Daystar RetainWall

User Manual

LICENSE & COPYRIGHT

INTRODUCTION

Daystar RetainWall calculates a complete analysis and design of concrete and masonry cantilevered retaining walls using your choice of the UBC, BOCA, SBCCI, or ACI building codes. Soil bearing values, overturning and sliding safety factors, shear stresses, moments, required area of steel, and rebar embedment lengths are calculated.

Any number of active and passive pressures, soil slopes, vertical point loads, horizontal distributed loads, horizontal point loads, moments, and surcharges can be applied to the retaining wall. Loads are assignable to any one of seven types (dead, floor live, roof live, wind, snow, seismic, or soil). RetainWall has incorporated seven standard load cases. You can use these load cases, turn some or all of them off and/or create your own. This gives you unmatched flexibility in combining your loads.

All input and output values can be viewed and printed as graphics or text. In addition, graphics can be saved in Windows Metafile format for use in virtually any graphics program. Text values can be saved as a text file for easy export to spreadsheet or word processing programs.

Daystar RetainWall is a structural design aid and is not to be used as a substitute for experienced engineering judgment. This program should only be used by professional engineers experienced in the field of retaining wall design. The final decision as to the applicability of the information produced by this program is strictly up to the user of this program.

TABLE OF CONTENTS

GETTING STARTED

System Requirements

Daystar RetainWall is a 32-bit application designed to work with the Windows® 95/98/Me, and Windows NT/2000/XP operating systems.

Installation

Before beginning installation exit all running programs. If you use a virus protection program on your computer, override it or turn it off. The setup program may not run properly with virus protection turned on or with other programs running. After running Setup, be sure to restart your virus protection program.

To install RetainWall using the CD-ROM:

1. Insert the CD-ROM into the CD-ROM drive.
2. If the CD-ROM does not automatically start, choose Run from the Start Menu
3. Type **d:\setup** where **d:** is the CD-ROM drive letter.
4. Press ENTER.

Files

RetainWall installs the following files:

RetainWall directory
 retainwl.hlp
 retainwl.exe
 example.rwl

BASICS

Toolbar

The toolbar displayed under the menu allows quick one button access to change the footing and wall geometry, add loads, print, etc. If you are unsure what each button does, simply move the cursor over the button and wait about a half-second. A small window will appear displaying the menu item associated with the button and a longer description will appear in the status bar at the bottom of the application window.

The toolbar can be attached to the top or bottom of the application window or float free. To cause the toolbar to float free click on it anywhere except on a button and drag it to where you want it to be. To attach it to the bottom or top of the application window, click on it anywhere except a button and drag it to the side you want it to attach to. When you release the toolbar it will reattach to the window.

Wherever you decide to put the toolbar, the program will remember and place it there every time you start the program.

The toolbar contains a combo box that you can use to select the currently displayed load case. This combo box will only appear if the screen resolution of your monitor is set to 800 x 600 or higher.

Current Load Case

The load case title displayed in the toolbar combo box is the currently selected load case. All loads associated with this load case are displayed on the retaining wall diagram. You may change the current load case by selecting a new one from the toolbar combo box or from the Case menu.

Double-clicking

Anywhere that the cursor turns into a magnifying glass is a place that you can double-click to either make changes or view data. The status bar at the bottom of the application window will display a message describing what will happen if you double-click. Double clicking on most objects will bring up a dialog box that allows you to change or delete the object.

Changing and Deleting Walls and Loads

Double clicking on a wall graphic in the Structure view will present a dialog box that allows you to change or delete the wall. If this is the only wall, you can change it but not delete it. Double clicking on the load arrows or text in the Structure view will present a dialog box that allows you to change or delete the load.

Dialog Box Graphical Buttons

The load dialog boxes have graphical buttons used to indicate the direction of the input loads. These buttons act just like standard radio buttons. Tabbing into a group of buttons or clicking on a button in the group will cause the selected button to show a dotted outline indicating it is the active button. You

can use the arrow keys to move from button to button in the group and the TAB key to move out of the group. As you select a button the load diagram will change to indicate the direction of the load.

Help
You can access on-line help at anytime by pressing the F1 button.

MENUS

This chapter describes the various menu commands available to you. The bold face item is the menu command and the item in parenthesis is the keyboard short cut. Not all menu items have keyboard short cuts.

Please see the TECHNICAL DISCUSSION and DEFINITIONS sections for further information about information contained in the dialog boxes.

FILE MENU

New   (Ctrl+N)
Use this command to create a new document.

Open   (Ctrl+O)
Use this command to open an existing document in a new window. You can open multiple documents at once. Use the Window menu to switch among the multiple open documents.

The following options allow you to specify which file to open:

File Name
> Type or select the filename you want to open. This box lists files with the extension you select in the List Files of Type box.

List Files of Type
> Select the type of file you want to open:

Drives
> Select the drive in which RetainWall stores the file that you want to open.

Directories
> Select the directory in which RetainWall stores the file that you want to open.

Network...
> Choose this button to connect to a network location, assigning it a new drive letter.

Close
Use this command to close the window containing the active document. RetainWall suggests that you save changes to your document before you close it. If you close a document without saving, you lose all changes made since the last time you saved it. Before closing an untitled document, RetainWall displays the Save As dialog box and suggests that you name and save the document.

Save   (Ctrl+S)
Use this command to save the active document to its current name and directory. When you save a document for the first time, RetainWall displays the Save As dialog box so you can name your

document. If you want to change the name and directory of an existing document before you save it, choose the Save As command.

Save As

Use this command to save and name the active document. RetainWall displays the Save As dialog box so you can name your document.

To save a document with its existing name and directory, use the Save command.

The following options allow you to specify the name and location of the file you're about to save:

File Name

Type a new filename to save a document with a different name. A filename can contain up to eight characters and an extension of up to three characters. RetainWall adds the extension you specify in the Save File As Type box.

Drives

Select the drive in which you want to store the document.

Directories

Select the directory in which you want to store the document.

Network...

Choose this button to connect to a network location, assigning it a new drive letter.

Export As Metafile

Use this command to export the contents of the Structure view to a Windows Metafile. This file can be opened by any program that recognizes metafiles. RetainWall displays the Save As dialog box so you can name the metafile. Please see Save As above for your options.

Some graphics programs are better at accepting images from the clipboard than importing images from a metafile. You may need to experiment with importation verses pasting to get the results you need. In addition, Windows places restrictions on the size of metafiles. Large retaining walls and/or large scales may cause the metafile to be distorted when exported or copied to the clipboard.

