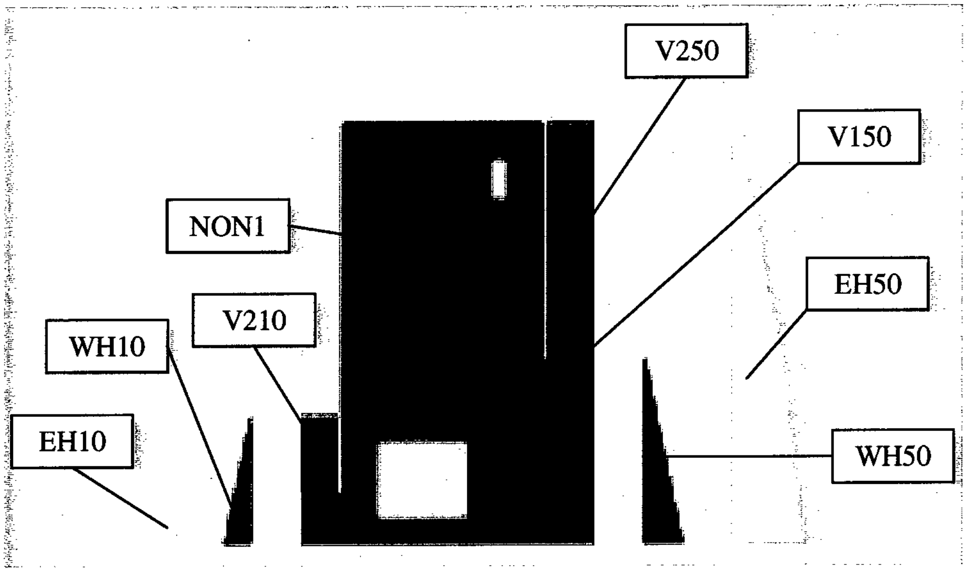


Figure 53. Front view of generated data

or creating three blocks as shown in Table 20. Note that original data have line numbers beginning at 100; added data have line numbers beginning at 200; and changed data have line numbers beginning at 300. Figure 55 shows a plot of the

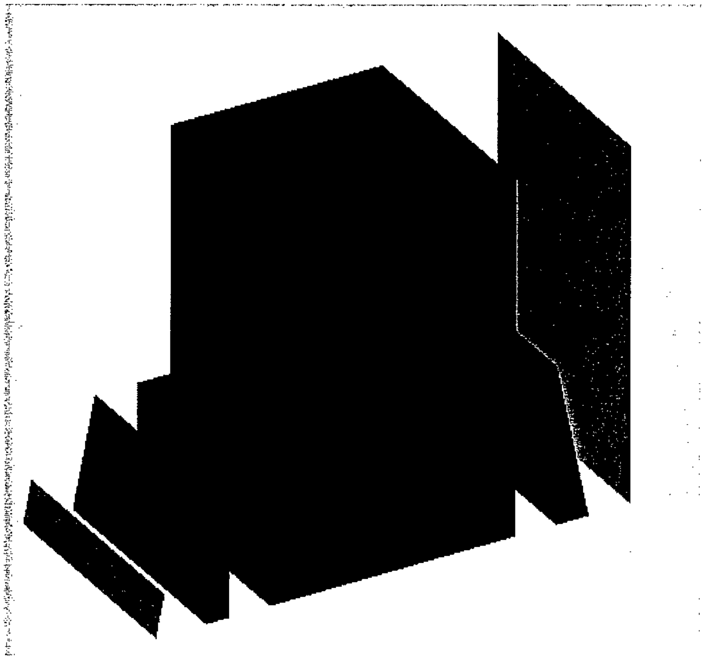


Figure 54. Isometric view of generated data

Table 18. Generated Geometry Data

```
101 POIN   22
102    1      .000       .000   357.000
103    2      .000       .000   367.000
104    3     8.000       .000   367.000
105    4     8.000       .000   367.000
106    5     8.000       .000   367.000
107    6     8.000       .000   367.000
108    7     8.000       .000   443.000
109    8    48.000       .000   443.000
110    9    48.000       .000   385.000
111   10    48.000       .000   385.000
112   11    48.000       .000   385.000
113   12    58.000       .000   380.000
114   13    58.000       .000   380.000
115   14    58.000       .000   357.000
116   15    15.000       .000   362.000
117   16    15.000       .000   378.000
118   17    33.000       .000   378.000
119   18    33.000       .000   362.000
120   19    37.250       .000   427.500
121   20    37.250       .000   435.500
122   21    40.750       .000   435.500
123   22    40.750       .000   427.500
```

(Continued)

Table 18. (Concluded)

```
124 BLOC NON1        .150     55.000     2
125      1.000      1.000
126   14     1    2     3     4     5     6     7     8     9    10
127   11    12   13    14
128      1.000      1.000
129    4    18   17    16    15
130      1.000      1.000
131    4    22   21    20    19
```

Table 19. Valve Geometry Data

```
201 POIN     4
202    23     14.000     14.500    378.000
203    24     14.000     14.500    443.000
204    25     34.000     14.500    443.000
205    26     34.000     14.500    378.000
206 BLOC VALV       .150     26.000
207       1.000      1.000
208     4    26    25    24    23
```

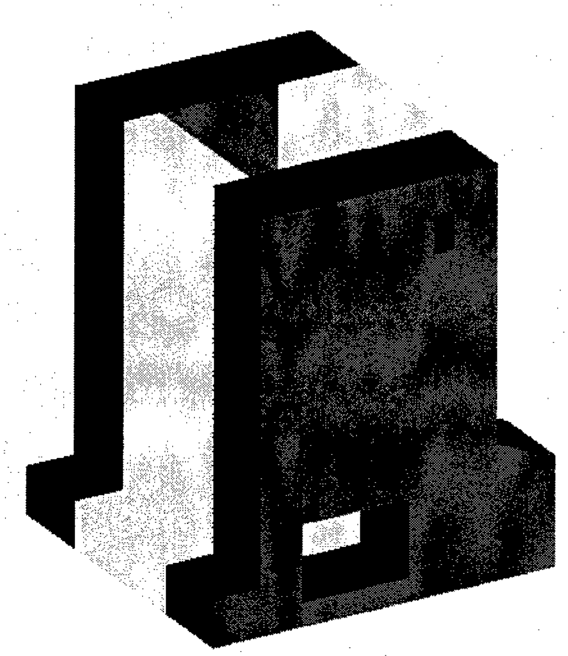


Figure 55. Data with valve

new geometry in Table 20 with Figure 56 showing the middle block separated to see it more clearly.

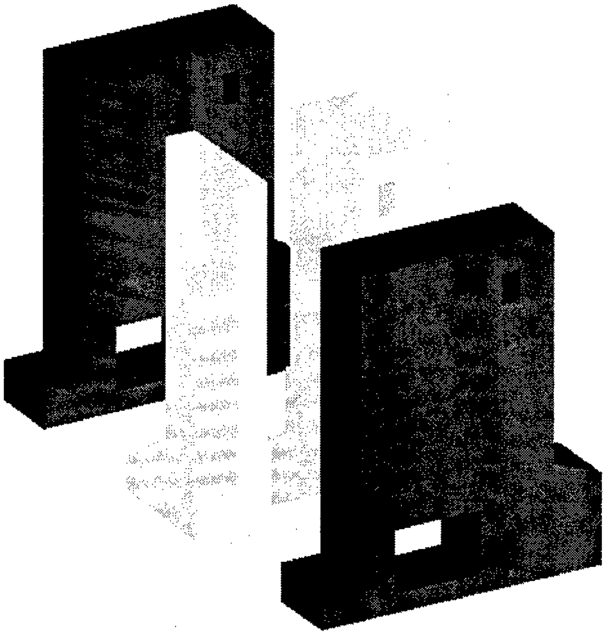


Figure 56. Valve with separation

Table 20. Three-Block Version

```
101-123 Same as before.
. . . .
324 BLOC NON1       .150    14.500    2
. . . .
125-131 Same as before.
. . . .
232 POIN     4
233   23     14.000     14.500   378.000
234   24     14.000     14.500   443.000
235   25     34.000     14.500   443.000
236   26     34.000     14.500   378.000
237 BLOC MIDL       .150    26.000    1
238      1.000      1.000
239   22    A1    A2    A3    A4    A5    A6    A7    24    23   A16
240  A15   A18   A17    26    25    A8    A9   A10   A11   A12   A13
241  A14
242      1.000      1.000
243    4   A22   A21   A20   A19
244 COPY NON1 NON2
245 TRAN NON2
246         0.       40.5        0.
```

Loads

The generated loads shown in Figures 53 and 54 do not represent all the loads for this problem, as some loads are missing, and some of the pressure volumes need modification. These will now be discussed.

Soil. For example, the data for the land side horizontal soil (EH50) as given in Table 21 goes down to EL 357 ft instead of stopping at EL 371 ft (see Figure 57). These data were generated by using the input horizontal earth pressure coefficient and densities to create a pressure volume yielding equivalent forces and moments.

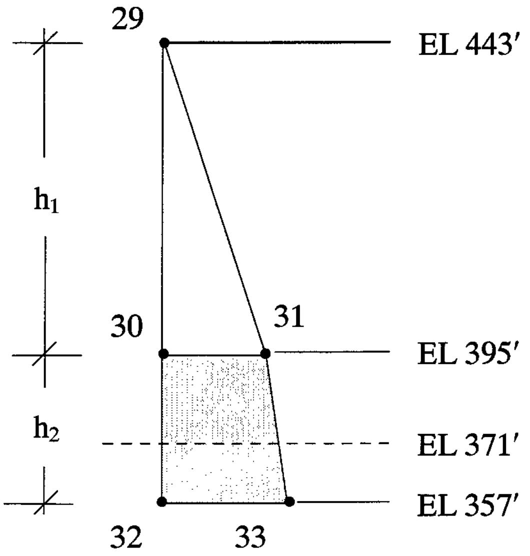


Figure 57. Pressure volume EH50

Table 21. EH50 Data

```
101 POIN     3
102   29     27.600        .000   443.000
103   30     27.600        .000   395.000
104   31     37.200        .000   395.000
105 POIN     2
106   32     27.600        .000   357.000
107   33     41.277        .000   357.000
108 BLOC    -X EH50     .29610     55.000
109       1.000      1.000
110     5    31    33    32    30    29
111 TRAN EH50
112     58.000          0.         0.
```

To illustrate, the horizontal earth force is given by

$$F_H = K_H \left(\frac{1}{2} \gamma_1' h_1^2 + \gamma_1' h_1 \, h_2 + \frac{1}{2} \gamma_2' h_2^2 \right) d \tag{6}$$

where

F_H = horizontal earth force

K_H = horizontal earth pressure coefficient

γ'_1 = moist soil density

γ'_2 = buoyant soil density

h_1 = height of moist soil

h_2 = height of saturated soil

d = depth of cross section extended in third dimension

The at-rest condition for K_H as dictated in EM 1110-2-2502 was chosen, so from Jeky's Equation

$$K_H = K_0 = 1 - \sin\phi' \tag{7}$$

where ϕ' equals the drained internal friction angle.

Rearranging Equation 6 gives

$$F_H = \left(5 K_H \gamma_1'\right) \left(\frac{1}{2} \left(\frac{h_1}{5} \right) h_1 + \left(\frac{h_1}{5} \right) h_2 + \frac{1}{2} \left(\frac{\gamma_2'}{\gamma_1'} \right) \left(\frac{h_2}{5} \right) h_2 \right) d \tag{8}$$

The factor 5 in Equation 8 is arbitrary and has the sole purpose of making the plots of the pressure volumes more aesthetic. Equation 8 allows us to understand Line 108 of Table 21. It describes a block whose force acts in the -x direction extending the full 16.76 m (55 ft) of the monolith with a density of

$$\begin{aligned} \gamma_B &= 5 K_H \gamma_1' \\ &= 5(1 - \sin 32^\circ)(0.126 \ kip/ft^3) \\ &= 0.296 \ kip/ft^3 \end{aligned} \tag{9}$$

The x coordinate of Point 31 (see Figure 57 and Equation 8) is then computed by

$$\begin{aligned} x_{31} &= x_{30} + \frac{h_1}{5} \\ &= 27.6\ ft + \frac{443 - 395}{5}\ ft \\ &= 37.2\ ft \end{aligned} \tag{10}$$

where

x_{30} = x coordinate of Point 30

x_{31} = x coordinate of Point 31

And the x coordinate of Point 33 at EL 357 ft is

$$\begin{aligned} X_{33} &= X_{31} + \left(\frac{\gamma'_2}{\gamma'_1}\right)\left(\frac{h_2}{5}\right) \\ &= 37.2\ ft + \left(\frac{0.13 - 0.0624}{0.126}\right)\left(\frac{395 - 357}{5}\right) ft \\ &= 41.277\ ft \end{aligned} \tag{11}$$

However, since the soil stops at EL 371 ft, the computation becomes

$$\begin{aligned} X_{33} &= X_{31} + \left(\frac{\gamma'_2}{\gamma'_1}\right)\left(\frac{h_2}{5}\right) \\ &= 37.2\ ft + \left(\frac{0.13 - 0.0624}{0.126}\right)\left(\frac{395 - 371}{5}\right) ft \\ &= 39.775\ ft \end{aligned} \tag{12}$$

So Lines 106-107 in Table 21 become

```
306    32     27.600         .000    371.000
307    33     39.775         .000    371.000
```

Rock. The rock on the lock chamber side is of such quality and set in such a way that the maximum 50-percent mobilization of passive forces is assumed for this example problem as specified in EM 1110-2-2502 for soil. This is a potentially controversial computation in that the equation for soil is applied to rock, so special attention should be given to other situations involving rock. However, this assumption should suffice to illustrate the mechanics of using 3DSAD. The horizontal force due to the rock on the lock chamber side is therefore

$$
\begin{aligned}
F_H &= \left(\frac{1}{2}K_P\gamma' h^2 + 2\sqrt{K_P}c'h\right)d \times 50\% \\
&= \left(\frac{5}{2}K_P\gamma'\right)\left[\frac{1}{2}\left(\frac{h}{5}\right)h\right]d + \left(\sqrt{K_P}c'\right)hd
\end{aligned}
\tag{13}
$$

where

K_P = horizontal passive earth pressure coefficient

γ' = buoyant rock density

d = height of rock

c' = drained cohesion of rock

and

$$
K_P = \frac{1+\sin\phi'}{1-\sin\phi'} \tag{14}
$$

CDAMS generates a pressure volume for the first term in Equation 13 (EH10 in Table 22) but not the second (c' is assumed to be zero), so a block must be added (COHE in Table 22). The block density of EH10 is computed by

$$
\begin{aligned}
\gamma_B &= \frac{5}{2}K_P\gamma' \\
&= \frac{5}{2}\left(\frac{1+\sin 53^\circ}{1-\sin 53^\circ}\right)(0.165 - 0.0624)\ kip/ft^3 \\
&= 2.29\ kip/ft^3
\end{aligned}
\tag{15}
$$

Since h = 3 m (10 ft), the x coordinate of Point 28 is 10/5 or 0.6 m (2 ft) less than the x coordinate of Point 27.

Table 22. Pressure Volumes for Rock

```
113 POIN     3
114   26   -25.200        .000   367.000
115   27   -25.200        .000   357.000
116   28   -27.200        .000   357.000
117 BLOC    +X EH10    2.29112    55.000
118      1.000      1.000
119    3   26    27    28
320 POIN     4
321   34         0.          0.       357.
322   35         0.          0.       367.
323   36         1.          0.       367.
324   37         1.          0.       357.
325 BLOC    +X COHE      21.52    55.000
326      1.000      1.000
327    4   34    35    36    37
328 TRAN COHE
329   -35.000        0.         0.
```

The block in Table 22 that represents the cohesion term (COHE) has a height of 3 m (10 ft), a length of 0.3 m (1 ft), and a block density of

$$
\begin{aligned}
\gamma_B &= \sqrt{K_P}\,c' \\
&= \sqrt{\left(\frac{1+\sin 53^\circ}{1-\sin 53^\circ}\right)}(50)\left(\frac{144}{1000}\right)\ kip/ft^3 \qquad (16)\\
&= 21.52\ kip/ft^3
\end{aligned}
$$

The remaining loads that must be added to the loads data are line pull, the weight of the water in the valve, the weight of the water in the culvert, and the front and back horizontal water force on the culvert in the longitudinal direction. These can all be generated using point loads and pressure volumes.

Nonsymmetrical U-Frame Inlet Manifold Monolith

This example illustrates the methodology of using geometric shapes to compute various aspects of the geometry and loads for a U-Frame lock monolith. Only an overall view of the geometry, loads, and load cases will be presented. The monolith used is Monolith L-1, Inlet Manifold of the J. Bennett Johnston Waterway, Russell B. Long Lock and Dam (formerly Red River Waterway, Lock and Dam No. 4) (provided by John Burnworth, Vicksburg District).

Geometry

A view looking downstream of the geometry in continuous tone format is given in Figure 58. Isometric views are given in Figures 59-61. Figure 59 does not use color or hidden lines, and Figures 60-61 use both. The data file is given in Table 23.