Export As Text

Use this command to export the contents of the Text view to a text file. This file can be opened by any program that recognizes text files. RetainWall displays the Save As dialog box so you can name the text file. Please see Save As above for your options.

Print   (Ctrl+P)

Use this command to print a document. This command presents a Print dialog box, where you may specify the range of pages to be printed, the number of copies, the destination printer, and other printer setup options.

The following options allow you to specify how the document should be printed:

Printer

This is the active printer and printer connection. Choose the Setup option to change the printer and printer connection.

Setup

Displays a Print Setup dialog box, so you can select a printer and printer connection.

Print Range

Specify the pages you want to print:

All   Prints the entire document.

Selection   Prints the currently selected text.

Pages   Prints the range of pages you specify in the From and To boxes.

Copies

Specify the number of copies you want to print for the above page range.

Collate Copies

Prints copies in page number order, instead of separated multiple copies of each page.

Print Quality

Select the quality of the printing. Generally, lower quality printing takes less time to produce.

Print Preview

Use this command to display the active document as it would appear when printed. When you choose this command, the main window will be replaced with a print preview window in which one or two pages will be displayed in their printed format. The print preview toolbar offers you options to view either one or two pages at a time; move back and forth through the document; zoom in and out of pages; and initiate a print job.

The print preview toolbar offers you the following options:

Print

Bring up the print dialog box, to start a print job.

Next Page

Preview the next printed page.

Prev Page

Preview the previous printed page.

One Page / Two Page

Preview one or two printed pages at a time.

Zoom In

Take a closer look at the printed page.

Zoom Out

Take a larger look at the printed page.

Close

Return from print preview to the editing window.

Print Setup

Use this command to select a printer and a printer connection. This command presents a Print Setup dialog box, where you specify the printer and its connection.

The following options allow you to select the destination printer and its connection.

Printer
Select the printer you want to use. Choose the Default Printer; or choose the Specific Printer option and select one of the current installed printers shown in the box. You install printers and configure ports using the Windows Control Panel.

Orientation
Choose Portrait or Landscape.

Paper Size
Select the size of paper that the document is to be printed on.

Paper Source
Some printers offer multiple trays for different paper sources. Specify the tray here.

Options
Displays a dialog box where you can make additional choices about printing, specific to the type of printer you have selected.

Network...
Choose this button to connect to a network location, assigning it a new drive letter.

1, 2, 3, 4 command (File menu)

Use the numbers and filenames listed at the bottom of the File menu to open the last four documents you closed. Choose the number that corresponds with the document you want to open.

Exit   (Alt+F4)

Use this command to end your RetainWall session. You can also use the Close command on the application Control menu. RetainWall prompts you to save documents with unsaved changes.

EDIT MENU

Undo   (Ctrl+Z)

Use this command to reverse the last editing action. The Undo command is grayed out on the menu if you cannot reverse your last action.

Copy   (Ctrl+C)

Use this command to copy whatever is displayed in the view onto the clipboard. In the Structure view the data is copied as a graphic. In the Text view the data is copied as text.

Copying data to the clipboard replaces the contents previously stored there.

Some graphics programs are better at accepting images from the clipboard than importing images from a metafile. You may need to experiment with importation verses pasting to get the results you need. In addition, Windows places restrictions on the size of metafiles. Large retaining walls and/or large scales may cause the metafile to be distorted when exported or copied to the clipboard.

Heading
Use this command to add a descriptive heading to the document. You are allowed up to four lines for the heading.

Title Block
Use this command to add a title block to the document. Anything entered in this dialog will be saved in the retainwl.ini file and will be used in all documents. You are allowed up to four lines for the title block.

WALL MENU

Add Wall   (Ctrl+W)
Use this command to add a wall. This command presents an Add Wall dialog box where you may specify the material type, height, thickness, etc.

The following options allow you to specify the wall geometry:

Material
> Use this to specify whether the wall is concrete or masonry.

Height
> This is the height of this wall.

Wall Location
> This indicates the placement of the wall in relation to the wall below. If this is the bottom wall then this option is ignored.

Thickness
> This is the wall thickness. If this is a masonry wall then this is a nominal thickness otherwise this is the actual thickness.

Rebar CL
> This is the distance from the heel side face of the wall to the centerline of the rebar.

Other
> If the wall material is masonry and you want to enter a specific rebar centerline distance, click the Other radio button and enter the rebar centerline distance in the Other edit box.

Rebar Size
> This is the size of the wall rebar. If you choose Calc in the rebar size list box, RetainWall will calculate the required size based on the input rebar spacing, input loads and building code.

Rebar Space

This is the spacing of the wall rebar. If the wall is concrete, you must check the Rebar Space check box before you can enter a rebar spacing.

Block Wt

This is the weight of the masonry block. Please see the tables in the TECHNICAL DISCUSSION for the block weight.

Grout Solid

Check this option to if you want the calculations to reflect that all cells are filled with grout.

Change Footing   (Ctrl+F)

Use this command to change the footing and key of the retaining wall. This command presents a Footing Dimensions dialog box where you may specify the thickness, toe width, etc.

The following options allow you to specify the footing geometry:

Thickness

This is the footing thickness.

Toe Width

This is the toe width from the outside of the toe to the toe side face of the bottom wall.

Heel Width

This is the heel width from the outside of the heel to the heel side face of the bottom wall.

Toe Rebar CL

This is the distance from the bottom of the footing to the centerline of the toe rebar.

Heel Rebar CL

This is the distance from the top of the footing to the centerline of the heel rebar.

Toe Rebar Size

This is the size of the toe rebar. If you choose Calc in the rebar size list box, RetainWall will calculate the required size based on the input rebar spacing, input loads and building code.

Toe Rebar Space

This is the spacing of the toe rebar. You must check the Toe Rebar Space check box before you can enter a rebar spacing.

Heel Rebar Size

This is the size of the heel rebar. If you choose Calc in the rebar size list box, RetainWall will calculate the required size based on the input rebar spacing, input loads and building code.

Heel Rebar Space

This is the spacing of the heel rebar. You must check the Heel Rebar Space check box before you can enter a rebar spacing.

Use Key

Check this box to include a key in the design.

Key Depth

This is the depth of the key measured from the bottom of the footing to the bottom of the key.

Key Width

This is the width of the key.

Key Loc

This is the location of the key measured from the left side of the toe to the left side of the key.