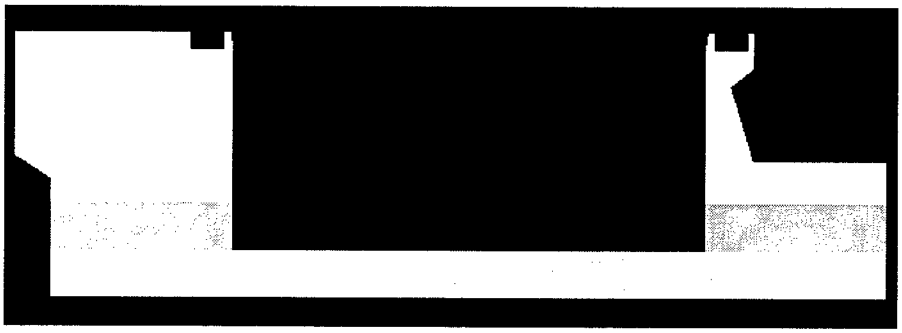


Figure 58. View looking downstream

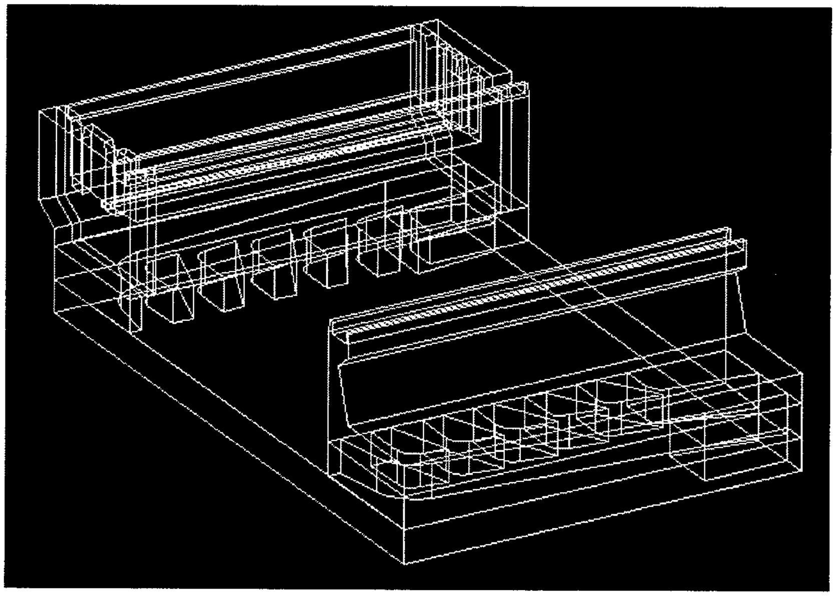


Figure 59. Isometric view of monolith with flow from left to right, land side at top and river side at bottom

Loads

The site had several loads considered, but the three load cases that are described are as follows:

1. Construction (Case 1a) (Elements BS01 - BS03, CW01 - CW02, CP01 - CP12, WC01 - WC08)

    a. Weight of the concrete.

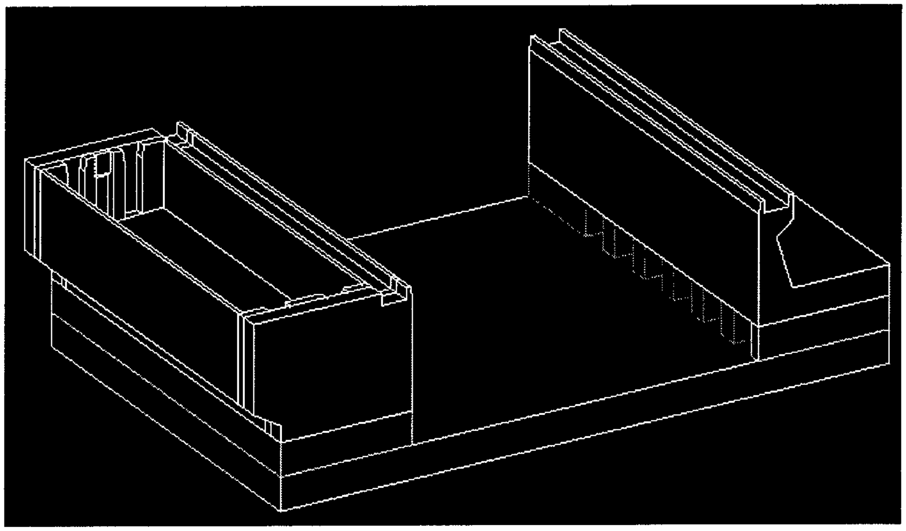


Figure 60. Isometric view looking downward and riverward

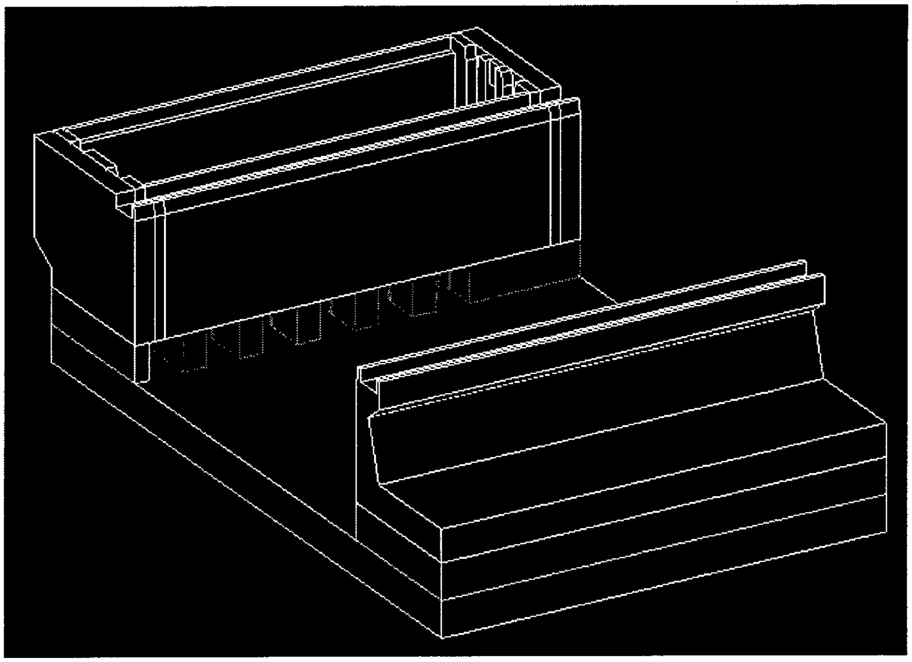


Figure 61. Isometric view looking downstream and landward

2. Normal operating (Case 2a) (Elements BS01 - BS03, CW01 - CW02, CP01 - CP12, WC01 - WC08, HE01 - HE13, HW01 - HW21, WAT1 - WAT6, UP01 - UP02, BLK1 - BLK5)

    a. Weight of the concrete.

    b. Horizontal soil.

    c. Horizontal water.

Table 23. Geometry Data

```
0010 XY
0020 POINTS 220
0030 001   -78.000   -74.000  75.000
0040 002   -78.000    74.000  75.000
0050 003 -175.000    74.000  75.000
0060 004 -175.000   -74.000  75.000
0070 005   -78.000   -74.000  85.000
0080 006   -78.000   -68.000  85.000
0090 007   -98.000   -68.000  85.000
0100 008 -161.354   -62.427  85.000
0110 009 -170.188   -54.115  85.000
0120 010 -172.000   -42.000  85.000
0130 011 -175.000   -42.000  85.000
0140 012 -175.000   -74.000  85.000
0150 013   -78.000    74.000  85.000
0160 014   -78.000    68.000  85.000
0170 015   -98.000    68.000  85.000
0180 016 -161.354    62.427  85.000
0190 017 -170.188    54.115  85.000
0200 018 -172.000    42.000  85.000
0210 019 -175.000    42.000  85.000
0220 020 -175.000    74.000  85.000
0230 021   -78.000   -56.000  85.000
0240 022   -78.000   -42.000  85.000
0250 023 -102.000   -42.000  85.000
0260 024 -102.000   -49.531  85.000
0270 025   -98.500   -53.500  85.000
0280 026   -78.000    56.000  85.000
0290 027   -78.000    42.000  85.000
0300 028 -102.000    42.000  85.000
0310 029 -102.000    49.531  85.000
0320 030   -98.500    53.500  85.000
0330 031 -109.500   -42.000  85.000
0340 032 -114.500   -42.000  85.000
0350 033 -114.500   -50.152  85.000
0360 034 -110.500   -54.121  85.000
0370 035 -100.833   -55.396  85.000
0380 036 -109.500    42.000  85.000
0390 037 -114.500    42.000  85.000
0400 038 -114.500    50.152  85.000
0410 039 -110.500    54.121  85.000
0420 040 -100.833    55.396  85.000
0430 041 -122.000   -42.000  85.000
0440 042 -127.000   -42.000  85.000
0450 043 -127.000   -50.781  85.000
```

(Sheet 1 of 8)

Table 23. (Continued)

0460	044	-123.500	-54.750	85.000
0470	045	-114.515	-55.875	85.000
0480	046	-122.000	42.000	85.000
0490	047	-127.000	42.000	85.000
0500	048	-127.000	50.781	85.000
0510	049	-123.500	54.750	85.000
0520	050	-114.515	55.875	85.000
0530	051	-134.500	-42.000	85.000
0540	052	-139.500	-42.000	85.000
0550	053	-139.500	-51.417	85.000
0560	054	-136.000	-55.385	85.000
0570	055	-127.490	-56.448	85.000
0580	056	-134.500	42.000	85.000
0590	057	-139.500	42.000	85.000
0600	058	-139.500	51.417	85.000
0610	059	-136.000	55.385	85.000
0620	060	-127.490	56.448	85.000
0630	061	-147.000	-42.000	85.000
0640	062	-152.000	-42.000	85.000
0650	063	-152.000	-52.042	85.000
0660	064	-148.500	-56.010	85.000
0670	065	-140.681	-56.985	85.000
0680	066	-147.000	42.000	85.000
0690	067	-152.000	42.000	85.000
0700	068	-152.000	52.042	85.000
0710	069	-148.500	56.010	85.000
0720	070	-140.681	56.985	85.000
0730	071	-159.500	-42.000	85.000
0740	072	-164.500	-42.000	85.000
0750	073	-164.500	-52.667	85.000
0760	074	-161.000	-56.635	85.000
0770	075	-154.490	-57.448	85.000
0780	076	-159.500	42.000	85.000
0790	077	-164.500	42.000	85.000
0800	078	-164.500	52.667	85.000
0810	079	-161.000	56.635	85.000
0820	080	-154.490	57.448	85.000
0830	081	-78.000	-68.000	83.000
0840	082	-78.000	-56.000	83.000
0850	083	-78.000	68.000	83.000
0860	084	-78.000	56.000	83.000
0870	085	-98.000	-74.000	75.000
0880	086	-98.000	74.000	75.000
0890	087	-78.000	-68.000	75.000
0900	088	-78.000	-56.000	75.000

(Sheet 2 of 8)

Table 23. (Continued)

0910	089	-78.000	56.000	75.000
0920	090	-78.000	68.000	75.000
0930	091	-98.000	-68.000	75.000
0940	092	-98.000	-53.561	75.000
0950	093	-98.000	53.561	75.000
0960	094	-98.000	68.000	75.000
0970	095	-98.000	-53.561	85.000
0980	096	-98.000	-68.000	85.000
0990	097	-98.000	68.000	85.000
1000	098	-98.000	53.561	85.000
1010	099	-78.000	-74.000	95.000
1020	100	-78.000	-74.000	104.000
1030	101	-78.000	-50.333	104.000
1040	102	-78.000	-46.333	120.000
1050	103	-78.000	-50.500	124.000
1060	104	-78.000	-50.500	131.500
1070	105	-78.000	-49.500	131.500
1080	106	-78.000	-49.500	128.000
1090	107	-78.000	-43.500	128.000
1100	108	-78.000	-43.500	131.500
1110	109	-78.000	-42.500	131.500
1120	110	-78.000	-42.000	128.000
1130	111	-78.000	-42.000	95.000
1140	112	-84.500	42.000	95.000
1150	113	-84.500	42.000	128.000
1160	114	-84.500	42.500	131.500
1170	115	-84.500	43.500	131.500
1180	116	-84.500	43.500	128.000
1190	117	-84.500	49.500	128.000
1200	118	-84.500	49.500	131.500
1210	119	-84.500	50.500	131.500
1220	120	-84.500	50.500	112.000
1230	121	-84.500	63.375	111.000
1240	122	-84.500	63.375	109.500
1250	123	-84.500	65.125	109.500
1260	124	-84.500	65.125	111.000
1270	125	-84.500	78.000	112.000
1280	126	-84.500	78.000	128.000
1290	127	-84.500	79.500	128.000
1300	128	-84.500	79.500	131.500
1310	129	-84.500	80.500	131.500
1320	130	-84.500	80.500	105.000
1330	131	-84.500	74.000	100.000
1340	132	-84.500	74.000	95.000
1350	133	-86.292	63.375	109.500

(Sheet 3 of 8)

Table 23. (Continued)

1360	134	-168.500	63.325	109.500
1370	135	-168.500	63.325	111.000
1380	139	-78.000	42.000	95.000
1390	140	-78.000	42.000	128.000
1400	141	-78.000	42.500	131.500
1410	142	-78.000	43.500	131.500
1420	143	-78.000	43.500	128.000
1430	144	-78.000	49.500	128.000
1440	145	-78.000	49.500	131.500
1450	146	-78.000	80.500	131.500
1460	147	-78.000	80.500	105.000
1470	148	-78.000	74.000	100.000
1480	149	-78.000	74.000	95.000
1490	150	-170.708	42.000	95.000
1500	151	-170.708	42.000	128.000
1510	152	-170.708	42.500	131.500
1520	153	-170.708	43.500	131.500
1530	154	-170.708	43.500	128.000
1540	155	-170.708	49.500	128.000
1550	156	-170.708	49.500	131.500
1560	157	-170.708	80.500	131.500
1570	158	-170.708	80.500	105.000
1580	159	-170.708	74.000	100.000
1590	160	-170.708	74.000	95.000
1600	161	-82.292	42.000	95.000
1610	162	-82.292	42.000	128.000
1620	163	-82.292	42.500	131.500
1630	164	-82.292	43.500	131.500
1640	165	-82.292	43.500	128.000
1650	166	-82.292	49.500	128.000
1660	167	-82.292	49.500	131.500
1670	168	-82.292	55.167	131.500
1680	169	-82.292	55.667	128.000
1690	170	-82.292	55.667	111.599
1700	171	-82.292	59.917	111.269
1710	172	-82.292	59.917	128.000
1720	173	-82.292	60.417	131.500
1730	174	-82.292	62.740	131.500
1740	175	-82.292	62.740	109.500
1750	176	-82.292	66.740	109.500
1760	177	-82.292	66.740	131.500
1770	178	-82.292	69.063	131.500
1780	179	-82.292	69.563	128.000
1790	180	-82.292	69.563	111.269
1800	181	-82.292	73.813	111.599

(Sheet 4 of 8)

Table 23. (Continued)

```
1810 182   -82.292    73.813 128.000
1820 183   -82.292    74.313 131.500
1830 184   -82.292    80.500 131.500
1840 185   -82.292    80.500 105.000
1850 186   -82.292    74.000 100.000
1860 187   -82.292    74.000  95.000
1870 188 -168.500    42.000  95.000
1880 189 -168.500    42.000 128.000
1890 190 -168.500    42.500 131.500
1900 191 -168.500    43.500 131.500
1910 192 -168.500    43.500 128.000
1920 193 -168.500    49.500 128.000
1930 194 -168.500    49.500 131.500
1940 195 -168.500    55.167 131.500
1950 196 -168.500    55.667 128.000
1960 197 -168.500    55.667 111.599
1970 198 -168.500    59.917 111.269
1980 199 -168.500    59.917 128.000
1990 200 -168.500    60.417 131.500
2000 201 -168.500    69.063 131.500
2010 202 -168.500    69.563 128.000
2020 203 -168.500    69.563 111.269
2030 204 -168.500    73.813 111.599
2040 205 -168.500    73.813 128.000
2050 206 -168.500    74.313 131.500
2060 207 -168.500    80.500 131.500
2070 208 -168.500    80.500 105.000
2080 209 -168.500    74.000 100.000
2090 210 -168.500    74.000  95.000
2100 211   -82.292    62.740 124.000
2110 212   -82.292    62.740 131.500
2120 213   -83.584    62.740 131.500
2130 214   -83.584    62.740 125.292
2140 215   -78.000   -74.000 120.000
2150 216   -78.000   -74.000  70.000
2160 217   -78.000    74.000  70.000
2170 218   -78.000    74.000  25.000
2180 219   -78.000   -74.000  25.000
2190 220   -78.000    74.000 100.000
2200 221   -78.000    80.500  95.000
2210 222   -78.000    80.500  80.000
2220 223   -78.000    74.000  80.000
2230 CIRCLE 008 009 9.792 RIGHT
2240 CIRCLE 016 017 9.792 LEFT
2250 CIRCLE 024 025 4.000 LEFT
```

(Sheet 5 of 8)

Table 23. (Continued)

```
2260 CIRCLE 029 030 4.000 RIGHT
2270 CIRCLE 033 034 4.000 LEFT
2280 CIRCLE 038 039 4.000 RIGHT
2290 CIRCLE 043 044 4.000 LEFT
2300 CIRCLE 048 049 4.000 RIGHT
2310 CIRCLE 053 054 4.000 LEFT
2320 CIRCLE 058 059 4.000 RIGHT
2330 CIRCLE 063 064 4.000 LEFT
2340 CIRCLE 068 069 4.000 RIGHT
2350 CIRCLE 073 074 4.000 LEFT
2360 CIRCLE 078 079 4.000 RIGHT
2365 XY
2370 BLOCK BS01 0.150 10.000 0
2380 1.0 1.0 0.0 0.0 0.0 0.0
2390 012 001 087 091 092 088 089 093 094
090 002 003 004
2400 BRICK BS02 0.150
2410 087 088 092 091 081 082 095 096
2420 BRICK BS03 0.150
2430 089 090 094 093 084 083 097 098
2421 COLOR YELLOW BS01
2422 COLOR YELLOW BS02
2423 COLOR YELLOW BS03
2440 BLOCK CW01 0.150 10.000 0
2450 1.0 1.0 0.0 0.0 0.0 0.0
2460 008 005 006 007 008 009 010 011 012
2470 BLOCK CW02 0.150 10.000 0
2480 1.0 1.0 0.0 0.0 0.0 0.0
2490 008 020 019 018 017 016 015 014 013
2491 COLOR CYAN CW01
2492 COLOR CYAN CW02
2493 COLOR CYAN CW03
2500 BLOCK CP01 0.150 10.000 0
2510 1.0 1.0 0.0 0.0 0.0 0.0
2520 005 021 022 023 024 025
2530 BLOCK CP02 0.150 10.000 0
2540 1.0 1.0 0.0 0.0 0.0 0.0
2550 005 030 029 028 027 026
2560 BLOCK CP03 0.150 10.000 0
2570 1.0 1.0 0.0 0.0 0.0 0.0
2580 005 031 032 033 034 035
2590 BLOCK CP04 0.150 10.000 0
2600 1.0 1.0 0.0 0.0 0.0 0.0
2610 005 040 039 038 037 036
2620 BLOCK CP05 0.150 10.000 0
```

(Sheet 6 of 8)

Table 23. (Continued)

```
2630 1.0 1.0 0.0 0.0 0.0 0.0
2640 005 041 042 043 044 045
2650 BLOCK CP06 0.150 10.000 0
2660 1.0 1.0 0.0 0.0 0.0 0.0
2670 005 050 049 048 047 046
2680 BLOCK CP07 0.150 10.000 0
2690 1.0 1.0 0.0 0.0 0.0 0.0
2700 005 051 052 053 054 055
2710 BLOCK CP08 0.150 10.000 0
2720 1.0 1.0 0.0 0.0 0.0 0.0
2730 005 060 059 058 057 056
2740 BLOCK CP09 0.150 10.000 0
2750 1.0 1.0 0.0 0.0 0.0 0.0
2760 005 061 062 063 064 065
2770 BLOCK CP10 0.150 10.000 0
2780 1.0 1.0 0.0 0.0 0.0 0.0
2790 005 070 069 068 067 066
2800 BLOCK CP11 0.150 10.000 0
2810 1.0 1.0 0.0 0.0 0.0 0.0
2820 005 071 072 073 074 075
2830 BLOCK CP12 0.150 10.000 0
2840 1.0 1.0 0.0 0.0 0.0 0.0
2850 005 080 079 078 077 076
2851 COLOR RED CP01
2852 COLOR RED CP02
2853 COLOR RED CP03
2854 COLOR RED CP04
2855 COLOR RED CP05
2856 COLOR RED CP06
2857 COLOR RED CP07
2858 COLOR RED CP08
2859 COLOR RED CP09
2860 COLOR RED CP10
2861 COLOR RED CP11
2862 COLOR RED CP12
2863 YZ
2870 BLOCK WC01 0.150 -97.000 0
2880 1.0 1.0 0.0 0.0 0.0 0.0
2890 013 099 100 101 102 103 104 105 106 107
2891 108 109 110 111
2900 BLOCK WC02 0.150 -84.000 0
2910 1.0 1.0 0.0 0.0 0.0 0.0
2920 021 112 113 114 115 116 117 118 119 120
2921 121 122 123 124 125 126
2930 127 128 129 130 131 132
```

(Sheet 7 of 8)

Table 23. (Concluded)

```
2940 XZ
2950 BLOCK WC03 0.150 1.750 0
2960 1.0 1.0 0.0 0.0 0.0 0.0
2970 003 133 134 135
2980 YZ
2990 BLOCK WC04 0.150 -4.292 0
3000 1.0 1.0 0.0 0.0 0.0 0.0
3010 011 139 140 141 142 143 144 145 146 147 148 149
3020 BLOCK WC05 0.150 -4.292 0
3030 1.0 1.0 0.0 0.0 0.0 0.0
3040 011 150 151 152 153 154 155 156 157 158 159 160
3050 BLOCK WC06 0.150 -2.208 0
3060 1.0 1.0 0.0 0.0 0.0 0.0
3070 027 161 162 163 164 165 166 167 168 169 170 171 172
3071 173 174 175
3080 176 177 178 179 180 181 182 183 184 185 186 187
3090 BLOCK WC07 0.150 -2.208 0
3100 1.0 1.0 0.0 0.0 0.0 0.0
3110 023 188 189 190 191 192 193 194 195 196 197 198 199
3111 200 201 202
3120 203 204 205 206 207 208 209 210
3130 XZ
3140 BLOCK WC08 0.150 4.000 0
3150 1.0 1.0 0.0 0.0 0.0 0.0
3160 004 214 213 212 211
3161 COLOR WHITE WC01
3162 COLOR WHITE WC02
3163 COLOR WHITE WC03
3164 COLOR WHITE WC04
3165 COLOR WHITE WC05
3166 COLOR WHITE WC06
```

(Sheet 8 of 8)

d. Vertical water.

e. Bulkheads in storage recess.

3. Emergency operation (Case 6a) (Elements BS01 - BS03, CW01 - CW02, CP01 - CP12, WC01 - WC08, HE01 - HE13, HW01 - HW21, WAT1 - WAT6, UP01 - UP02)

   a. Weight of the concrete.

   b. Horizontal soil.

   c. Horizontal water.

   d. Vertical water.

Figure 62 shows a plot of the horizontal soil loads with the structure, and Table 24 gives the data. Figure 63 shows a plot of the horizontal water loads without the structure, and Table 25 gives the data. Figure 64 shows a plot of the vertical water loads without the structure, and Table 26 gives the data. Figure 65 shows the view looking downstream; Figure 66 shows the view looking toward the river side of the emergency bulkhead loads with the structure; and Table 27 gives the data. Table 28 gives a description of the 3DSAD elements found in the tables.

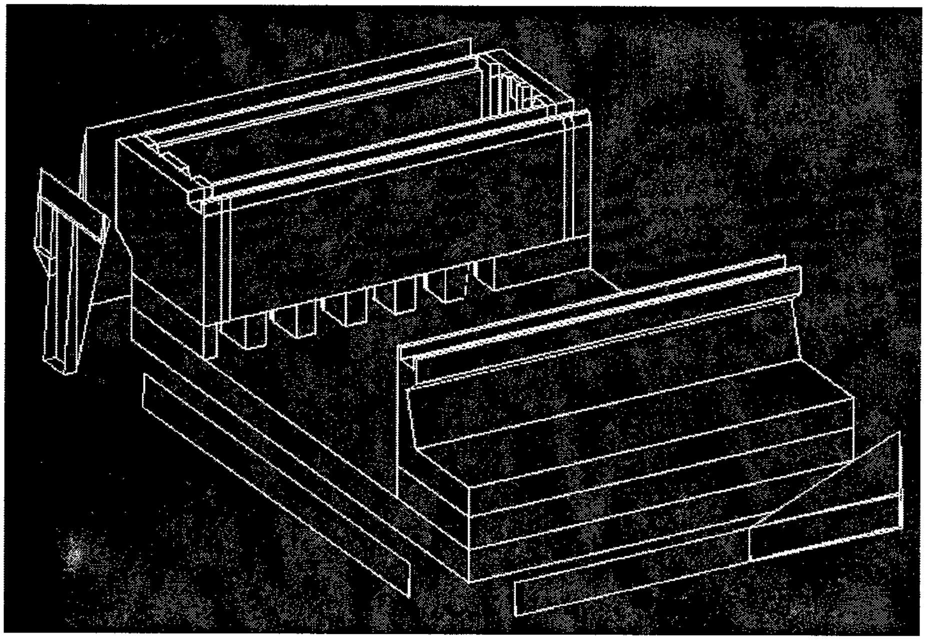


Figure 62. Isometric view of horizontal soil loads

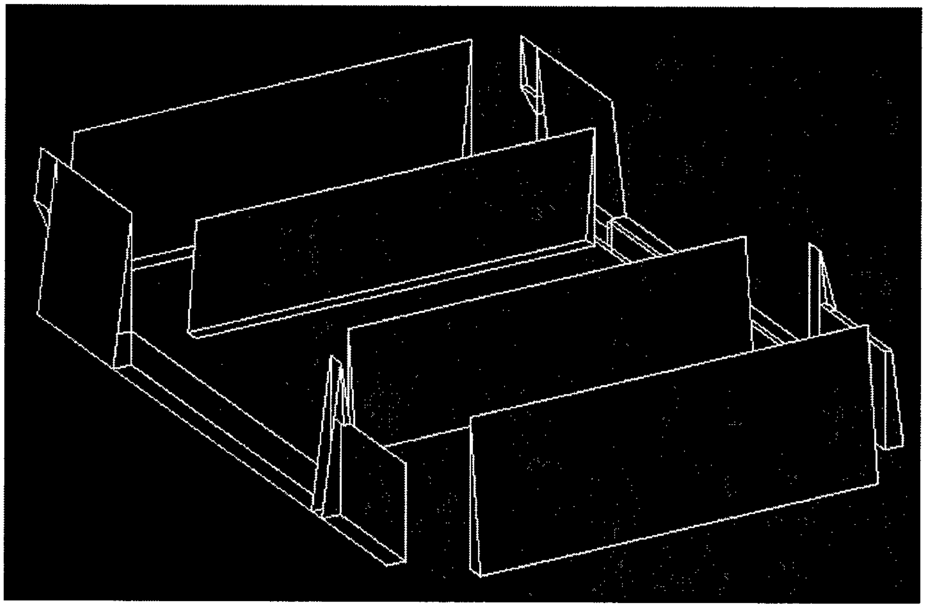


Figure 63. Isometric view of horizontal water loads

Table 24. Horizontal Soil Data

```
0010 POINTS 33
0020 180 -116.000  -94.000  85.000
0030 181  -78.000  -94.000  85.000
0040 182  -78.000  -94.000 104.000
0050 183  -78.000  -94.950  85.000
0060 184 -116.000  -94.000  75.000
0070 185 -116.000  -94.500  75.000
0080 186  -78.000  -95.450  75.000
0090 187  -78.000  -94.500  75.000
0100 188  -78.000  -94.000  75.000
0110 189 -190.000  -74.000  85.000
0120 190 -190.000  -74.000  75.000
0130 191 -190.500  -74.000  75.000
0140 192  -78.000   94.000 128.000
0150 193  -78.000   94.000  75.000
0160 194  -78.000   95.600  75.000
0170 195  -78.000  100.100  75.000
0180 196  -78.000   95.600 120.000
0190 197 -194.000   50.500 128.000
0200 198 -194.000   53.229 128.000
0210 199 -194.000   53.229 120.000
0220 200 -194.800   53.229 120.000
0230 201 -194.000   65.167 120.000
0240 202 -194.000   65.167  75.000
0250 203 -197.050   65.167  75.000
0260 204 -194.800   65.167 120.000
0270 205 -194.000   74.000 120.000
0280 206 -194.000   74.000 105.000
0290 207 -194.000   74.000 100.000
0300 208 -195.800   74.000 100.000
0310 209 -195.550   74.000 105.000
0320 210 -194.800   74.000 120.000
0330 211 -194.000   80.500 105.000
0340 212 -195.550   80.500 105.000
0350 XZ
0360 BLOCK +X HE01 0.625 116.000 0
0370 1.0 1.0 0.0 0.0 0.0 0.0
0380 003 189 190 191
0390 YZ
0400 BR8 +Y HE02 0.3125
0410 181 183 180 180 182 182 182 182
0420 BR8 +Y HE03 0.3125
0430 188 187 184 184 181 183 180 180
0440 BR8 +Y HE04 0.3125
0450 187 186 185 184 183 186 185 180
```

(Continued)

Table 24. (Concluded)

```
0460 BLOCK +Y HE05 0.3125 -59.000 0
0470 1.0 1.0 0.0 0.0 0.0 0.0
0480 003 180 184 185
0490 BLOCK -Y HE06 0.3125 -97.000 0
0500 1.0 1.0 0.0 0.0 0.0 0.0
0510 004 192 196 194 193
0520 BLOCK -Y HE07 0.3125 -97.000 0
0530 1.0 1.0 0.0 0.0 0.0 0.0
0540 003 196 194 195
0550 XZ
0560 BR8 +X HE08 0.3125
0570 199 199 200 200 198 197 197 198
0580 BLOCK +X HE09 0.3125 27.271 0
0590 1.0 1.0 0.0 0.0 0.0 0.0
0600 003 198 200 199
0610 BR8 +X HE10 0.3125
0620 202 202 201 199 203 203 204 200
0630 BLOCK +X HE11 0.3125 8.833 0
0640 1.0 1.0 0.0 0.0 0.0 0.0
0650 004 201 204 203 202
0660 BLOCK +X HE12 0.3125 6.500 0
0670 1.0 1.0 0.0 0.0 0.0 0.0
0680 004 205 210 209 206
0690 BR8 +X HE13 0.3125
0700 207 207 206 211 208 208 209 212
0701 COLOR YELLOW HE01
0702 COLOR YELLOW HE02
0703 COLOR YELLOW HE03
0704 COLOR YELLOW HE04
0705 COLOR YELLOW HE05
0706 COLOR YELLOW HE06
0707 COLOR YELLOW HE07
0708 COLOR YELLOW HE08
0709 COLOR YELLOW HE09
0710 COLOR YELLOW HE10
0711 COLOR YELLOW HE11
0712 COLOR YELLOW HE12
```

Table 25. Horizontal Water Data

```
0010 POINTS 72
0020 108   -78.000   -84.000 120.000
0030 109   -78.000   -84.000  75.000
0040 110   -78.000   -88.500  75.000
0050 111   -78.000    84.000 120.000
0060 112   -78.000    84.000  75.000
0070 113   -78.000    88.500  75.000
0080 114   -78.000   -32.000 120.000
0090 115   -78.000   -32.000  85.000
0100 116   -78.000   -35.500  85.000
0110 117   -78.000    32.000 120.000
0120 118   -78.000    32.000  85.000
0130 119   -78.000    35.500  85.000
0140 130 -185.000   -42.000 120.000
0150 131 -185.000   -42.000  75.000
0160 132 -189.500   -42.000  75.000
0170 133 -185.000   -46.333 120.000
0180 134 -185.000   -46.333 104.000
0190 135 -185.000   -46.333  75.000
0200 136 -189.500   -46.333  75.000
0210 137 -186.600   -46.333 104.000
0220 138 -185.000   -50.333 104.000
0230 139 -186.600   -50.333 104.000
0240 140   -68.000    42.000 120.000
0250 141   -68.000    42.000  75.000
0260 142   -63.500    42.000  75.000
0270 143   -68.000    74.000 120.000
0280 144   -68.000    74.000 105.000
0290 145   -66.500    74.000 105.000
0300 146   -66.500    80.500 105.000
0310 147   -68.000    80.500 105.000
0320 148   -66.000    74.000 100.000
0330 149   -68.000    74.000 100.000
0340 150 -185.000    42.000 120.000
0350 151 -185.000    42.000  75.000
0360 152 -189.500    42.000  75.000
0370 153 -185.000    74.000 120.000
0380 154 -185.000    74.000 105.000
0390 155 -186.500    74.000 105.000
0400 156 -186.500    80.500 105.000
0410 157 -185.000    80.500 105.000
0420 158 -187.000    74.000 100.000
0430 159 -185.000    74.000 100.000
0440 160   -68.000   -42.000  85.000
0450 161   -68.000   -42.000  75.000
```

(Sheet 1 of 3)

Table 25. (Continued)

```
0460 162  -63.500  -42.000  75.000
0470 163  -64.500  -42.000  85.000
0480 164 -185.000  -42.000  85.000
0490 165 -185.000  -42.000  75.000
0500 166 -189.500  -42.000  75.000
0510 167 -188.500  -42.000  85.000
0520 168  -68.000  -43.500  81.500
0530 169  -68.000  -43.500  76.500
0540 170  -63.650  -43.500  76.500
0550 171  -64.150  -43.500  81.500
0560 172  -68.000   43.500  81.500
0570 173  -68.000   43.500  76.500
0580 174  -63.650   43.500  76.500
0590 175  -64.150   43.500  81.500
0600 176  -68.000  -43.500  83.500
0610 177  -68.000  -43.500  76.500
0620 178  -63.650  -43.500  76.500
0630 179  -64.350  -43.500  83.500
0140 330  -68.000  -42.000 120.000
0150 331  -68.000  -42.000  75.000
0160 332  -63.500  -42.000  75.000
0170 333  -68.000  -46.333 120.000
0180 334  -68.000  -46.333 104.000
0190 335  -68.000  -46.333  75.000
0200 336  -63.500  -46.333  75.000
0210 337  -66.400  -46.333 104.000
0220 338  -68.000  -50.333 104.000
0230 339  -66.400  -50.333 104.000
0640 YZ
0650 BLOCK +Y HW01 0.625 -97.000 0
0660 1.0 1.0 0.0 0.0 0.0 0.0
0670 003 108 109 110
0680 BLOCK -Y HW02 0.625 -97.000 0
0690 1.0 1.0 0.0 0.0 0.0 0.0
0700 003 111 112 113
0710 BLOCK +Y HW03 0.625 -97.000 0
0720 1.0 1.0 0.0 0.0 0.0 0.0
0730 003 114 115 116
0740 BLOCK -Y HW04 0.625 -97.000 0
0750 1.0 1.0 0.0 0.0 0.0 0.0
0760 003 117 118 119
0770 XZ
0780 BLOCK -X HW05 0.625 -4.333 0
0790 1.0 1.0 0.0 0.0 0.0 0.0
0800 003 330 331 332
```

(Sheet 2 of 3)

Table 25. (Concluded)

```
0810 BLOCK -X HW06 0.625 -27.667 0
0820 1.0 1.0 0.0 0.0 0.0 0.0
0830 004 334 335 336 337
0840 BR8 -X HW07 0.625
0850 334 337 339 338 333 333 333 333
0860 BLOCK +X HW08 0.625 -4.333 0
0870 1.0 1.0 0.0 0.0 0.0 0.0
0880 003 130 131 132
0890 BLOCK +X HW09 0.625 -27.667 0
0900 1.0 1.0 0.0 0.0 0.0 0.0
0910 004 134 135 136 137
0920 BR8 +X HW10 0.625
0930 134 137 139 138 133 133 133 133
0940 BLOCK -X HW11 0.625 32.000 0
0950 1.0 1.0 0.0 0.0 0.0 0.0
0960 003 140 141 142
0970 BLOCK -X HW12 0.625   6.500 0
0980 1.0 1.0 0.0 0.0 0.0 0.0
0990 003 143 144 145
1000 BR8 -X HW13 0.625
1010 147 149 148 146 147 144 145 146
1020 BLOCK +X HW14 0.625 32.000 0
1030 1.0 1.0 0.0 0.0 0.0 0.0
1040 003 150 151 152
1050 BLOCK +X HW15 0.625   6.500 0
1060 1.0 1.0 0.0 0.0 0.0 0.0
1070 003 153 154 155
1080 BR8 +X HW16 0.625
1090 157 159 158 156 157 154 155 156
1100 BLOCK -X HW17 0.625  84.000 0
1110 1.0 1.0 0.0 0.0 0.0 0.0
1120 004 160 163 162 161
1140 BLOCK +X HW18 0.625  84.000 0
1150 1.0 1.0 0.0 0.0 0.0 0.0
1160 004 164 167 166 165
1170 BLOCK +X HW19 0.625 -26.000 0
1180 1.0 1.0 0.0 0.0 0.0 0.0
1190 004 168 171 170 169
1200 BLOCK +X HW20 -0.625  26.000 0
1210 1.0 1.0 0.0 0.0 0.0 0.0
1220 004 172 175 174 173
1230 BLOCK +X HW21 0.625  87.000 0
1240 1.0 1.0 0.0 0.0 0.0 0.0
1250 004 176 179 178 177
```