Physical Properties

Use this command to make changes to the physical properties of the retaining wall. This command presents a Physical Properties dialog box where you may specify f'c, fy and other options.

The following options allow you to specify the retaining wall physical properties:

f'c

This is the compressive strength of the concrete.

fy

This is the yield strength of the reinforcing steel.

f'm

This is the compressive strength of the masonry.

fs

This is the allowable tensile stress of the reinforcing steel.

Allow. Soil Bearing

This is the maximum allowable service bearing pressure on the soil .

Soil/Footing Friction

This is the coefficient of friction between the soil and the bottom of the footing.

Concrete Unit Weight

This is the density of the concrete.

% Min Concrete Steel

This is the minimum percentage of reinforcing steel to be used in the concrete design.

Special Inspection

Check this option to indicate that the masonry walls will have special inspection during construction. This item will only be enabled if the building code is UBC '91 or UBC '94.

LOADS MENU

Add Pa   *(Ctrl+A)*

Use this command to add active soil pressures to the retaining wall. This command presents an Add Pa dialog box where you may specify the active pressure, soil unit weight, and depth.

The following options allow you to specify the active pressure information:

Pa
> This is the magnitude of the active pressure.

Unit Wt
> This is the density of the soil.

Depth
> This is the depth of the active pressure.

This newly added load may not appear in the Structure view if the soil load type is not included in the Current Load Case. To see the load, change the Current Load Case to one that includes soil.

Change Soil Slope
Use this command to add a sloped active pressure load to the retaining wall. This command presents a Soil Slope dialog box where you may specify the active pressure, soil unit weight, and slope.

The following options allow you to specify the soil slope information:

Pa
> This is the magnitude of the active pressure.

Unit Wt
> This is the density of the soil.

Slope
> This is the slope of the active pressure.

This newly added load may not appear in the Structure view if the soil load type is not included in the Current Load Case. To see the load, change the Current Load Case to one that includes soil.

Add Vert. Point Load (Ctrl+L)
Use this command to add vertical point loads to the top of the retaining wall. This command presents an Add Vertical Point Load dialog box where you may specify load magnitude, direction, and type.

The following options allow you to specify the vertical point load information:

Point Load
> This is the magnitude of the vertical point load.

Direction
> This is the direction of the vertical point load.

Load Type
> This is the type of load that this vertical point load represents.

Loads are represented in the Structure view by an arrow and text displaying the load type and magnitude. This newly added load may not appear in the Structure view if the Load Type selected is

not included in the Current Load Case. To see the load, change the Current Load Case to one that includes this Load Type.

Add Moment Load   (Ctrl+M)

Use this command to add moment loads to the retaining wall. This command presents an Add Moment Load dialog box where you may specify load magnitude, direction, and type.

The following options allow you to specify the moment load information:

Moment
  This is the magnitude of the moment load.

Direction
  This is the direction of the moment load.

Load Type
  This is the type of load that this moment load represents.

Loads are represented in the Structure view by an arrow and text displaying the load type and magnitude. This newly added load may not appear in the Structure view if the Load Type selected is not included in the Current Load Case. To see the load, change the Current Load Case to one that includes this Load Type.

Add Horiz. Distributed Load (Ctrl+D)

Use this command to add horizontal distributed loads to the retaining wall. This command presents an Add Horizontal Distributed Load dialog box, where you may specify load magnitude, location, and other options.

The following options allow you to specify the horizontal distributed load information:

Top Load
  This is the magnitude of the upper horizontal distributed load.

Bottom Load
  This is the magnitude of the lower horizontal distributed load.

Top Location
  This is the vertical distance from the top of the footing to the application point of the upper horizontal distributed load.

Bottom Location
  This is the vertical distance from the top of the footing to the application point of the lower horizontal distributed load.

Direction
  This is the direction of the horizontal distributed load.

Load Type
  This is the type of load that this horizontal distributed load represents.

Loads are represented in the Structure view by arrows and text displaying the load type and magnitude. This newly added load may not appear in the Structure view if the Load Type selected is not included in the Current Load Case. To see the load, change the Current Load Case to one that includes this Load Type.

Add Horiz. Point Load   (Ctrl+H)

Use this command to add horizontal point loads to the top of the retaining wall. This command presents an Add Horizontal Point Load dialog box where you may specify load magnitude, direction, and type.

The following options allow you to specify the horizontal point load information:

Point Load

This is the magnitude of the horizontal point load.

Direction

This is the direction of the horizontal point load.

Load Type

This is the type of load that this horizontal point load represents.

Loads are represented in the Structure view by an arrow and text displaying the load type and magnitude. This newly added load may not appear in the Structure view if the Load Type selected is not included in the Current Load Case. To see the load, change the Current Load Case to one that includes this Load Type.

Add Surcharge Load (Ctrl+G)

Use this command to add surcharge loads on the toe and heel of the footing. This command presents an Add Surcharge Load dialog box where you may specify load magnitude, location, and type.

The following options allow you to specify the surcharge load information:

Surcharge

This is the magnitude of the surcharge load.

Location

This is the location of the surcharge load. Either over the heel or toe.

Load Type

This is the type of load that this surcharge load represents.

Loads are represented in the Structure view by an arrow and text displaying the load type and magnitude. This newly added load may not appear in the Structure view if the Load Type selected is not included in the Current Load Case. To see the load, change the Current Load Case to one that includes this Load Type.

Add Pp   *(Ctrl+R)*

Use this command to add passive soil pressures to the retaining wall. This command presents an Add Pp dialog box where you may specify the passive pressure, soil unit weight, and depth.

The following options allow you to specify the passive pressure information:

Pp
> This is the magnitude of the passive pressure.

Unit Wt
> This is the density of the soil.

Depth
> This is the depth of the passive pressure.

This newly added load may not appear in the Structure view if the soil load type is not included in the Current Load Case. To see the load, change the Current Load Case to one that includes soil.

CASE MENU

Calculate Now   *(F9)*

Use this command to immediately analyze and design the retaining wall. You can calculate at any time.

Building Code   *(Ctrl+B)*

Use this command to select the appropriate building code for this retaining wall design. This command presents a Building Code dialog box, where you may specify the building code.

Select Standard Load Cases

Use this command to selectively turn on and off the standard service and factored load cases built into RetainWall. This command presents a Select Standard Load Cases dialog box, where you may check which load cases you want to include in this retaining wall design.

These standard load cases are not necessarily applicable to all the building codes available in RetainWall. They are included as a convenience to aid you in your design.