(Sheet 3 of 3)

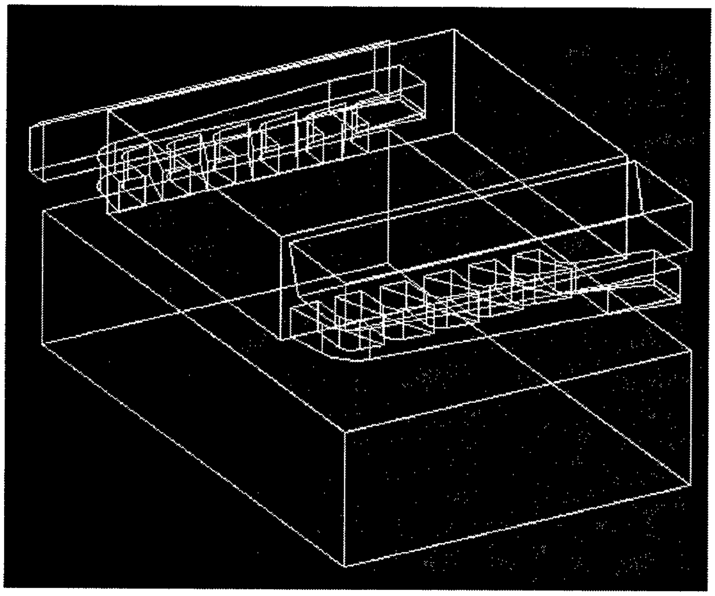


Figure 64. Isometric view of vertical water loads

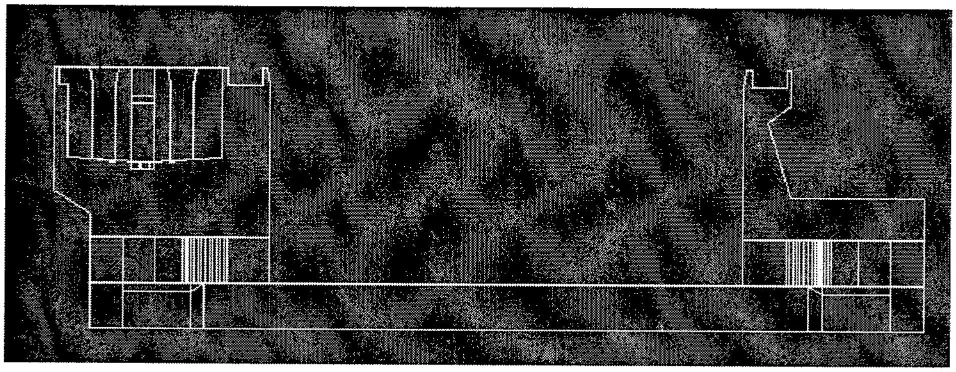


Figure 65. View of bulkhead loads looking downstream

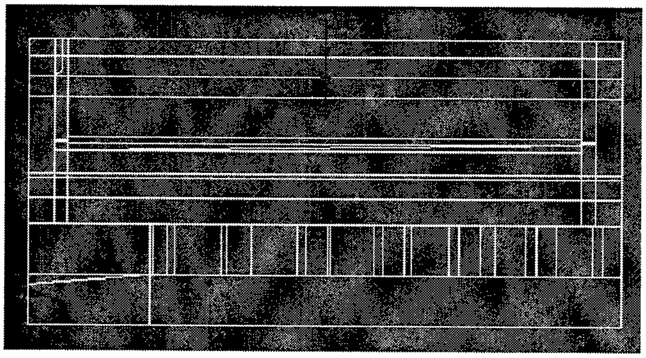


Figure 66. View of bulkhead loads looking riverward

Table 26. Vertical Water Data

```
0010 XY
0020 POINTS 220
0030 001  -78.000  -74.000  75.000
0040 002  -78.000   74.000  75.000
0050 003 -175.000   74.000  75.000
0060 004 -175.000  -74.000  75.000
0070 005  -78.000  -74.000  85.000
0080 006  -78.000  -68.000  85.000
0090 007  -98.000  -68.000  85.000
0100 008 -161.354  -62.427  85.000
0110 009 -170.188  -54.115  85.000
0120 010 -172.000  -42.000  85.000
0130 011 -175.000  -42.000  85.000
0140 012 -175.000  -74.000  85.000
0150 013  -78.000   74.000  85.000
0160 014  -78.000   68.000  85.000
0170 015  -98.000   68.000  85.000
0180 016 -161.354   62.427  85.000
0190 017 -170.188   54.115  85.000
0200 018 -172.000   42.000  85.000
0210 019 -175.000   42.000  85.000
0220 020 -175.000   74.000  85.000
0230 021  -78.000  -56.000  85.000
0240 022  -78.000  -42.000  85.000
0250 023 -102.000  -42.000  85.000
0260 024 -102.000  -49.531  85.000
0270 025  -98.500  -53.500  85.000
0280 026  -78.000   56.000  85.000
0290 027  -78.000   42.000  85.000
0300 028 -102.000   42.000  85.000
0310 029 -102.000   49.531  85.000
0320 030  -98.500   53.500  85.000
0330 031 -109.500  -42.000  85.000
0340 032 -114.500  -42.000  85.000
0350 033 -114.500  -50.152  85.000
0360 034 -110.500  -54.121  85.000
0370 035 -100.833  -55.396  85.000
0380 036 -109.500   42.000  85.000
0390 037 -114.500   42.000  85.000
0400 038 -114.500   50.152  85.000
0410 039 -110.500   54.121  85.000
0420 040 -100.833   55.396  85.000
0430 041 -122.000  -42.000  85.000
0440 042 -127.000  -42.000  85.000
0450 043 -127.000  -50.781  85.000
```

(Sheet 1 of 4)

Table 26. (Continued)

0460	044	-123.500	-54.750	85.000
0470	045	-114.515	-55.875	85.000
0480	046	-122.000	42.000	85.000
0490	047	-127.000	42.000	85.000
0500	048	-127.000	50.781	85.000
0510	049	-123.500	54.750	85.000
0520	050	-114.515	55.875	85.000
0530	051	-134.500	-42.000	85.000
0540	052	-139.500	-42.000	85.000
0550	053	-139.500	-51.417	85.000
0560	054	-136.000	-55.385	85.000
0570	055	-127.490	-56.448	85.000
0580	056	-134.500	42.000	85.000
0590	057	-139.500	42.000	85.000
0600	058	-139.500	51.417	85.000
0610	059	-136.000	55.385	85.000
0620	060	-127.490	56.448	85.000
0630	061	-147.000	-42.000	85.000
0640	062	-152.000	-42.000	85.000
0650	063	-152.000	-52.042	85.000
0660	064	-148.500	-56.010	85.000
0670	065	-140.681	-56.985	85.000
0680	066	-147.000	42.000	85.000
0690	067	-152.000	42.000	85.000
0700	068	-152.000	52.042	85.000
0710	069	-148.500	56.010	85.000
0720	070	-140.681	56.985	85.000
0730	071	-159.500	-42.000	85.000
0740	072	-164.500	-42.000	85.000
0750	073	-164.500	-52.667	85.000
0760	074	-161.000	-56.635	85.000
0770	075	-154.490	-57.448	85.000
0780	076	-159.500	42.000	85.000
0790	077	-164.500	42.000	85.000
0800	078	-164.500	52.667	85.000
0810	079	-161.000	56.635	85.000
0820	080	-154.490	57.448	85.000
0830	081	-78.000	-68.000	83.000
0840	082	-78.000	-56.000	83.000
0850	083	-78.000	68.000	83.000
0860	084	-78.000	56.000	83.000
0870	085	-98.000	-74.000	75.000
0880	086	-98.000	74.000	75.000
0890	087	-78.000	-68.000	75.000
0900	088	-78.000	-56.000	75.000

(Sheet 2 of 4)

Table 26. (Continued)

```
1960 197 -168.500   55.667 111.599
1970 198 -168.500   59.917 111.269
1980 199 -168.500   59.917 128.000
1990 200 -168.500   60.417 131.500
2000 201 -168.500   69.063 131.500
2010 202 -168.500   69.563 128.000
2020 203 -168.500   69.563 111.269
2030 204 -168.500   73.813 111.599
2040 205 -168.500   73.813 128.000
2050 206 -168.500   74.313 131.500
2060 207 -168.500   80.500 131.500
2070 208 -168.500   80.500 105.000
2080 209 -168.500   74.000 100.000
2090 210 -168.500   74.000  95.000
2100 211  -82.292   62.740 124.000
2110 212  -82.292   62.740 131.500
2120 213  -83.584   62.740 131.500
2130 214  -83.584   62.740 125.292
2140 215  -78.000  -74.000 120.000
2150 216  -78.000  -74.000  70.000
2160 217  -78.000   74.000  70.000
2170 218  -78.000   74.000  25.000
2180 219  -78.000  -74.000  25.000
2190 220  -78.000   74.000 100.000
2200 221  -78.000   80.500  95.000
2210 222  -78.000   80.500  80.000
2220 223  -78.000   74.000  80.000
2230 CIRCLE 008 009 9.792 RIGHT
2240 CIRCLE 016 017 9.792 LEFT
2250 CIRCLE 024 025 4.000 LEFT
2260 CIRCLE 029 030 4.000 RIGHT
2270 CIRCLE 033 034 4.000 LEFT
2280 CIRCLE 038 039 4.000 RIGHT
2290 CIRCLE 043 044 4.000 LEFT
2300 CIRCLE 048 049 4.000 RIGHT
2310 CIRCLE 053 054 4.000 LEFT
2320 CIRCLE 058 059 4.000 RIGHT
2330 CIRCLE 063 064 4.000 LEFT
2340 CIRCLE 068 069 4.000 RIGHT
2350 CIRCLE 073 074 4.000 LEFT
2360 CIRCLE 078 079 4.000 RIGHT
3170 XY
3180 BLOCK WAT1 0.0625 35.000 0
3190 1.0 1.0 0.0 0.0 0.0 0.0
3200 004 027 019 011 022
```

(Sheet 3 of 4)

Table 26. (Concluded)

```
3210 BLOCK WAT2 0.0625 10.000 0
3220 1.0 1.0 0.0 0.0 0.0 0.0
3230 034 021 025 024 023 031 035 034 033 032 041 045
3240 044 043 042 051 055 054 053 052 061 065 064 063
3250 062 071 075 074 073 072 010 009 008 007 006
3260 BLOCK WAT3 0.0625 10.000 0
3270 1.0 1.0 0.0 0.0 0.0 0.0
3280 034 014 015 016 017 018 077 078 079 080 076 067
3290 068 069 070 066 057 058 059 060 056 047 048 049
3300 050 046 037 038 039 040 036 028 029 030 026
3310 BR8 WAT4 0.0625
3320 081 082 095 096 006 021 095 096
3330 BR8 WAT5 0.0625
3340 083 097 098 084 014 097 098 026
3350 YZ
3360 BLOCK WAT6 0.0625 -97.000 0
3370 1.0 1.0 0.0 0.0 0.0 0.0
3380 004 100 215 102 101
3390 BLOCK UP01 -0.0625 -97.000 0
3400 1.0 1.0 0.0 0.0 0.0 0.0
3410 004 216 217 218 219
3420 BLOCK UP02 -0.0625 -97.000 0
3430 1.0 1.0 0.0 0.0 0.0 0.0
3440 004 220 221 222 223
```

(Sheet 4 of 4)

Table 27. Storage Locations and Loads for Emergency Bulkheads

```
0020 PTLD BLK1 -126.600  58.521 115.750 000.000 000.000 -52.000
0030 PTLD BLK2 -126.600  58.521 122.250 000.000 000.000 -52.000
0040 PTLD BLK3 -126.600  72.417 115.750 000.000 000.000 -67.500
0050 PTLD BLK4 -126.600  72.417 122.250 000.000 000.000 -52.000
0060 PTLD BLK5 -126.600  72.417 128.250 000.000 000.000 -60.000
0061 COLOR BLACK BLK1
0062 COLOR BLACK BLK2
0063 COLOR BLACK BLK3
0064 COLOR BLACK BLK4
0065 COLOR BLACK BLK5
```

Table 28. 3DSAD Elements

Geometry Elements	
BS01 – BS03	Monolith base concrete
CW01 – CW02	Exterior culvert wall concrete
CP01 – CP12	Culvert manifold pillars (odd numbers river side, even numbers land side)
WC01	Upper lock wall, river side
WC02 – WC08	Upper lock wall, land side
Loads Elements	
HE01 – HE13	Horizontal soil
HW01 – HW21	Horizontal water
WAT1 – WAT6	Vertical water
UP01 – UP02	Uplift
BLK1 – BLK5	Emergency bulkheads in storage recess

Miter Gate Monolith

This example consists of a preliminary design for a miter gate monolith for the Marmet Lock and Dam Project (provided by Robert Taylor, Great Lakes and Ohio River Division, and Richard K. Rutherford, Huntington District). Even though this is not the final design, it should give a good example of the capabilities of 3DSAD. Four load cases will now be shown.

Load Case 1 - Normal Condition

The lock sits on rock and has rock at EL 531.0 ft on the lockside and at EL 552 ft on the landside. Water is at EL 590.0 ft upstream of the miter gate and EL 566.0 ft downstream of the gate on the lockside and at EL 578.0 on the landside. Backfill from the rock to EL 597.0 ft on the landside has a moist density of 100 lb/ft^3, a saturated density of 125 lb/ft^3, and an internal friction angle of 32 deg. The foundation rock used for sliding has a cohesion of zero and a internal friction angle of 23 deg. The concrete has a density of 0.145 kip/ft^3. The weight of the miter gate is 201 kips. When the gates are mitered, the water load applies a longitudinal and normal thrust to the monolith of 600 and 800 kips at EL 578.0 ft, respectively. A vertical shear soil load of 496.0 kips is applied to the landside of the monolith (ETL 1110-2-352). A boat load of 100 kips is applied at EL 570.0 on the lockside. Figure 67 shows a front view of the geometry and loads for Load Case 1, and Figure 68 shows an isometric view. Table 29 gives the geometry and loads data, and Table 30 gives the General Analysis Module data.

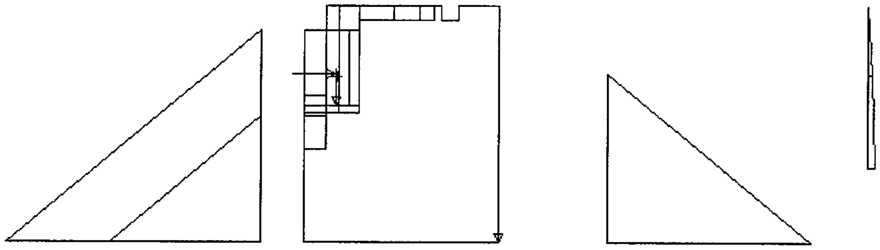


Figure 67. Front view for Load Case 1

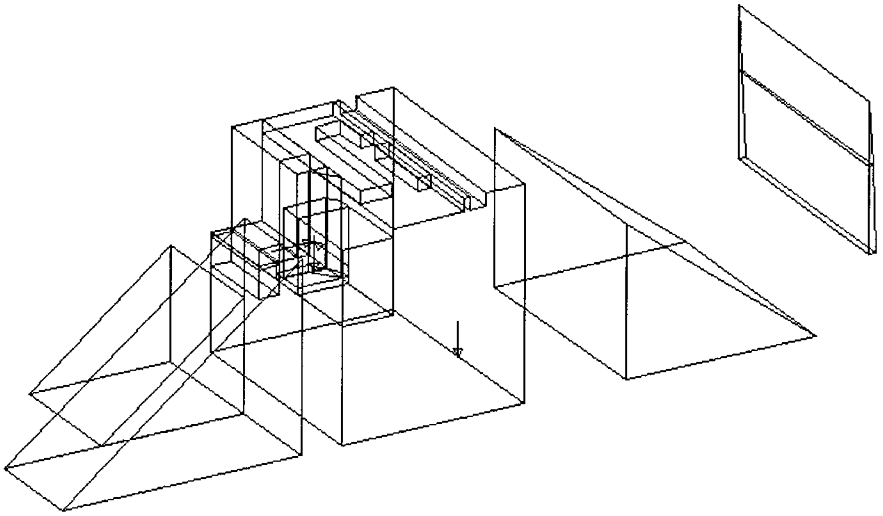


Figure 68. Isometric view for Load Case 1

Load Case 2 - Drawdown Condition

For Load Case 2, the drawdown load case is investigated. Water is at EL 590.0 ft upstream of the miter gate and EL 587.0 ft downstream of the gate on the lockside and EL 597.0 ft on the landside. The backfill has the same soil parameters as Load Case 1 but is completely saturated. When the gate is mitered, the water load applies a longitudinal and normal thrust to the monolith of 240 and 180 kips, respectively. The vertical shear from the soil is 354 kips. Figure 69 shows a front view of the geometry and loads for Load Case 2, and Figure 70 shows an isometric view. Table 31 gives the geometry and loads data, and Table 32 gives the General Analysis Module data.