Add Load Case

Use this command to create service or factored load cases that you want to use in your design. This command presents an Add Load Case dialog box where you may enter the load case name and load multipliers.

The following options allow you to specify the load case information:

Load Case Name
> This is the name that will be used for the load case.

Dead, Floor Live, Roof Live, Snow, Wind, Seismic, Soil

    These are the load types that are to be included in the load case. Enter the multiplier for each in the edit box to the left. Any multipliers that are left blank are considered zero.

After entering the load case name and multipliers, click the Add button to add the load case to the design. After clicking the Add button the load case name will be blanked and the multipliers will be zeroed so that you can add another load case. When you are finished adding load cases, click the Close button to close the dialog box.

The Cancel button will blank the load case name and zero the multipliers and may be used to clear entries you have made in the name and multiplier edit boxes but do not want to keep. This button will not affect any load cases that have already been added by clicking the Add button.

Change Load Case

Use this command to change service or factored load cases that you previously entered using the Add Load Case command. This command presents a Change Load Case dialog box, where you may select an existing load case from the Load Case list box and change the load case name and load type multipliers. Please see the Add Load Case command for a description of the load case name and multipliers options.

After selecting a load case from the Load Case list box, the load case name and multiplier edit boxes will be filled in with the information from the selected load case. After changing the load case information, click the Change button to change the load case. You may then continue selecting load cases and making changes. When you are finished changing load cases, click the Close button to close the dialog box.

The Cancel button will blank the load case name and zero the multipliers and may be used to clear entries you have made in the name and multiplier edit boxes but do not want to keep. This button will not affect any load cases that have already been added by clicking the Change button.

Delete Load Case

Use this command to delete service or factored load cases that you previously entered using the Add Load Case command. This command presents a Delete Load Case dialog box, where you may select an existing load case from the Load Case list box and delete it.

After selecting a load case from the Load Case list box, click the Delete button to delete the load case. You may continue selecting load cases and deleting. When you are finished deleting load cases, click the Close button to close the dialog box.

Current Load Cases

Use the load case names listed at the bottom of the Case menu to select the load case that you want to make current. This can also be accomplished by selecting a load case in the toolbar combo box.

VIEW MENU

Display Text/Display Structure
Use this command to change the document view from the Structure view to the Text view and back. The command title will change each time you select it.

Toolbar
Use this command to display and hide the Toolbar, which includes buttons for some of the most common commands in RetainWall, such as File Open. A check mark appears next to the menu item when the Toolbar is displayed.

Status Bar
Use this command to display and hide the Status Bar, which describes the action to be executed by the selected menu item or depressed toolbar button, and keyboard latch state. A check mark appears next to the menu item when the Status Bar is displayed.

Options
Use this command to select the units, numeric format, scale, and display parameters of the document. This command presents a tabbed Options dialog box, where you may set all display parameters for the document.

WINDOW MENU

Cascade
Use this command to arrange multiple opened windows in an overlapped fashion.

Tile
Use this command to arrange multiple opened windows in a non-overlapped fashion.

Arrange Icons
Use this command to arrange the icons for minimized windows at the bottom of the main window. If there is an open document window at the bottom of the main window, then some or all of the icons may not be visible because they will be underneath this document window.

#1, 2, ... command (Window menu)
RetainWall displays a list of currently open document windows at the bottom of the Window menu. A check mark appears in front of the document name of the active window. Choose a document from this list to make its window active.

HELP MENU

Index

Use this command to display the opening screen of Help. From the opening screen, you can jump to step-by-step instructions for using RetainWall and various types of reference information.

Once you open Help, you can click the Contents button whenever you want to return to the opening screen.

Using Help

Use this command for instructions about using Help.

About Daystar RetainWall

Use this command to display the copyright notice and version number of your copy of RetainWall.

EXAMPLE

This example will show you some of the features of RetainWall and how to use them. The design criteria are as follows:

Building Code = UBC' 94

f'c = 3,000 psi
fy = 60,000 psi
f'm = 1,500 psi
fs = 24,000 psi
Allow Soil Bearing = 3000 psf
Soil/Footing Friction = 0.4
% Min Concrete Steel = 0.0018
Concrete Weight = 145 pcf
No Special Inspection

Bottom Wall
    Material = Concrete
    Height = 5'-0"
    Thickness = 12"
    Rebar CL = 3.5"
    No Rebar Size or Rebar Space is entered

Top Wall
    Material = Masonry
    Height = 4'-0"
    Wall Location = Left
    Thickness = 8"
    Rebar CL = Center
    Rebar Size = US#6
    Rebar Space = 48"
    Block Wt = Normal
    Do not grout solid
    Align the outside face of this wall with the bottom wall.

Toe Width = 3'-0"
Heel Width = 3'-0"
Footing Thickness = 12"
Toe Rebar CL = 3"
Heel Rebar CL = 3"
Toe Rebar Size = US#6
Heel Rebar Size = US#6

Toe Rebar Space = 12"
Heel Rebar Space = 12"

Key Depth = 1'-0"
Key Width = 12"
Key Loc = 2'-0"

Active Pressures

Pa (psf/ft)	Unit Wt (pcf)	Depth (ft)
30	120	4.0000
20	100	4.0000

Soil Slope

Pa=20 psf/ft
Unit Wt=100 pcf
Slope=10 deg

Vertical Point Loads

Load (lb/ft)	Type
500	Dead

Moment Loads

Load (lb-ft/ft)	Type
125	Dead

Horizontal Distributed Loads

Top Load (psf)	Bot Load (psf)	Top Loc (ft)	Bot Loc (ft)	Type
25	25	9.0000	0.0000	Seismic

Surcharge Loads

Load (psf)	Location	Type
100	Heel	Dead
100	Toe	Dead
200	Toe	Floor Live

Passive Pressures

Pp	Unit Wt	Depth
(psf/ft)	(pcf)	(ft)
250	120	2.0000
100	100	2.0000

Start up RetainWall and select the Physical Properties menu item under the Wall menu. When the Physical Properties dialog box appears, enter 3000 in the Allow. Soil Bearing edit box and click the OK button.

Double-click the wall diagram. When the Change Wall dialog box appears, enter 5 in the Height edit box, 12 in the Thickness edit box, and 3.5 in the Rebar CL edit box. Now click the OK button.

Click the Add Wall toolbar button or select the Add Wall menu item under the Wall menu. When the Add Wall dialog box appears, select Masonry under the Material type and enter 4 in the Height edit box. Select the left button under the Wall Location and select 8 in the Thickness combo box. Select Center under the Rebar CL, US# 6 in the Rebar Size combo box, and 48 in the Rebar Space combo box. Now click the OK button.

Double-click the footing diagram or select the Change Footing menu item under the Wall menu. When the Footing Dimensions dialog box appears, enter 12 in the Thickness edit box, 3 in the Toe and Heel Width edit boxes, 3 in the Toe and Heel Rebar CL edit boxes, US# 6 in the Toe and Heel Rebar Size combo boxes, and 12 in the Toe and Heel Rebar Space edit boxes. Enter 2 in the Key Loc edit box and click the OK button.

Click the Add Pa toolbar button or select the Add Pa menu item under the Loads menu. When the Add Pa dialog box appears, enter 30 in the Pa edit box, 120 in the Unit Wt edit box, and 4 in the Depth edit box. Now click the OK button.

Click the Add Pa toolbar button again and when the Add Pa dialog box appears, enter 20 in the Pa edit box, 100 in the Unit Wt edit box, and 4 in the Depth edit box. Now click the OK button.

Click the Change Soil Slope toolbar button or select the Change Soil Slope menu item under the Loads menu. When the Soil Slope dialog box appears, enter 20 in the Pa edit box, 100 in the Unit Wt edit box, and 10 in the Slope edit box. Now click the OK button.

Click the Add Vert. Point Load toolbar button or select the Add Vert. Point Load menu item under the Loads menu. When the Add Vertical Point Load dialog box appears, enter 500 in the Point Load edit box. Now click the OK button.

Click the Add Moment Load toolbar button or select the Add Moment Load menu item under the Loads menu. When the Add Moment Load dialog box appears, enter 125 in the Moment edit box and click the OK button.

Click the Add Horiz. Distributed Load toolbar button or select the Add Horiz. Distributed Load menu item under the Loads menu. When the Add Horizontal Distributed Load dialog box appears, enter 25 in the Top Load and Bottom Load edit boxes, 9 in the Top Location edit box, and 0 in the Bottom Location edit box. Click the Seismic radio button for the Load Type and then click the OK button.

Click the Add Surcharge Load toolbar button or select the Add Surcharge Load menu item under the Loads menu. When the Add Surcharge Load dialog box appears, enter 100 in the Surcharge edit box and click the OK button.

Click the Add Surcharge toolbar button again and when the Add Surcharge dialog box appears, enter 100 in the Surcharge edit box and click the Toe button under Location. Now click the OK button.

Click the Add Surcharge toolbar button one more time and when the Add Surcharge dialog box appears, enter 200 in the Surcharge edit box, click the Toe button under Location, and click Floor Live under Load Type. Now click the OK button.

Click the Add Pp toolbar button or select the Add Pp menu item under the Loads menu. When the Add Pp dialog box appears, enter 250 in the Pp edit box, 120 in the Unit Wt edit box, and 2 in the Depth edit box. Now click the OK button.

Click the Add Pp toolbar button again and when the Add Pp dialog box appears, enter 100 in the Pp edit box, 100 in the Unit Wt edit box, and 2 in the Depth edit box. Now click the OK button.

Select the Calculate Now menu item under the Case menu to analyze and design the retaining wall. Note that the input rebar size for the toe and heel makes for a very conservative design. To change this we will allow RetainWall to calculate the size of the rebar. Double-click the footing diagram and when the Footing Dimensions dialog box appears enter select Calc in the Toe Rebar Size and Heel Rebar Size combo boxes. Click the OK button and then select Calculate Now again. Note that RetainWall chose smaller rebar sizes for a more efficient design.

This example is in the directory where you installed RetainWall and also accessible from the Daystar program group. Open it and experiment with the wide variety of tools at your disposal.

TECHNICAL DISCUSSION

General

The sign conventions for the external loads are as follows:

Vert. Point Load	down is positive.
Moment Load	counter-clockwise is positive.
Horiz. Distributed Load	to the left is positive
Horiz. Point Load	to the left is positive.

All rebar sizes are based on ASTM standard bar size designations (i.e. #3 is a 0.375" diameter bar).

RetainWall takes stress reversals into account when calculating stresses. Therefore, when tensile stresses move from one side of the wall to the other, a new d is calculated based on the distance from the rebar centerline to the tension face of the wall. Depending on the location of the rebar, this new d may control the design because this distance may be much smaller than the input value.

Surcharge loads are divided by the density of the soil immediately below them giving an equivalent soil height. If the surcharge is on the heel side of the wall, this height is multiplied by the active pressure of the soil and the active pressure on the wall is modified accordingly. If the surcharge is on the toe side of the wall, this height is multiplied by the passive pressure of the soil and the passive pressure on the wall is modified accordingly.

Active pressure due to sloping backfill is calculated as follows:

depth = tan(slope) x distance from the wall to the back of the heel
Lateral Load = input active pressure x depth^2/2

If the heel width is zero, the lateral load due to the sloping backfill will be zero. This lateral load is applied at the top of the last input active pressure.

The lateral load due to the active pressure is calculated as:

Pa(depth)^2/2

If there is more than one active pressure load, a soil slope, or surcharge load, the active pressure is calculated as follows:

b1 = Σ Pa(depth)
b = b1 + (current active pressure)depth
lateral load for current active pressure = depth(b+b1)/2

Surcharge and soil slope pressures are converted to active pressure as described above and included in the b1 calculation.

The lateral load due to the passive pressure is calculated as:

$$Pp(depth)^2/2$$

If there is more than one passive pressure load or surcharge load, the passive pressure is calculated as follows:

b1 = Σ Pp(depth)
b = b1 + (current passive pressure)depth
lateral load for current passive pressure = depth(b+b1)/2

Surcharge loads are converted to passive pressure as described above and included in the b1 calculation.

Overturning Safety Factor is calculated as follow:
1) Overturning moments are calculated by taking all loads for a particular load case that cause counterclockwise rotation about the toe and summing them.
2) Resisting moments are calculated by taking all loads for a particular load case that cause clockwise rotation about the toe and summing them.
3) Overturning Safety Factor = Resisting Moment/Overturning Moment.

Sliding Safety Factor is calculated as follows:
1) Sliding forces are calculated by summing all horizontal loads for a particular load case that cause the retaining wall to move to the left and summing them.
2) Resistance to sliding forces are calculated by summing all horizontal loads for a particular load case that cause the retaining wall to move to the right and summing them.
3) Vertical forces are calculated by summing all vertical loads for a particular load case.
4) Sliding Safety Factor =
    ((Vertical forces)(Friction Factor) + Resisting Forces)/Sliding Forces.