Table 29. Geometry and Loads Data for Load Case 1

```
1000 POINTS 12
1100 1 0 0 0
1200 2 45 0 0
1300 3 45 0 66
1400 4 35.5 0 66
1500 5 35.5 0 62
1600 6 31.5 0 62
1700 7 31.5 0 66
1800 8 30 0 66
1900 9 30 0 62
2000 10 12.5 0 62
2100 11 12.5 0 36
2200 12 0 0 36
2300 BLOCK -Z BL1 .145 56
2400 1. 1.
2500 12 12 11 10 9 8 7 6 5 4 3 2 1
2550 XY
2600 POINTS 5
2700 13 0 19 36
2800 14 12.5 19 36
2900 15 12.5 21.96 36
3000 16 7.8125 28.25 36
3000 17 0 28.25 36
3100 BLOCK -Z BL2 .145 2
3200 1. 1.
3300 5 13 14 15 16 17
3350 XZ
3400 POINTS 6
3500 18 0 28.25 36
3600 19 12.5 28.25 36
3700 20 12.5 28.25 66
3800 21 5 28.25 66
3900 22 5 28.25 41
4000 23 0 28.25 41
4100 BLOCK -Z BL3 .145 7.75
4200 1. 1.
4300 6 23 22 21 20 19 18
4400 XY
4500 POINTS 3
4600 24 12.5 21.96 36
4700 25 12.5 28.25 36
4700 26 7.8125 28.25 36
4800 BLOCK -Z BL4 .145 30
4900 1. 1.
5000 3 24 25 26
```

(Sheet 1 of 4)

Table 29. (Continued)

```
5100 XY
5200 POINTS 8
5300 27 12.5 13.92 62
5400 28 20.43 13.92 62
5500 29 20.43 47.09 62
5600 30 26.68 47.09 62
5700 31 26.68 38.84 62
5800 32 30.0 38.84 62
5900 33 30.0 56 62
6000 34 12.5 56 62
6400 BLOCK -Z BL5 .145 4
6500 1. 1.
6600 8 27 28 29 30 31 32 33 34
6700 XZ
6800 POINTS 4
6900 35 26.68 13.92 62
7000 36 30.0 13.92 62
7100 37 30.0 13.92 66
7200 38 26.68 13.92 66
7300 BLOCK -Z BL6 .145 18.42
7400 1. 1.
7500 4 38 37 36 35
7600 PTLD GTWT 7.35 25 38 0 0 -201
7700 PTLD GTLG 7.35 25 47 800 0 0
7800 PTLD GTNM 7.35 25 47 0 600 0
7950 PTLD VSHR 45 28 0 0 0 -496.02
8000 XZ
8100 POINTS 4
8200 39 0 0 36
8300 40 12.5 0 36
8400 41 12.5 0 59
8500 42 0 0 59
8600 BLOCK -Z WL1 .0625 19
8700 1. 1.
8800 4 42 41 40 39
8900 XY
9000 POINTS 5
9100 43 0 19 38
9200 44 12.5 19 38
9300 45 12.5 21.96 38
9400 46 10.22 25 38
9500 47 0 25 38
9600 BLOCK -Z WL2 .0625 21
9700 1. 1.
9800 5 47 46 45 44 43
```

(Sheet 2 of 4)

Table 29. (Continued)

```
9900 XZ
10000 POINTS 3
10100 48 -10 0 0
10200 49 -10 0 59
10300 50 -69 0 0
10400 BLOCK +X WH1 .0625 25
10500 1. 1.
10600 3 50 49 48
10700 POINTS 3
10800 51 -10 25 0
10900 52 -10 25 35
11000 53 -45 25 0
11100 BLOCK +X WH2 .0625 31
11200 1. 1.
11300 3 53 52 51
11400 POINTS 3
11500 54 70 0 0
11600 55 117 0 0
11700 56 70 0 47
11800 BLOCKS -X WH3 .0625 56
11900 1. 1.
12000 3 56 55 54
12100 XZ
12200 POINTS 3
12300 57 130 0 47
12400 58 130.893 0 47
12500 59 130 0 66
12600 BLOCK -X SH1 1 56
12700 1. 1.
12800 3 59 58 57
12900 XZ
13000 POINTS 4
13100 60 130 0 21
13200 61 131.65675 0 21
13300 62 130.893 0 47
13400 63 130 0 47
13500 BLOCK -X SH2 1 56
13600 1. 1.
13700 4 63 62 61 60
13800 POINTS 4
13900 64 5 36 36
14000 65 12.5 36 36
14100 66 12.5 36 66
14200 67 5 36 66
14300 BLOCK -Z BL7 .145 20
```

(Sheet 3 of 4)

Table 29. (Concluded)

```
14400 1. 1.
14500 4 67 66 65 64
14600 POINTS 4
14700 68 0 36 26
14800 69 5 36 26
14900 70 5 36 36
15000 71 0 36 36
15100 BLOCK +Z DL1 .145 20
15200 1. 1.
15300 4 71 70 69 68
15400 POINTS 4
15500 72 0 36 26
15600 73 5 36 26
15700 74 5 36 35
15800 75 0 36 35
15900 BLOCK -Z BL8 .0625 20
16000 1. 1.
16100 4 75 74 73 72
140000 COLOR RED GTWT
141000 COLOR RED GTLG
142000 COLOR RED GTNM
143000 COLOR RED BOAT
143100 COLOR RED DL1
144000 COLOR BLUE WL1
145000 COLOR BLUE WL2
146000 COLOR BLUE WH1
147000 COLOR BLUE WH2
148000 COLOR BLUE WH3
148100 COLOR BLUE BL8
149000 COLOR YELLOW SH1
150000 COLOR YELLOW SH2
151000 BACKGROUND BLACK
```

(Sheet 4 of 4)

Table 30. General Analysis Module Data for Load Case 1

```
10 POINTS 6
20 1 0 0 0
30 2 0 25 0
40 3 0 25.01 0
50 4 0 56 0
60 5 45 56 0
70 6 45 0 0
80 UPLIFT 6
90 1 3.6875
100 2 3.6875
110 3 2.1875
120 4 2.1875
130 5 2.9375
140 6 2.9375
150 PHI 23
160 SHRSTR 0
165 BASE
166 6 1 6 5 4 3 2
170 CASE LC-1 1
180 -1490.81 600 -22737.82 -
670993.3 506500.90 75871.55
```

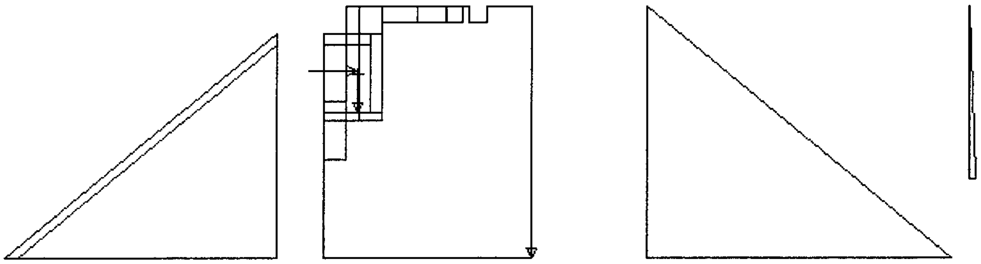


Figure 69. Front view for Load Case 2

Load Case 3 - Construction Condition

For Load Case 3 the construction load case is investigated. The water is at EL 531.0 ft on both the lock and landside. The backfill uses a moist unit weight of 100 lb/ft^3. The miter gate is assumed to be swinging free causing a moment couple of 240K normal to the monolith applied at EL 594.0 ft and EL 569.6 ft. The vertical shear from the soil is 567.0 kips. Figure 71 shows a front view of the geometry and loads for Load Case 3, and Figure 72 shows an isometric view. Table 33 gives the geometry and loads data, and Table 34 gives the General Analysis Module data.

Table 31. Geometry and Loads Data for Load Case 2

```
1000 POINTS 12
1100 1 0 0 0
1200 2 45 0 0
1300 3 45 0 66
1400 4 35.5 0 66
1500 5 35.5 0 62
1600 6 31.5 0 62
1700 7 31.5 0 66
1800 8 30 0 66
1900 9 30 0 62
2000 10 12.5 0 62
2100 11 12.5 0 36
2200 12 0 0 36
2300 BLOCK -Z BL1 .145 56
2400 1. 1.
2500 12 12 11 10 9 8 7 6 5 4 3 2 1
2550 XY
2600 POINTS 5
2700 13 0 19 36
2800 14 12.5 19 36
2900 15 12.5 21.96 36
3000 16 7.8125 28.25 36
3000 17 0 28.25 36
3100 BLOCK -Z BL2 .145 2
3200 1. 1.
3300 5 13 14 15 16 17
3350 XZ
3400 POINTS 6
3500 18 0 28.25 36
3600 19 12.5 28.25 36
3700 20 12.5 28.25 66
3800 21 5 28.25 66
3900 22 5 28.25 41
4000 23 0 28.25 41
4100 BLOCK -Z BL3 .145 7.75
4200 1. 1.
4300 6 23 22 21 20 19 18
4400 XY
4500 POINTS 3
4600 24 12.5 21.96 36
4700 25 12.5 28.25 36
4700 26 7.8125 28.25 36
4800 BLOCK -Z BL4 .145 30
4900 1. 1.
5000 3 24 25 26
```

(Sheet 1 of 4)

Table 31. (Continued)

```
5100 XY
5200 POINTS 8
5300 27 12.5 13.92 62
5400 28 20.43 13.92 62
5500 29 20.43 47.09 62
5600 30 26.68 47.09 62
5700 31 26.68 38.84 62
5800 32 30.0 38.84 62
5900 33 30.0 56 62
6000 34 12.5 56 62
6400 BLOCK -Z BL5 .145 4
6500 1. 1.
6600 8 27 28 29 30 31 32 33 34
6700 XZ
6800 POINTS 4
6900 35 26.68 13.92 62
7000 36 30.0 13.92 62
7100 37 30.0 13.92 66
7200 38 26.68 13.92 66
7300 BLOCK -Z BL6 .145 18.42
7400 1. 1.
7500 4 38 37 36 35
7600 PTLD GTWT 7.35 25 38 0 0 -201
7700 PTLD GTNM 7.35 25 49.27 240 0
0
7800 PTLD GTLG 7.35 25 49.27 0 180
0
7950 PTLD VSHR 45 28 0 0 0 -354.37
8000 XZ
8100 POINTS 4
8200 39 0 0 36
8300 40 12.5 0 36
8400 41 12.5 0 59
8500 42 0 0 59
8600 BLOCK -Z WL1 .0625 19
8700 1. 1.
8800 4 42 41 40 39
8900 XY
9000 POINTS 5
9100 43 0 19 38
9200 44 12.5 19 38
9300 45 12.5 21.96 38
9400 46 10.22 25 38
9500 47 0 25 38
9600 BLOCK -Z WL2 .0625 21
```

(Sheet 2 of 4)

Table 31. (Continued)

```
9810 XY
9812 POINTS 4
9813 48 0 25 38
9814 49 10.22 25 38
9815 50 7.8125 28.25 38
9816 51 0 28.25 38
9817 BLOCK -Z WL3 .0625 18
9818 1. 1.
9819 4 51 50 49 48
9850 XZ
9851 POINTS 4
9852 52 0 28.25 41
9853 53 5 28.25 41
9854 54 5 28.25 56
9855 55 0 28.25 56
9856 BLOCK -Z WL4 .0625 7.75
9857 1. 1.
9858 4 55 54 53 52
9900 XZ
10000 POINTS 3
10100 56 -10 0 0
10200 57 -10 0 59
10300 58 -69 0 0
10400 BLOCK +X WH1 .0625 25
10500 1. 1.
10600 3 58 57 56
10700 POINTS 3
10800 55 -10 25 0
10900 56 -10 25 56
11000 57 -66 25 0
11100 BLOCK +X WH2 .0625 31
11200 1. 1.
11300 3 57 56 55
11400 POINTS 3
11500 58 70 0 0
11600 59 136 0 0
11700 60 70 0 66
11800 BLOCKS -X WH3 .0625 56
11900 1. 1.
12000 3 60 59 58
12800 POINTS 3
12900 68 140 0 21
13000 69 141.32188 0 21
13100 70 140 0 66
13300 BLOCKS -X SH1 1 56
```

(Sheet 3 of 4)

Table 31. (Concluded)

```
13400 1. 1.
13500 3 70 69 68
13600 POINTS 4
13700 71 5 36 36
13800 72 12.5 36 36
13900 73 12.5 36 66
14000 74 5 36 66
14100 BLOCK -Z BL7  .145 20
14200 1. 1.
14300 4 74 73 72 71
14400 POINTS 4
14500 75 0 36 26
14600 76 5 36 26
14700 77 5 36 36
14800 78 0 36 36
14900 BLOCK +Z DL1 .145 20
15000 1. 1.
15100 4 78 77 76 75
15200 POINTS 4
15300 79 0 36 26
15400 80 5 36 26
15500 81 5 36 56
15600 82 0 36 56
15700 BLOCK -Z WL5 .0625 20
15800 1. 1.
15900 4 82 81 80 79
140000 COLOR RED GTWT
141000 COLOR RED GTLG
142000 COLOR RED GTNM
143000 COLOR RED BOAT
143100 COLOR RED DL1
144000 COLOR BLUE WL1
145000 COLOR BLUE WL2
146000 COLOR BLUE WL3
146400 COLOR BLUE WL4
146500 COLOR BLUE WH1
147000 COLOR BLUE WH2
148000 COLOR BLUE WH3
148100 COLOR BLUE WL5
149000 COLOR YELLOW SH1
151000 BACKGROUND BLACK
```

(Sheet 4 of 4)

Table 32. General Analysis Module Data for Load Case 2

```
10 POINTS 6
20 1 0 0 0
30 2 0 25 0
40 3 0 25.01 0
50 4 0 56 0
60 5 45 56 0
70 6 45 0 0
80 UPLIFT 6
90 1 3.6875
100 2 3.6875
110 3 3.5
120 4 3.5
130 5 4.125
140 6 4.125
150 PHI 23
160 SHRSTR 0
165 BASE
166 6 1 6 5 4 3 2
170 CASE LC-2 1
180 -3291.03 180 -22796.71 -
655775.6 436720.4 98369.61
```

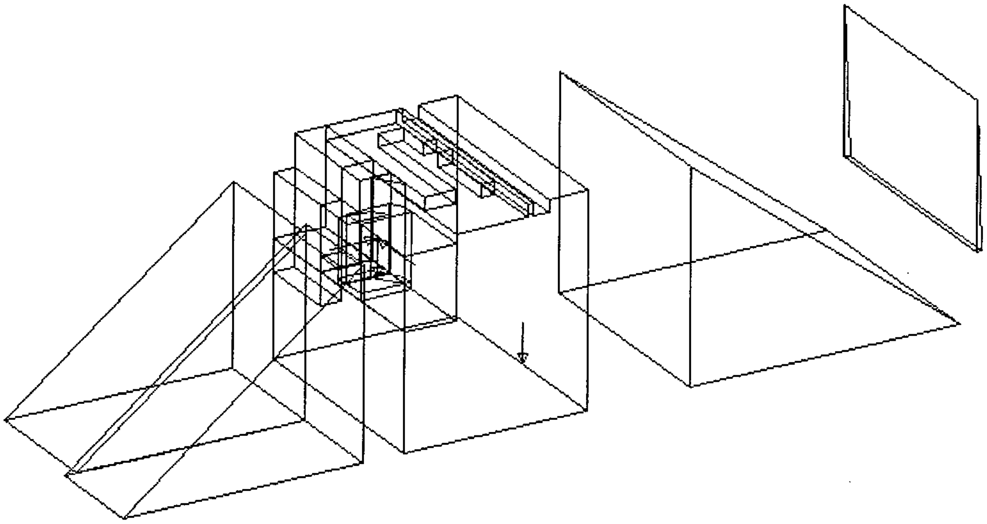


Figure 70. Isometric view for Load Case 2

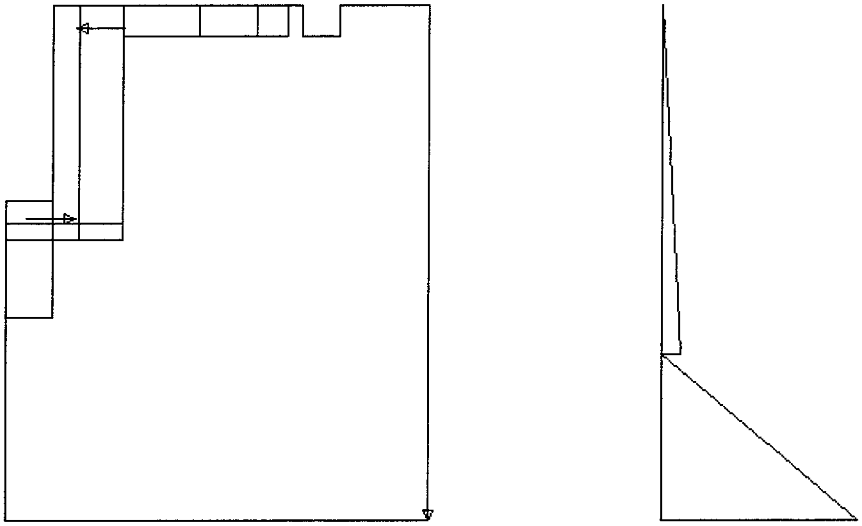


Figure 71. Front view for Load Case 3

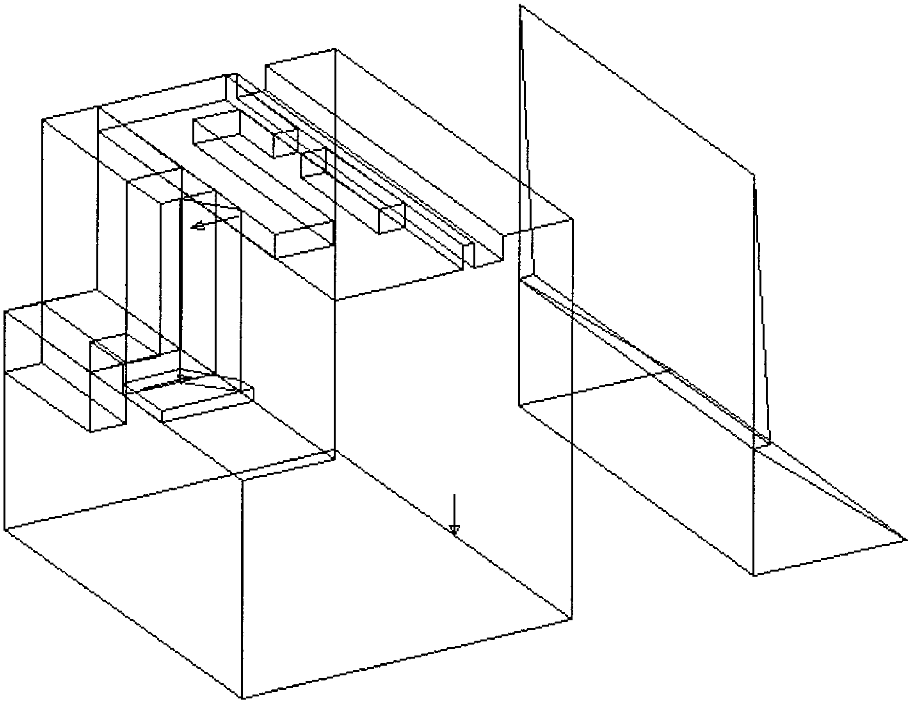


Figure 72. Isometric view for Load Case 3

Table 33. Geometry and Loads Data for Load Case 3

```
1000 POINTS 12
1100 1 0 0 0
1200 2 45 0 0
1300 3 45 0 66
1400 4 35.5 0 66
1500 5 35.5 0 62
1600 6 31.5 0 62
1700 7 31.5 0 66
1800 8 30 0 66
1900 9 30 0 62
2000 10 12.5 0 62
2100 11 12.5 0 36
2200 12 0 0 36
2300 BLOCK -Z BL1 .145 56
2400 1. 1.
2500 12 12 11 10 9 8 7 6 5 4 3 2 1
2550 XY
2600 POINTS 5
2700 13 0 19 36
2800 14 12.5 19 36
2900 15 12.5 21.96 36
3000 16 7.8125 28.25 36
3000 17 0 28.25 36
3100 BLOCK -Z BL2 .145 2
3200 1. 1.
3300 5 13 14 15 16 17
3350 XZ
3400 POINTS 6
3500 18 0 28.25 36
3600 19 12.5 28.25 36
3700 20 12.5 28.25 66
3800 21 5 28.25 66
3900 22 5 28.25 41
4000 23 0 28.25 41
4100 BLOCK -Z BL3 .145 7.75
4200 1. 1.
4300 6 23 22 21 20 19 18
4400 XY
4500 POINTS 3
4600 24 12.5 21.96 36
4700 25 12.5 28.25 36
4700 26 7.8125 28.25 36
4800 BLOCK -Z BL4 .145 30
4900 1. 1.
5000 3 24 25 26
```

(Sheet 1 of 3)

Table 33. (Continued)

```
5100 XY
5200 POINTS 8
5300 27 12.5 13.92 62
5400 28 20.43 13.92 62
5500 29 20.43 47.09 62
5600 30 26.68 47.09 62
5700 31 26.68 38.84 62
5800 32 30.0 38.84 62
5900 33 30.0 56 62
6000 34 12.5 56 62
6400 BLOCK -Z BL5 .145 4
6500 1. 1.
6600 8 27 28 29 30 31 32 33 34
6700 XZ
6800 POINTS 4
6900 35 26.68 13.92 62
7000 36 30.0 13.92 62
7100 37 30.0 13.92 66
7200 38 26.68 13.92 66
7300 BLOCK -Z BL6 .145 18.42
7400 1. 1.
7500 4 38 37 36 35
7610 PTLD GTNM 7.35 25 63 -240 0 0
7660 PTLD GBNM 7.35 25 38.6 240 0
0
8000 PTLD VSHR 45 28 0 0 0 -567.0
11400 POINTS 3
11500 39 70 0 21
11600 40 72.115 0 21
11700 41 70 0 66
11800 BLOCK -X SH1 1 56
11900 1. 1.
12000 3 41 40 39
13000 POINTS 4
14000 42 5 36 36
15000 43 12.5 36 36
16000 44 12.5 36 66
17000 45 5 36 66
18000 BLOCK -Z BL7 .145 20
19000 1. 1.
20000 4 45 44 43 42
21000 POINTS 4
22000 46 0 36 26
23000 47 5 36 26
24000 48 5 36 36
```

(Sheet 2 of 3)

Table 33. (Concluded)

```
26000 BLOCK +Z DL1 .145 20
27000 1. 1.
28000 4 49 48 47 46
29000 POINTS 3
30000 50 70 0 0
31000 51 91 0 0
32000 52 70 0 21
33000 BLOCK -X WL1 .0625 56
34000 1. 1.
35000 3 52 51 50
140000 COLOR RED GTWT
141000 COLOR RED GBNM
142000 COLOR RED GTNM
143000 COLOR RED VSHR
143001 COLOR RED DL1
144000 COLOR BLUE WL1
145000 COLOR BLUE WL2
146000 COLOR BLUE WL3
148000 COLOR BLUE WH3
149000 COLOR YELLOW SH1
149500 COLOR YELLOW SH2
151000 BACKGROUND BLACK
```

(Sheet 3 of 3)

Table 34. General Analysis Module Data for Load Case 3

```
10 POINTS 6
20 1 0 0 0
30 2 0 25 0
40 3 0 25.01 0
50 4 0 56 0
60 5 45 56 0
70 6 45 0 0
80 UPLIFT 6
90 1 0
100 2 0
110 3 0
120 4 0
130 5 1.3125
140 6 1.3125
150 PHI 23
160 SHRSTR 0
165 BASE
166 6 1 6 5 4 3 2
170 CASE LC-3 1
180 -3436.64 0 -22116.26 -631868.4
439859.8 96226.05
```

Load Case 4 - Maintenance Condition

For Load Case 3, the maintenance condition is investigated. Water is at El 531.0 ft in a dewatered lock chamber and El 578.0 ft on the landside. The backfill soil loading is the same as Load Case 1. The miter gate is assumed to be swinging free as in Load Case 3. The vertical soil shear is 496.0 kips. Figure 73 shows a front view of the geometry and loads for Load Case 4, and Figure 74 shows an isometric view. Table 35 gives the geometry and loads data, and Table 36 gives the General Analysis Module data.

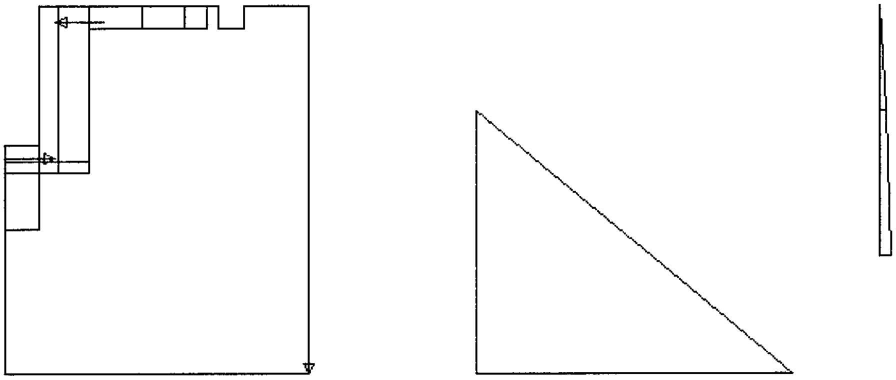


Figure 73. Front view for Load Case 4

Table 35. Geometry and Loads Data for Load Case 4

```
1000 POINTS 12
1100 1 0 0 0
1200 2 45 0 0
1300 3 45 0 66
1400 4 35.5 0 66
1500 5 35.5 0 62
1600 6 31.5 0 62
1700 7 31.5 0 66
1800 8 30 0 66
1900 9 30 0 62
2000 10 12.5 0 62
2100 11 12.5 0 36
2200 12 0 0 36
2300 BLOCK -Z BL1 .145 56
2400 1. 1.
2500 12 12 11 10 9 8 7 6 5 4 3 2 1
2550 XY
2600 POINTS 5
2700 13 0 19 36
2800 14 12.5 19 36
2900 15 12.5 21.96 36
3000 16 7.8125 28.25 36
3000 17 0 28.25 36
3100 BLOCK -Z BL2 .145 2
3200 1. 1.
3300 5 13 14 15 16 17
3350 XZ
3400 POINTS 6
3500 18 0 28.25 36
3600 19 12.5 28.25 36
3700 20 12.5 28.25 66
3800 21 5 28.25 66
3900 22 5 28.25 41
4000 23 0 28.25 41
4100 BLOCK -Z BL3 .145 7.75
4200 1. 1.
4300 6 23 22 21 20 19 18
4400 XY
4500 POINTS 3
4600 24 12.5 21.96 36
4700 25 12.5 28.25 36
4700 26 7.8125 28.25 36
4800 BLOCK -Z BL4 .145 30
4900 1. 1.
5000 3 24 25 26
```

(Sheet 1 of 3)

Table 35. (Continued)

```
5100 XY
5200 POINTS 8
5300 27 12.5 13.92 62
5400 28 20.43 13.92 62
5500 29 20.43 47.09 62
5600 30 26.68 47.09 62
5700 31 26.68 38.84 62
5800 32 30.0 38.84 62
5900 33 30.0 56 62
6000 34 12.5 56 62
6400 BLOCK -Z BL5 .145 4
6500 1. 1.
6600 8 27 28 29 30 31 32 33 34
6700 XZ
6800 POINTS 4
6900 35 26.68 13.92 62
7000 36 30.0 13.92 62
7100 37 30.0 13.92 66
7200 38 26.68 13.92 66
7300 BLOCK -Z BL6 .145 18.42
7400 1. 1.
7500 4 38 37 36 35
7610 PTLD GTNM 7.35 25 63 -240 0 0
7660 PTLD GBNM 7.35 25 38.6 240 0
0
8000 PTLD VSHR 45 28 0 0 0 -496.02
11400 POINTS 3
11500 58 70 0 0
11600 59 117 0 0
11700 60 70 0 47
11800 BLOCKS -X WH1 .0625 56
11900 1. 1.
12000 3 60 59 58
12100 XZ
12200 POINTS 3
12300 57 130 0 47
12400 58 130.893 0 47
12500 59 130 0 66
12600 BLOCK -X SH1 1 56
12700 1. 1.
12800 3 59 58 57
12900 XZ
13000 POINTS 4
13100 60 130 0 21
13200 61 131.65675 0 21
```

(Sheet 2 of 3)

Table 35. (Concluded)

```
13400 63 130 0 47
13500 BLOCK -X SH2 1 56
13600 1. 1.
13700 4 63 62 61 60
13800 POINTS 4
13900 64 5 36 36
14000 65 12.5 36 36
14100 66 12.5 36 66
14200 67 5 36 66
14300 BLOCK -Z BL7 .145 20
14400 1. 1.
14500 4 67 66 65 64
14600 POINTS 4
14700 68 0 36 26
14800 69 5 36 26
14900 70 5 36 36
15000 71 0 36 36
15100 BLOCK +Z DL1 .145 20
15200 1. 1.
15300 4 71 70 69 68
140000 COLOR RED GTWT
141000 COLOR RED GTLG
142000 COLOR RED GTNM
143000 COLOR RED VSHR
143100 COLOR RED DL1
144000 COLOR BLUE WL1
145000 COLOR BLUE WL2
146000 COLOR BLUE WL3
146400 COLOR BLUE WL4
146500 COLOR BLUE WH1
148000 COLOR BLUE WH3
149000 COLOR YELLOW SH1
149500 COLOR YELLOW SH2
151000 BACKGROUND BLACK
```

(Sheet 3 of 3)

Table 36. General Analysis Module Data for Load Case 4

```
10 POINTS 6
20 1 0 0 0
30 2 0 25 0
40 3 0 25.01 0
50 4 0 56 0
60 5 45 56 0
70 6 45 0 0
80 UPLIFT 6
90 1 0
100 2 0
110 3 0
120 4 0
130 5 2.9375
140 6 2.9375
150 PHI 23
160 SHRSTR 0
165 BASE
166 6 1 6 5 4 3 2
170 CASE LC-4 1
180 -6197.06 0 -22045.28 -
629880.90 391402.10 173517.8
```

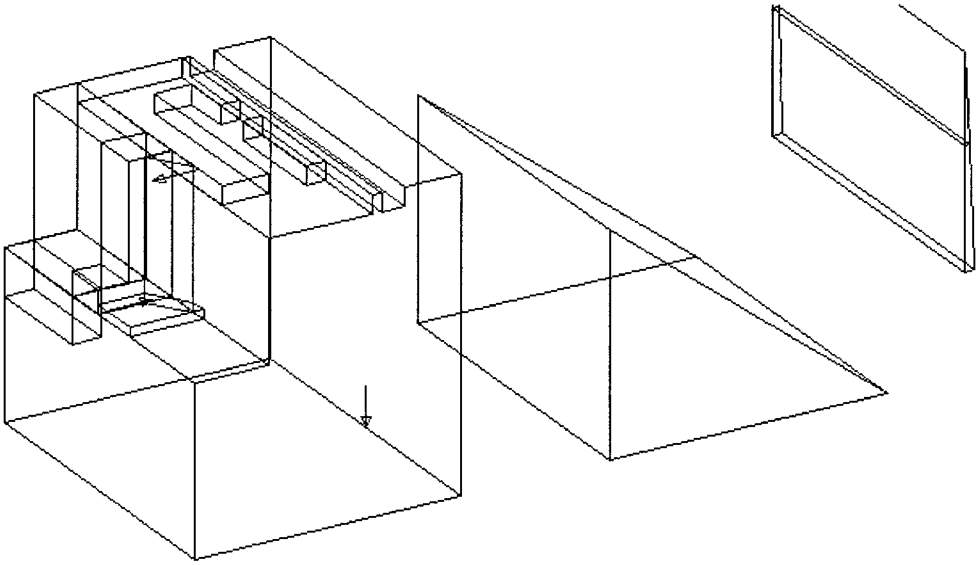


Figure 74. Isometric view for Load Case 4

Downdrag on Backs of Rock-Founded Concrete Gravity Retaining Walls

The evaluation of the stability of rock-founded gravity retaining structures using a complete soil-structure interaction analysis was investigated during the first Repair, Evaluation, Maintenance, and Rehabilitation (REMR) research program, as reported by Ebeling et al. (1992) and Ebeling, Duncan, and Clough (1990). This study found that the conventional equilibrium analysis, according to Corps guidance in use prior to publishing the results from the REMR study, did not include all forces acting on these massive retaining structures. Specifically, a shear force acting along the wall-to-backfill interface was not included in the conventional equilibrium analysis. The Ebeling et al. (1992) and Ebeling, Duncan, and Claugh (1990) REMR studies found that this shear force acts downward along the back of the wall and results from the differential settlement within the backfill region adjacent to the wall. The moment (about the toe of the wall) due to this shear force acts to counter the overturning moment due to the earth pressure force acting normal to the wall-to-backfill interface. Thus, the shear force along the back of the wall is a stabilizing force. This shear force is also referred to as "downdrag." This shear force can easily be incorporated as a surface traction force applied to the free body section of the lock using 3DSAD.

Two methods are used to calculate the magnitude of the downdrag force acting along the backs of rock-founded gravity retaining walls. The first, referred to as the simplified procedure, makes use of design charts. These design charts are limited to a "standard" set of wall proportions that are typical of several of the Corps' rock-founded lock walls. Calculations involve vertical earth pressure coefficients and correction factors for wall geometry, surcharge loadings, and sloped backfills. Chapter 3 of Ebeling, Pace, and Morrison (1997) summarizes the simplified procedure for walls backfilled with "dry" backfills or when the water pressures are hydrostatic within the backfill and the rise in water table is concurrent with the placement of soil lifts. Appendix F of Engineering Circular 1110-2-291 describes the extension of this simplified procedure for the computing downdrag for a postconstruction rise in groundwater conditions.

The second method for calculating downdrag along the backs of gravity walls is the Clough and Duncan (1969) backfill placement method of analysis. It is a finite-element-based method of analysis and, unlike the simplified method, is applicable to all wall proportions and geometries. A complete soil-structure interaction (SSI) analysis (Ebeling 1990) for computing shear loads along the backs of gravity walls can be accomplished using a finite element program such as SOILSTRUCT (Ebeling, Peters, and Clough 1992). Unlike conventional equilibrium procedures, an SSI analysis does not require the use of predetermined pressure distributions between the soil and the wall. Instead, it allows for development of these pressures through soil-structure interaction by simulating the staged construction that occurs. The computer program SOILSTRUCT can model the nonlinear stress-strain behavior of the soil and allow for relative movement between the soil and the structure by incorporating interface elements in the mesh. SSI analyses are especially useful for analyzing retaining structures founded on either soils or compressible rock foundations. Differential settlements within the foundation affect the magnitude of the shear force that the backfill exerts on the wall. These shear forces may first be computed using SOILSTRUCT and then added as a surface traction force applied to the free body section of the lock using 3DSAD. The SSI analysis procedure has been successfully used for a wide variety of problems, including the Port Allen and Old River locks (Clough and Duncan 1969) and, more recently, Locks 27 (Ebeling, Pace, and Morrison 1997) and the new McAlpine lock (Ebeling and Wahl 1997). The Locks 27 and new McAlpine lock studies report the magnitudes of vertical shear developed along the backs of the rock-founded lock walls analyzed as well as report the magnitudes of the vertical earth pressure coefficients. These vertical earth pressure coefficients can be used in the previously described simplified procedure.

Both calculation procedures described in the previous paragraphs are restricted to walls with engineered backfills that do not creep. Thus, the procedures are applicable to walls backfilled with soils classified as SW, SP, GW, and GP according to the Unified Soil Classification System (American Society for Testing and Materials 1990). They are also applicable to select SM backfills with nonplastic fines that do not creep.

References

American Society for Testing and Materials. (1990). "Standard test method for classification of soils for engineering purposes," Practice No. D2487-90, 1990 Book of ASTM Standards, 04.08, 309-319.