Service soil bearing values are calculated as follows:
1) Eccentricity = (Total footing length)/2 -
        (Resisting Moment - Overturning Moment)/(Vertical Load)
2) If Eccentricity ≤ (Footing Length)/6
        Bearing = (Vertical load)(1 ± 6(Eccentricity)/(Footing Length))/(Footing Length)
    If Eccentricity > (Footing Width)/6
        Bearing = 2(Vertical load)/(3((Footing Length)/2 - Eccentricity))

Minimum Overturning Safety Factor = 1.5
Minimum Sliding Safety Factor = 1.5

The embedment length given for each wall section is the length of rebar embedment into the wall section immediately below it. If the wall section is the bottom wall then this is the length of embedment into the footing. RetainWall assumes that the reinforcement is not epoxy coated and that the concrete is normal weight aggregate. Please see the building code sections for the embedment equations.

Masonry
All designs are based on concrete masonry.

The analysis and design are based on working stress design.

All tensile stresses are taken by the reinforcing steel.

RetainWall does not check minimum reinforcement requirements.

The h/t calculations are based on the height of the each individual wall section not the total retaining wall height.

RetainWall uses the following equations from the referenced code books to perform the design.

IBC 2000
wall h' = 2(wall ht)

If the h'/t ratio of the wall section exceeds 30, this condition is indicated in both the Structure and Text views. Although calculations are completed based on this h'/t, the codebook should be consulted for possible slender wall design requirements.

$Fa = 0.25f'm[1 - (h'/140r)^2]$ for $h'/r \leq 99$
$Fa = 0.25f'm(70r/h')^2$ for $h'/r > 99$
$Fb = f'm/3$ 2,000 psi max.
$Fs = $ input fs   24,000 psi max.
$Fv = 1.0(fm)^{(1/2)}$ 50 psi max.

All of the above except Fs are reduced by 1/2 if there is no special inspection.

All of the above are increased by 4/3 if the load case includes a wind or seismic load.

$fa = $ Axial/Effective Area
$fv = $ Shear/Effective Area

$fb = M(2/jk)/(bd^2)$
$fs = M/(Asjd)$

b = 12"

$p = As/(bd)$

$n = Es/Em$

$k = [(np)^2 + 2np]^{(1/2)} - np$

$j = 1 - k/3$

$Em = 750f'm$ 3,000,000 psi max.

$Es = 29,000,000$ psi

The design is controlled by one of the following:

$fa/Fa + fb/Fb$

fv/Fv

fs/Fs

Embedment Length = 0.002(rebar dia)Fs   Minimum 12"

UBC '91

wall h' = 2(wall ht)

If the h'/t ratio of the wall section exceeds 30, this condition is indicated in both the Structure and Text views. Although calculations are completed based on this h'/t, the code book should be consulted for possible slender wall design requirements.

$Fa = 0.20f'm[1-(h'/42t)^3]$

$Fb = f'm/3$ 2,000 psi max.

$Fs =$ input fs   24,000 psi max.

$Fv = 1.0(f'm)^{(1/2)}$ 50 psi max.

All of the above except Fs are reduced by 1/2 if there is no special inspection.

All of the above are increased by 4/3 if the load case includes a wind or seismic load.

fa = Axial/Effective Area

fv = Shear/Effective Area

$fb = M(2/jk)/(bd^2)$

$fs = M/(Asjd)$

b = 12"

$p = As/(bd)$

$n = Es/Em$

$k = [(np)^2 + 2np]^{(1/2)}$ - np
$j = 1 - k/3$

Em = 750f'm   3,000,000 psi max.
Es = 29,000,000 psi

The design is controlled by one of the following:

fa/Fa + fb/Fb
fv/Fv
fs/Fs

Embedment Length = 0.002(rebar dia)Fs   Minimum 12"

UBC '94
wall h' = 2(wall ht)

If the h'/t ratio of the wall section exceeds 30, this condition is indicated in both the Structure and Text views. Although calculations are completed based on this h'/t, the code book should be consulted for possible slender wall design requirements.

Fa = 0.25f'm[1 - (h'/140r)^2]   for h'/r ≤ 99
Fa = 0.25f'm(70r/h')^2 for h'/r > 99
Fb = f'm/3   2,000 psi max.
Fs = input fs   24,000 psi max.
Fv = 1.0(fm)$^{(1/2)}$ 50 psi max.

All of the above except Fs are reduced by 1/2 if there is no special inspection.

All of the above are increased by 4/3 if the load case includes a wind or seismic load.

fa = Axial/Effective Area
fv = Shear/Effective Area

fb = M(2/jk)/(bd^2)
fs = M/(Asjd)

b = 12"
p = As/(bd)
n = Es/Em
$k = [(np)^2 + 2np]^{(1/2)}$ - np
$j = 1 - k/3$

Em = 750f'm   3,000,000 psi max.
Es = 29,000,000 psi

The design is controlled by one of the following:

fa/Fa + fb/Fb
fv/Fv
fs/Fs

Embedment Length = 0.002(rebar dia)Fs   Minimum 12"

UBC '97
wall h' = 2(wall ht)

If the h'/t ratio of the wall section exceeds 30, this condition is indicated in both the Structure and Text views. Although calculations are completed based on this h'/t, the code book should be consulted for possible slender wall design requirements.

Fa = 0.25f'm[1 - (h'/140r)^2]   for h'/r ≤ 99
Fa = 0.25f'm(70r/h')^2 for h'/r > 99
Fb = f'm/3   2,000 psi max.
Fs = input fs   24,000 psi max.
Fv = 1.0(f'm)$^{(1/2)}$ 50 psi max.

All of the above except Fs are reduced by 1/2 if there is no special inspection.

All of the above are increased by 4/3 if the load case includes a wind or seismic load.

fa = Axial/Effective Area
fv = Shear/Effective Area

fb = M(2/jk)/(bd^2)
fs = M/(Asjd)

b = 12"
p = As/(bd)
n = Es/Em
k = [(np)^2 + 2np]$^{(1/2)}$ - np
j = 1 - k/3

Em = 750f'm   3,000,000 psi max.