Clough, G. W., and Duncan, J. M. (1969). "Finite element analyses of Port Allen and Old River locks," Contract Report S-69-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Ebeling, R. M. (1990). "Review of finite element procedures for earth retaining structures," Miscellaneous Paper ITL-90-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Ebeling, R. M., Clough, G. W., Duncan, J. M., and Brandon, T. L. (1992). "Methods of evaluating the stability and safety of gravity earth retaining structures founded on rock," Technical Report REMR CS-29, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Ebeling, R. M., Duncan, J. M., and Clough, G. W. (1990). "Methods of evaluating the stability and safety of gravity earth retaining structures founded on rock - Phase 2 study," Technical Report ITL-90-7, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Ebeling, R. M., Pace, M. E., and Morrison, E. E. (1997). "Evaluating the stability of existing massive concrete gravity structures founded on rock," Technical Report REMR CS-54, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Ebeling, R. M., Peters, J. F., and Clough, G. W. (1992). "User's guide for the incremental construction soil-structure interaction program SOILSTRUCT," Technical Report ITL-97-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Ebeling, R. M., and Wahl, R. E. (1997). "Soil-structure-foundation interaction analysis of new roller-compacted concrete North Lock Wall at McAlpine locks," Technical Report ITL-97-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Headquarters, Department of the Army. (1998). "Stability analysis of concrete structures," Engineering Circular 1110-2-291, Washington, DC.

Appendix A
Graphic Screens

This appendix gives three screens each (Figures A1-A9) for an overflow cross section, pier, and nonoverflow cross section.

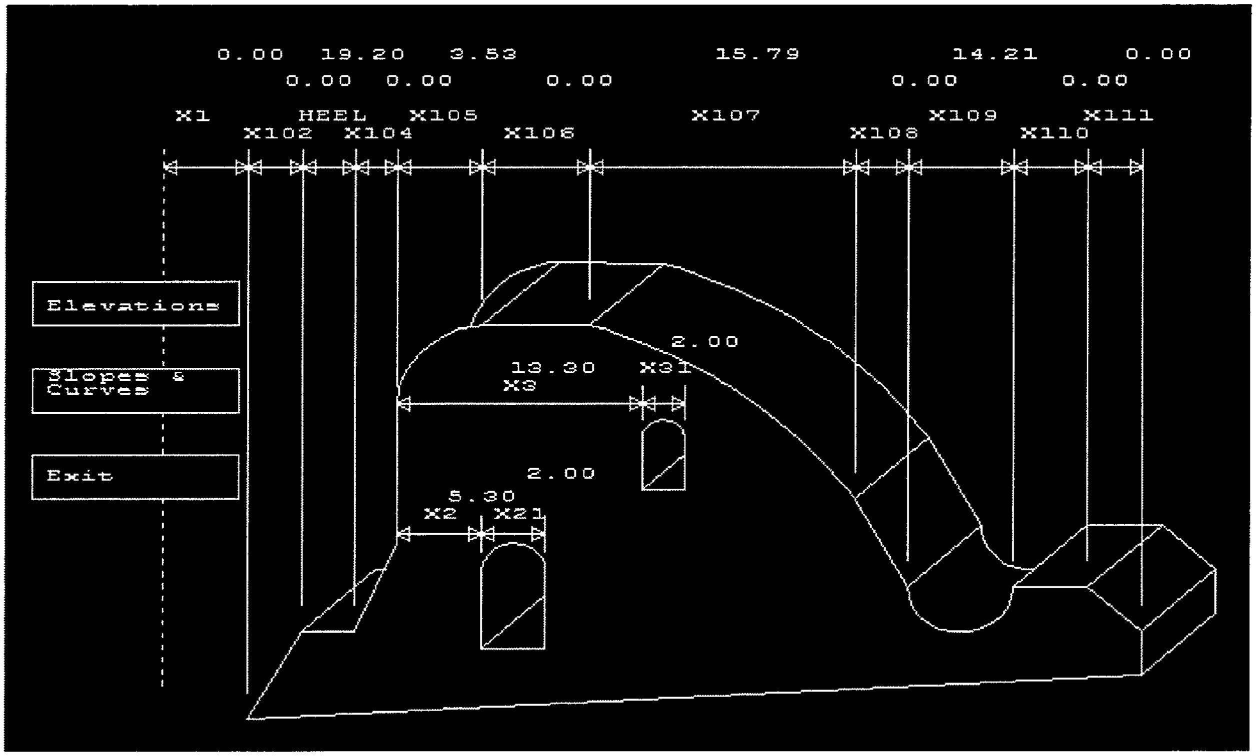


Figure A1. Overflow cross-section horizontal distances

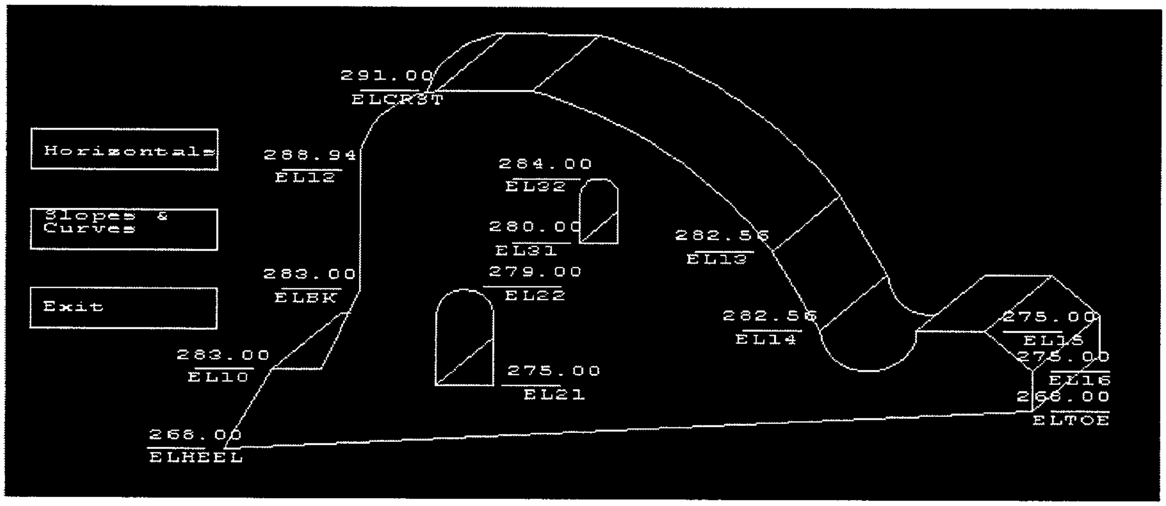


Figure A2. Overflow cross-section elevations

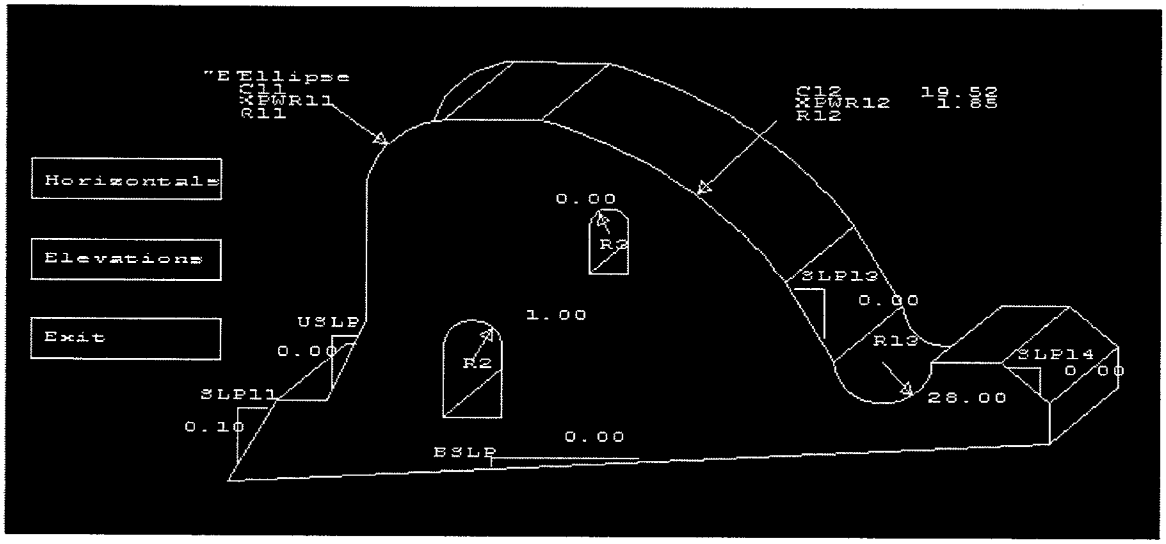


Figure A3. Overflow cross-section slopes and curves

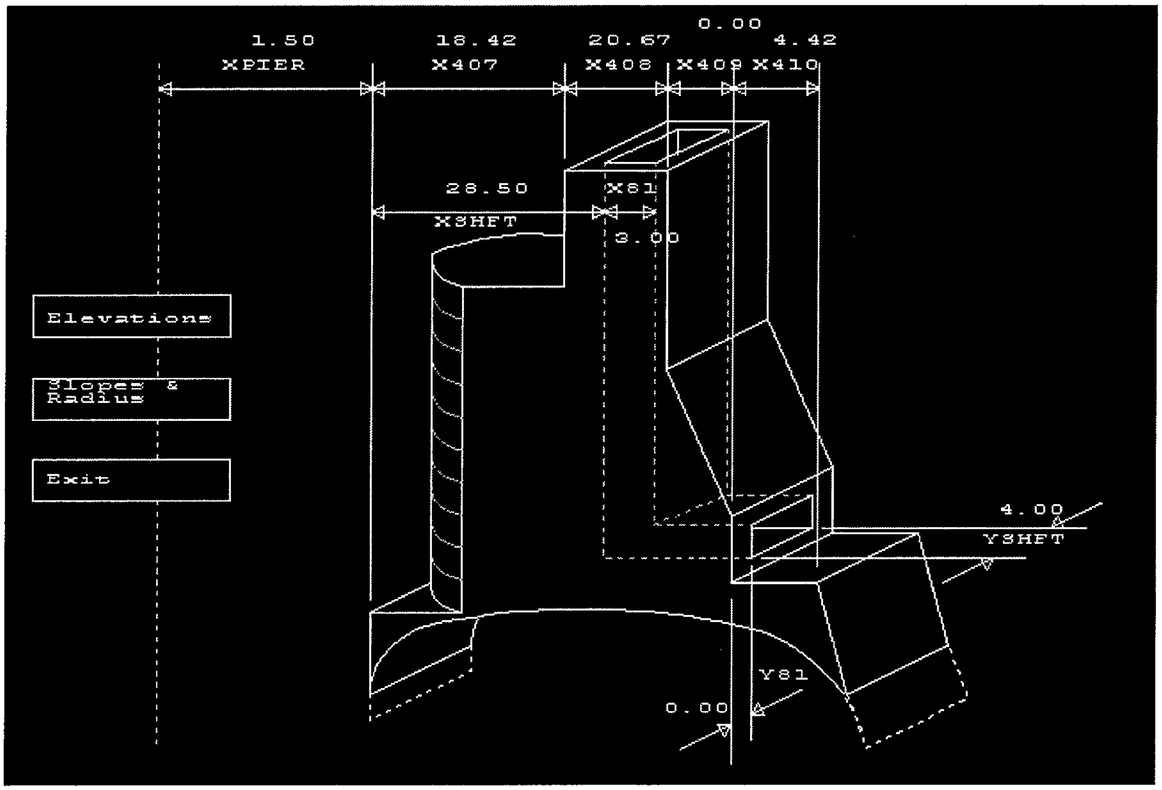


Figure A4. Pier horizontal distances

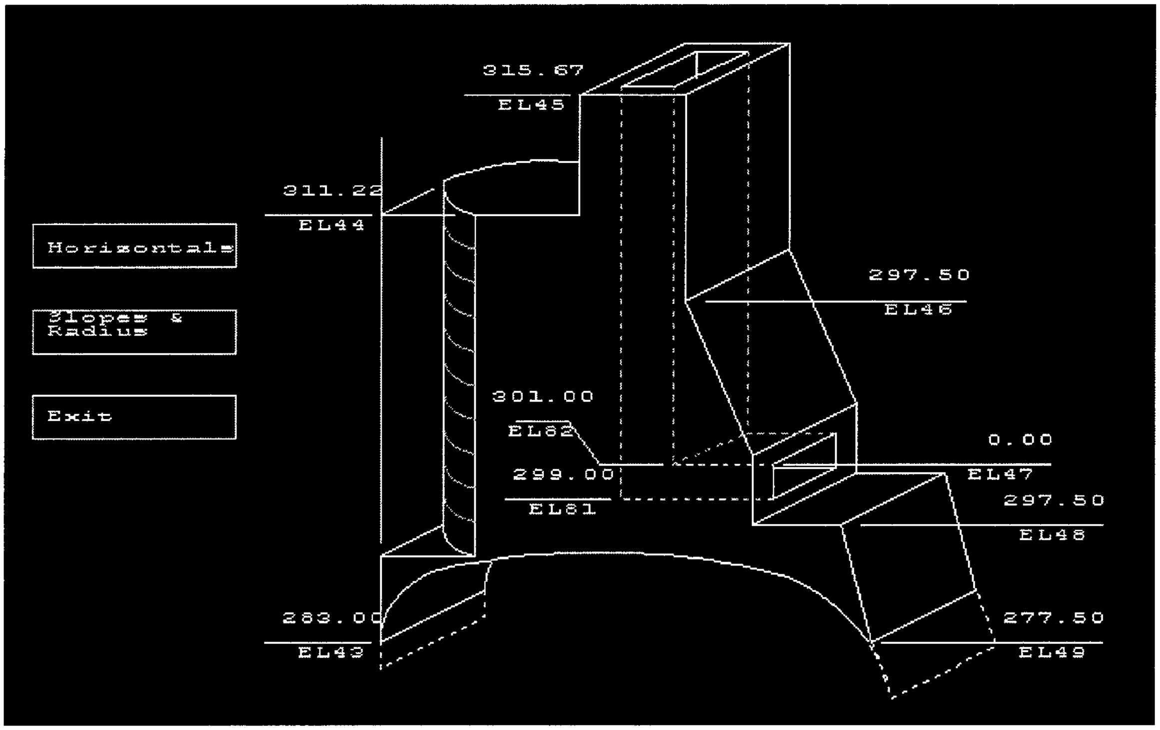


Figure A5. Pier elevations

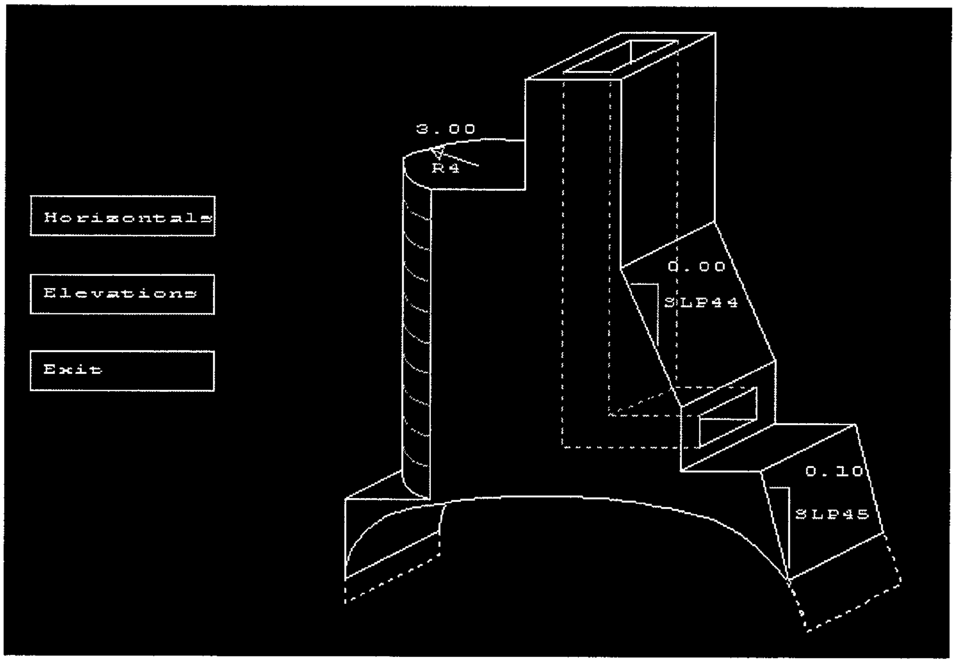


Figure A6. Pier slopes and curves

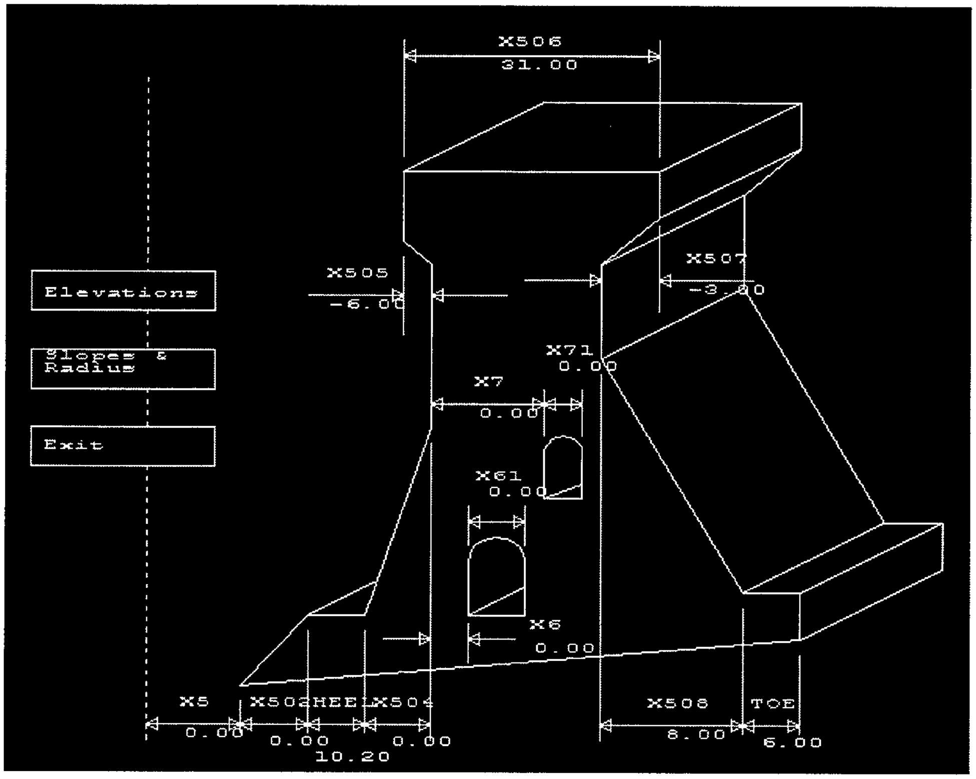


Figure A7. Nonoverflow cross-section horizontal distances

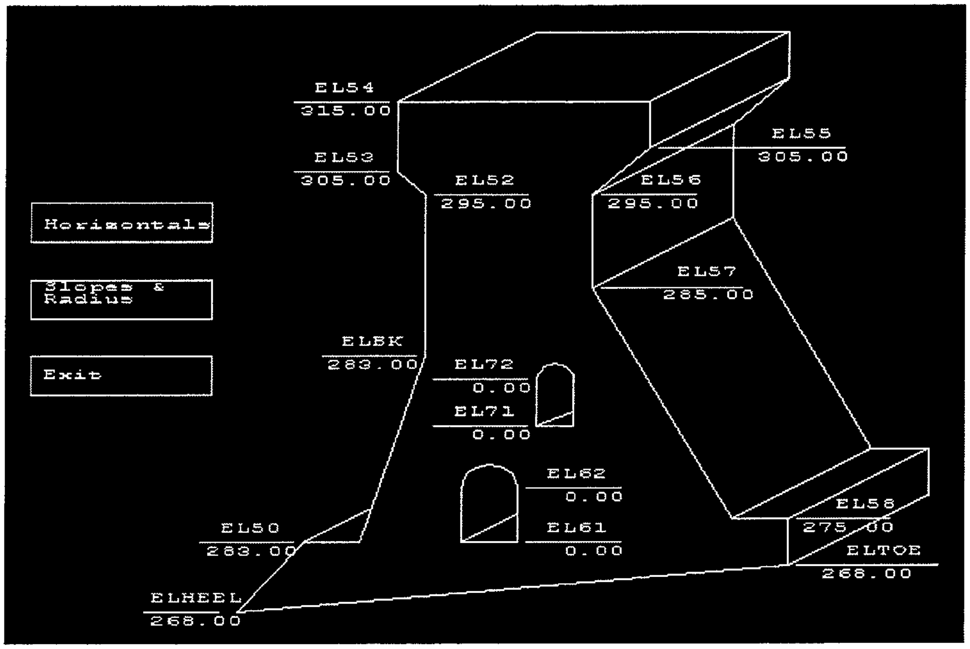


Figure A8. Nonoverflow cross-section elevations

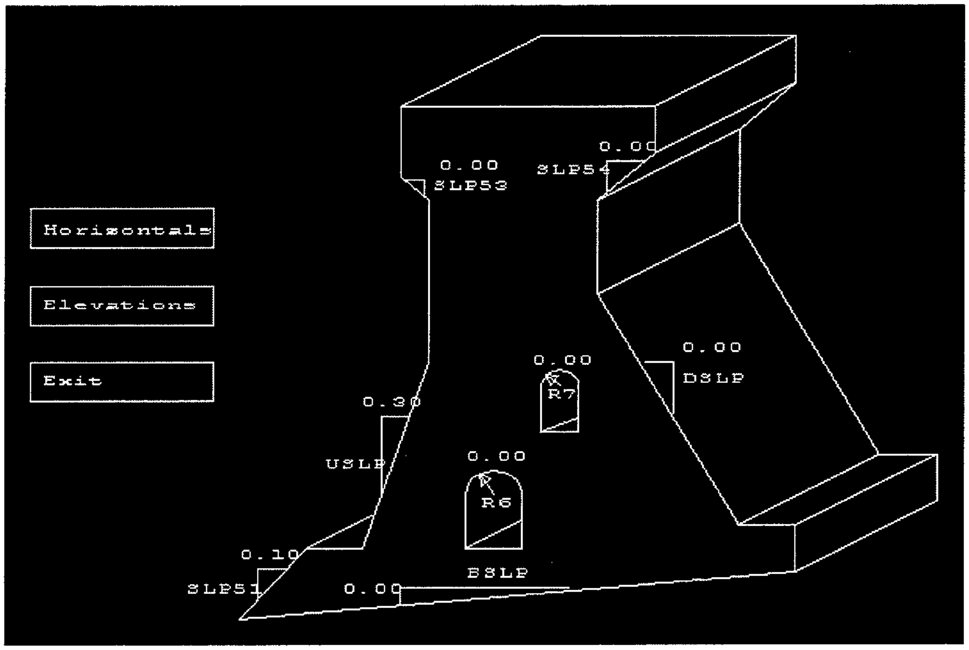


Figure A9. Nonoverflow cross-section slopes and curves

Appendix B
CDAMS Input File Structure

This appendix describes the format of an input file used by the CDAMS Module. It is provided as a reference because some earlier files omitted values at the ends of input lines and assumed those omitted values were zero. This new version of 3DSAD requires all data elements be declared. All lines in the input file are preceded by an integer value representing the input line number. All values except where noted are values of type REAL. To describe it, an input file can be broken down into sections as follows. There can be up to two overflow and/or two nonoverflow sections in the input file. Those section definitions can appear in any sequence after the "General Data" is declared. Refer to the graphical input screen for the structure geometry variables.

GENERAL DATA, 10 lines as follows:

1. String, 80 characters maximum - Project Description.
2. Three real values – Allowable Bearing, PHI, Shear Strength.
3. One real value – Upstream Surface Elevation.
4. Four real values – (Upstream Surface Soil data) Dry Unit Weight, Buoyant Weight, K, PHI.
5. One real value – Downstream Surface Elevation.
6. Four real values – (Downstream Surface Soil data) Dry Unit Weight, Buoyant Weight, K, PHI.
7. Three real values – Unit Weight of Water, Wind Pressure, Seismic Coefficient.
8. Two real values – Normal Elevation (Headwater), Normal Elevation (Tailwater).
9. Two real values – Induced Surcharge Elevation (Headwater), Induced Surcharge Elevation (Tailwater).
10. Two real values – Flood Elevation (Headwater), Flood Elevation (Tailwater).

If an OVERFLOW section is defined: 14 lines plus one for each gallery (maximum total of 16):

1. String (8 characters), two real values, one integer value – Description, Depth, Unit Weight, Number of Galleries.
2. Two real values – XDRAIN, Percentage Effective.
3. Five real values – X1, ELHEEL, X102, EL10, SLP11.
4. Four real values – HEEL, X104, ELBK, USLP.
5. Six real values, quoted space or "E" – EL12 X105, ELCRST, R11, XPWR11, C11, ELLIPS.
6. Six real values – X106, X107, EL13, R12, XPWR12, C12.
7. Three real values – X108, EL14, SLP13.
8. Three real values – X109, EL15, R13.
9. Four real values – X110, X111, EL16, SLP14.
10. Two real values – ELTOE, BLSP.
11. If one or more galleries: Five real values – X2, X21, EL21, EL22, R2.
12. If two galleries: Five real values – X3, X31, EL31, EL32, R3.
13. Four real values – Anchor Load, XANCHOR, YANCHOR, ELANCHOR.
14. Four real values – Miscellaneous Load, XMISC, YMISC, ELMISC.
15. Two real values – Ice Load, Ice Thickness.
16. String (four characters) – Gate Type (tainter, vertical, or none). If a gate will be defined as part of the overflow section, then the above string would be followed by a single real value – WT.

If a GATE TYPE is defined: 11 lines if tainter gate, 10 lines if vertical gate:

1. If Gate type = tainter, three real values, otherwise two real values – XGATE, ELTG (tainter gate only), RGATE.
2. If Gate type = tainter, two real values, otherwise line is omitted – WT, ELTR.
3. Four real values – WT, XLOG, WLOG, DLOG.
4. Three real values – WT, XMACHINE, ELMACHINE.

5. Three real values – WT, XBRIDGE, ELBRIDGE.
6. Two real values, string (6 characters maximum) – Pier Width, Unit Weight, Pier Location (NEAR, CENTER, or FAR).
7. Three real values – XPIER, EL43, R4.
8. Five real values – X407, EL44, X408, EL45, EL46.
9. Five real values – EL47, X409, SLP44, EL48, X410.
10. Two real values – EL49, SLP45.
11. Six real values – XSHFT, YSHFT, X81, EL81, EL82, Y81.

If a NONOVERFLOW Section is defined, 12 lines plus one for each gallery (maximum total of 14):

1. String (11 characters), two real values, one integer value – Description, Depth, Unit Weight, Number of Galleries.
2. Two real values – XDRAIN, Percent Effective.
3. Five real values – X5, ELHEEL, X502, EL50, SLP51.
4. Four real values – HEEL, X504, ELBK, USLP.
5. Four real values – EL52, X505, EL53, SLP53.
6. Three real values – EL54, X506, EL55.
7. Three real values – X507, EL56, SLP54.
8. Four real values – EL57, X508, EL58, DSLP.
9. Three real values – TOE, ELTOE, BSLP.
10. If one or more galleries, five real values – X6, X61, EL61, EL62, R6.
11. If two galleries, five real values – X7, X71, EL71, EL72, R7.
12. Four real values – Anchor Load, XANCHOR, YANCHOR, ELANCHOR.
13. Four real values – Miscellaneous Load, XMISC, YMISC, ELMISC.
14. Two real values – Ice Load, Ice Thickness.

Table B1 illustrates a properly formatted input file, showing general data and both section types and a pier. This file is included as the example X8100D1.DAT.

Table B1. Input File

```
1000 DAM TEST
1010 6.000 19.600 0.220
1020 283.000
1030 0.133 0.075 0.350 30.000
1040 268.000
1050 0.133 0.075 0.350 30.000
1060 0.0625 0.030 0.100
1070 300.000 270.000
1080 302.000 271.000
1090 305.200 300.500
1100 OVERFLOW 32.000 0.150 2
1110 10.000 25.000
1120 0.000 268.000 0.000 283.000 0.100
1130 19.200 0.000 283.000 0.000
1140 288.940 3.530 291.000 0.000 2.000 6.050
"  "
1150 0.000 15.790 282.560 0.000 1.850 19.520
1160 0.000 282.560 0.000
1170 14.210 275.000 28.000
1180 0.000 0.000 0.000 0.000
1190 268.000 0.000
1200 5.300 2.000 275.000 279.000 1.000
1210 13.300 2.000 280.000 284.000 0.000
1220 50.000 5.000 10.000 291.000
1230 -50.000 5.000 21.000 291.000
1240 0.000 0.000
1250 TAIN 50.000
1260 24.230 301.000 20.000
1270 5.100 291.000
1280 30.000 19.000 1.000 1.000
1290 6.000 25.000 315.670
1300 20.000 10.500 311.220
1310 6.000 0.150 CENTER
1320 1.500 283.000 3.000
1330 18.420 311.220 20.670 315.670 297.500
1340 0.000 0.000 0.000 297.500 4.420
1350 277.500 0.100
1360 28.500 4.000 3.000 299.000 301.000 0.000
```

(Continued)

Table B1. (Concluded)

```
1370 NONOVERFLOW 10.000 0.150 0
1380 10.000 25.000
1390 0.000 268.000 0.000 283.000 0.100
1400 10.200 0.000 283.000 0.300
1410 295.000 -6.000 305.000 0.000
1420 315.000 31.000 305.000
1430  -3.000 295.000 0.000
1440 285.000 8.000 275.000 0.000
1450 6.000 268.000 0.000
1460 50.000 5.000 0.000 315.000
1470 0.000 0.000 0.000 0.000
1480 0.000 0.000
```

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	Title	Date
Technical Report K-78-1	List of Computer Programs for Computer-Aided Structural Engineering	Feb 1978
Instruction Report O-79-2	User's Guide: Computer Program with Interactive Graphics for Analysis of Plane Frame Structures (CFRAME)	Mar 1979
Technical Report K-80-1	Survey of Bridge-Oriented Design Software	Jan 1980
Technical Report K-80-2	Evaluation of Computer Programs for the Design/Analysis of Highway and Railway Bridges	Jan 1980
Instruction Report K-80-1	User's Guide: Computer Program for Design/Review of Curvilinear Conduits/Culverts (CURCON)	Feb 1980
Instruction Report K-80-3	A Three-Dimensional Finite Element Data Edit Program	Mar 1980
Instruction Report K-80-4	A Three-Dimensional Stability Analysis/Design Program (3DSAD)	
	Report 1: General Geometry Module	Jun 1980
	Report 3: General Analysis Module (CGAM)	Jun 1982
	Report 4: Special-Purpose Modules for Dams (CDAMS)	Aug 1983
Instruction Report K-80-6	Basic User's Guide: Computer Program for Design and Analysis of Inverted-T Retaining Walls and Floodwalls (TWDA)	Dec 1980
Instruction Report K-80-7	User's Reference Manual: Computer Program for Design and Analysis of Inverted-T Retaining Walls and Floodwalls (TWDA)	Dec 1980
Technical Report K-80-4	Documentation of Finite Element Analyses	
	Report 1: Longview Outlet Works Conduit	Dec 1980
	Report 2: Anchored Wall Monolith, Bay Springs Lock	Dec 1980
Technical Report K-80-5	Basic Pile Group Behavior	Dec 1980
Instruction Report K-81-2	User's Guide: Computer Program for Design and Analysis of Sheet Pile Walls by Classical Methods (CSHTWAL)	
	Report 1: Computational Processes	Feb 1981
	Report 2: Interactive Graphics Options	Mar 1981
Instruction Report K-81-3	Validation Report: Computer Program for Design and Analysis of Inverted-T Retaining Walls and Floodwalls (TWDA)	Feb 1981
Instruction Report K-81-4	User's Guide: Computer Program for Design and Analysis of Cast-in-Place Tunnel Linings (NEWTUN)	Mar 1981
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Instruction Report K-81-9	User's Guide: Computer Program for Three-Dimensional Analysis of Building Systems (CTABS80)	Aug 1981
Technical Report K-81-2	Theoretical Basis for CTABS80: A Computer Program for Three-Dimensional Analysis of Building Systems	Sep 1981
Instruction Report K-82-6	User's Guide: Computer Program for Analysis of Beam-Column Structures with Nonlinear Supports (CBEAMC)	Jun 1982

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Instruction Report K-83-1	User's Guide: Computer Program with Interactive Graphics for Analysis of Plane Frame Structures (CFRAME)	Jan 1983
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Technical Report K-83-1	Basic Pile Group Behavior	Sep 1983
Technical Report K-83-3	Reference Manual: Computer Graphics Program for Generation of Engineering Geometry (SKETCH)	Sep 1983
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Contract Report ITL-89-1	State of the Art on Expert Systems Applications in Design, Construction, and Maintenance of Structures	Sep 1989
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	Report 3: Scheme C	Jun 1992
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	Report 3: Field Test and Analysis Correlation of a Vertically Framed Miter Gate at Emsworth Lock and Dam	Dec 1993
Instruction Report GL-87-1	User's Guide: UTEXAS3 Slope-Stability Package; Volume III, Example Problems	Dec 1992
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Instruction Report ITL-94-2	User's Guide: Computer-Aided Structural Modeling (CASM); Version 5.00	Apr 1994
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Instruction Report ITL-94-6	User's Guide: Computer Program for Analysis of Beam-Column Structures with Nonlinear Supports (CBEAMC)	Nov 1994
Instruction Report ITL-94-7	User's Guide to CTWALL – A Microcomputer Program for the Analysis of Retaining and Flood Walls	Dec 1994
Contract Report ITL-95-1	Comparison of Barge Impact Experimental and Finite Element Results for the Lower Miter Gate of Lock and Dam 26	Jun 1995
Technical Report ITL-95-5	Soil-Structure Interaction Parameters for Structured/Cemented Silts	Aug 1995
Instruction Report ITL-95-1	User's Guide: Computer Program for the Design and Investigation of Horizontally Framed Miter Gates Using the Load and Resistance Factor Criteria (CMITER-LRFD)	Aug 1995
Technical Report ITL-95-8	Constitutive Modeling of Concrete for Massive Concrete Structures, A Simplified Overview	Sep 1995
Instruction Report ITL-96-1	User's Guide: Computer Program for Two-Dimensional Dynamic Analysis of U-Frame or W-Frame Structures (CDWFRM)	Jun 1996
Instruction Report ITL-96-2	Computer-Aided Structural Modeling (CASM), Version 6.00 Report 1: Tutorial Guide Report 2: User's Guide Report 3: Scheme A Report 4: Scheme B Report 5: Scheme C	Jun 1996
Technical Report ITL-96-8	Hyperbolic Stress-Strain Parameters for Structured/Cemented Silts	Aug 1996
Instruction Report ITL-96-3	User's Guide: Computer Program for the Design and Investigation of Horizontally Framed Miter Gates Using the Load and Resistance Factor Criteria (CMITERW-LRFD) Windows Version	Sep 1996
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Instruction Report ITL-97-2	User's Guide: Arch Dam Stress Analysis System (ADSAS)	Aug 1997
Instruction Report ITL-98-1	User's Guide for the Three-Dimensional Stability Analysis/Design (3DSAD) Program	Sep 1998
Technical Report ITL-98-4	Investigation of At-Rest Soil Pressures due to Irregular Sloping Soil Surfaces and CSOILP User's Guide	Sep 1998

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13. ABSTRACT *(Maximum 200 words)*

This report documents the Three-Dimensional (3-D) Stability Analysis/Design (3DSAD) computer program. Both general purpose and specific modules are discussed. Currently, the four general modules are Geometry, Loads, Analysis, and Free-Body. The General Geometry Module defines geometry and performs volume, weight, and centroid computations. It also utilizes interactive computer graphics. The General Loads Module computes forces and moments for the defined loads on a general 3-D structure using pressure volumes, surface loads, and point loads. It also allows the definition of different load cases. The General Analysis Module performs overturning, bearing, and sliding computations for any planar or near-planar base. The Free-Body Module "clips" the structure and loads by an arbitrary plane to produce a "free body" so that computations can be performed on the new part. In addition to the general capabilities that are useful for any 3-D structure, 3DSAD provides for simplified geometry and loads input, along with criteria check and design modules, for dams (CDAMS). Finally, examples of locks done by practicing engineers are provided.

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