Es = 29,000,000 psi

The design is controlled by one of the following:

fa/Fa + fb/Fb
fv/Fv
fs/Fs

Embedment Length = 0.002(rebar dia)Fs   Minimum 12"

BOCA '93
wall h'=2 x wall ht

$Fa = 0.25f'm[1 - (h'/140r)^2]$	for h'/r ≤ 99
$Fa = 0.25f'm(70r/h')^2$	for h'/r > 99
$Fb = f'm/3$	2,000 psi max.
Fs = input fs	24,000 psi max.
$Fv = 1.0(fm)^{(1/2)}$	50 psi max.

All of the above are increased by 4/3 if the load case includes a wind or seismic load.

fa = Axial/Effective Area
fv = Shear/Effective Area

$fb = M(2/jk)/(bd)^2$
fs = M/(Asjd)

b = 12"
p = As/(bd)
n = Es/Em
$k = [(np)^2 + 2np]^{(1/2)}$ - np
j = 1 - k/3

Em =   The compressive strength of masonry units is found in the following "Compressive Strength of Masonry Units" table based on f'm and the Em is found in the following "Em for ACI, SBCCI, and BOCA Building Codes" table.

Es = 29,000,000 psi

The design is controlled by one of the following:

fa/Fa + fb/Fb
fv/Fv
fs/Fs

Embedment Length = 0.0015(rebar dia)Fs   Minimum 12"

SBCCI '91
wall h'=2 x wall ht

$Fa = 0.25f'm[1 - (h'/140r)^2]$ for h'/r ≤ 99
$Fa = 0.25f'm(70r/h')^2$ for h'/r > 99
Fb = f'm/3   2,000 psi max.
Fs = input fs   24,000 psi max.
$Fv = 1.0(fm)^{(1/2)}$ 50 psi max.

All of the above are increased by 4/3 if the load case includes a wind or seismic load.

fa = Axial/Effective Area
fv = Shear/Effective Area

$fb = M(2/jk)/(bd)^2$
fs = M/(Asjd)

b = 12"
p = As/(bd)
n = Es/Em
$k = [(np)^2 + 2np]^{(1/2)} - np$
j = 1 - k/3

Em =   The compressive strength of masonry units is found in the following "Compressive Strength of
       Masonry Units" table based on f'm and the Em is found in the following "Em for ACI, SBCCI,
       and BOCA Building Codes" table.
Es = 29,000,000 psi

The design is controlled by one of the following:

fa/Fa + fb/Fb
fv/Fv
fs/Fs

Embedment Length = 0.0015(rebar dia)Fs   Minimum 12"

SBCCI '94
wall h'=2 x wall ht

$Fa = 0.25f'm[1 - (h'/140r)^2]$ for $h'/r \le 99$
$Fa = 0.25f'm(70r/h')^2$ for $h'/r > 99$
$Fb = f'm/3$ 2,000 psi max.
Fs = input fs   24,000 psi max.
$Fv = 1.0(fm)^{(1/2)}$ 50 psi max.

All of the above are increased by 4/3 if the load case includes a wind or seismic load.

fa = Axial/Effective Area
fv = Shear/Effective Area

$fb = M(2/jk)/(bd)^2$
$fs = M/(Asjd)$

$b = 12"$
$p = As/(bd)$
$n = Es/Em$
$k = [(np)^2 + 2np]^{(1/2)} - np$
$j = 1 - k/3$

Em =   The compressive strength of masonry units is found in the following "Compressive Strength of
       Masonry Units" table based on f'm and the Em is found in the following "Em for ACI, SBCCI,
       and BOCA Building Codes" table.
Es = 29,000,000 psi

The design is controlled by one of the following:

fa/Fa + fb/Fb
fv/Fv
fs/Fs

Embedment Length = 0.0015(rebar dia)Fs   Minimum 12"

ACI 530-92
wall h'=2 x wall ht

$Fa = 0.25f'm[1 - (h'/140r)^2]$ for $h'/r \leq 99$

$Fa = 0.25f'm(70r/h')^2$ for $h'/r > 99$

$Fb = f'm/3$ 2,000 psi max.

$Fs = $ input fs   24,000 psi max.

$Fv = 1.0(fm)^{(1/2)}$ 50 psi max.

All of the above are increased by 4/3 if the load case includes a wind or seismic load.

fa = Axial/Effective Area

fv = Shear/Effective Area

$fb = M(2/jk)/(bd)^2$

$fs = M/(Asjd)$

b = 12"

$p = As/(bd)$

$n = Es/Em$

$k = [(np)^2 + 2np]^{(1/2)} - np$

$j = 1 - k/3$

Em =   The compressive strength of masonry units is found in the following "Compressive Strength of Masonry Units" table based on f'm and the Em is found in the following "Em for ACI, SBCCI, and BOCA Building Codes" table.

Es = 29,000,000 psi

The design is controlled by one of the following:

fa/Fa + fb/Fb

fv/Fv

fs/Fs

Embedment Length = 0.0015(rebar dia)Fs   Minimum 12"

Concrete

RetainWall does not consider any axial load when designing concrete walls.

Service loads entered as Floor Live, Roof Live, or Snow are combined as a Live Load in factored load cases.

Shear in the toe is calculated at a distance d from the toe side of the bottom wall section and is calculated as follows:

       (Factored soil pressures pushing upward under the toe) -

(Factored downward loads over the toe) - (Factored toe weight).

Shear in the heel is calculated at a distance d from the heel side of the bottom wall section and is calculated as follows:
(Factored downward loads over the heel) + (Factored heel weight).

The weight of the key is not included in either shear calculation.

Shear in each wall section is calculated at the base of the section and is calculated as follows:
(Factored lateral loads on the heel side of the wall section) -
(Factored lateral loads on the toe side of the wall section).

Passive pressures and surcharge loads over the toe are not included in the wall section shear calculation.

Moment in the toe is calculated at the toe side of the bottom wall section and is calculated as follows:
(Factored soil pressures pushing upward)(arm) -
(Factored downward loads over the toe)(arm) - (Factored toe weight)(arm).

Moment in the heel is calculated at the heel side of the bottom wall section and is calculated as follows:
(Factored downward loads over the heel)(arm) + (Factored heel weight)(arm).

The weight of the key is not included in either moment calculation.

Moment in each wall section is calculated at the base of the section and is calculated as follows:
(Factored lateral loads on the heel side of the wall section)(arm) -
(Factored lateral loads on the toe side of the wall section)(arm).

Passive pressures and surcharge loads over the toe are not included in the wall section moment calculation.

RetainWall calculates the rebar spacing and rebar size as follows:

1) If you input a rebar size and set the rebar spacing to Calc, the rebar spacing is determined by the minimum of As req'd, 3 x thickness, or 18".
2) If you input a rebar spacing and set the rebar size to Calc, the rebar size is determined based on the As req'd.

RetainWall does not calculate required temperature and shrinkage reinforcement.

RetainWall uses the following equations from the referenced codebooks to perform the design.

IBC 2000

b = 12"

$v_u = Shear/(0.85bd)$

$v_c = 2f'c^{(1/2)}$

b = 12"

$m = f_y/(0.85f'c)$

$R_u = Moment/(0.9bd^2)$

$rho = [1 - (1-2mR_u/f_y)^{1/2}]/m$

As req'd = (rho)bd

If As req'd is less than the larger of $200/f_y$ or $3(f'c)^{1/2}/f_y$ then As req'd is multiplied by 4/3. If this new As req'd is greater than the larger of the above, As req'd is set to the larger of the above. Finally if As req'd is less than the input % Min Steel then the As req'd is increased to the input minimum.

The As max in the wall sections and footing are calculated as follows:

> For f'c ≤ 4,000 psi
> $\quad \beta 1 = 0.85$
> For f'c > 4,000 psi
> $\quad \beta 1 = 0.85 - 0.05((f'c - 4,000)/1,000)$ min=0.65

> rho Bal = $0.85\beta 1f'c(87,000/(87,000 + f_y))/f_y$
> As max = 0.75(rho Bal)bd

Embedment Length

Basic $l_{db} = (3/40)(f_y/(f'c)^{1/2})$(bar dia)   f'c max = 10,000 psi

Modifier 1:
- 1) Horizontal rebar so placed that more than 12" of fresh concrete is cast in the member below the development length..1.3
- 2) Otherwise 1.0

Modifier 2:
- 1) No. 6 and smaller bars 0.8
- 2) Otherwise 1.0

Modifier 3:
- 1) Spacing or cover dimension

Modifier 4:
- 1) Rebar in excess of that required by analysis............................(As req'd/As provided)

Final l_{db} = (Modifier 1)(Modifier 2)(Modifier 4)(l_{db})/(Modifier2/bar dia)   min 12"

Hook Length

Basic l_{hb} = $1200d_b/f'c^{(1/2)}$ f'c max = 10,000 psi

Modifier 1:
    1)   fy/60000.

Modifier 2:
    1)   RetainWall assumes that concrete side cover is adequate.....................................0.7

Modifier 3:
    1)   Rebar in excess of that required by analysis...........................(As req'd/As provided)

Final l_{hb} = (Modifier 1)(Modifier 2)(Modifier 3)(Basic l_{hb})   min $8d_b$ or 6"

IBC 2003
b = 12"
vu = Shear/(0.85bd)
vc = $2f'c^{(1/2)}$

b = 12"
m = fy/(0.85f'c)
Ru = Moment/($0.9bd^2$)
rho = [1 - $(1-2mRu/fy)^{1/2}$]/m
As req'd = (rho)bd

If As req'd is less than the larger of 200/fy or $3(f'c)^{1/2}/fy$ then As req'd is multiplied by 4/3. If this new As req'd is greater than the larger of the above, As req'd is set to the larger of the above. Finally if As req'd is less than the input % Min Steel then the As req'd is increased to the input minimum.

The As max in the wall sections and footing are calculated as follows:

    For f'c ≤ 4,000 psi
        β1 = 0.85
    For f'c > 4,000 psi
        β1 = 0.85 - 0.05((f'c - 4,000)/1,000) min=0.65

    rho Bal = 0.85β1f'c(87,000/(87,000 + fy))/fy

As max = 0.75(rho Bal)bd

Embedment Length

Basic l_{db} = (3/40)(fy/(f'c)$^{1/2}$)(bar dia)　　　　　　f'c max = 10,000 psi

Modifier 1:
3)　　Horizontal rebar so placed that more than 12" of fresh concrete is cast in the member below the development length...1.3
4)　　Otherwise 1.0

Modifier 2:
3)　　No. 6 and smaller bars 0.8
4)　　Otherwise 1.0

Modifier 3:
1)　　Spacing or cover dimension

Modifier 4:
2)　　Rebar in excess of that required by analysis............................(As req'd/As provided)

Final l_{db} = (Modifier 1)(Modifier 2)(Modifier 4)(l_{db})/(Modifier2/bar dia)　　　　min 12"

Hook Length

Basic l_{hb} = 1200d_b/f'c$^{(1/2)}$　　　　　f'c max = 10,000 psi

Modifier 1:
2)　　fy/60000.

Modifier 2:
2)　　RetainWall assumes that concrete side cover is adequate.....................................0.7

Modifier 3:
2)　　Rebar in excess of that required by analysis............................(As req'd/As provided)

Final l_{hb} = (Modifier 1)(Modifier 2)(Modifier 3)(Basic l_{hb})　　　　　　min 8d_b or 6"

UBC '91
b = 12"
vu = Shear/(0.85bd)

35

$vc = 2f'c^{(1/2)}$

$b = 12''$
$m = fy/(0.85f'c)$
$Ru = Moment/(0.9bd^2)$
$rho = [1 - (1-2mRu/fy)^{1/2}]/m$
As req'd = (rho)bd

If As req'd is less than 200/fy then As req'd is multiplied by 4/3. If this new As req'd is greater than 200/fy then As req'd is set to 200/fy. Finally if As req'd is less than the input % Min Steel then the As req'd is increased to the input minimum.

The As max in the wall sections and footing are calculated as follows:

       For f'c ≤ 4,000 psi
            $\beta 1 = 0.85$
       For f'c > 4,000 psi
            $\beta 1 = 0.85 - 0.05((f'c - 4,000)/1,000)$ min=0.65

       rho Bal = $0.85\beta 1 f'c(87,000/(87,000 + fy))/fy$
       As max = 0.75(rho Bal)bd

Embedment Length

Basic $l_{db} = 0.04A_b fy/f'c^{(1/2)}$ f'c max = 10,000 psi

Modifier 1:
      1)   If the rebar cover is greater than 2(rebar diameter) and the rebar spacing is equal to or greater than 3(rebar diameter) 1.0
      2)   If the rebar cover is equal to or less than the rebar diameter or the rebar spacing is equal to or less than 2(rebar diameter)..2.0
      3)   For all bars not included above...1.4
      4)   If the rebar cover is equal to or greater than 2.5(rebar diameter) and the rebar spacing is equal to or greater than 5(rebar diameter)...0.8

l_{db} = (Modifier 1) (Basic l_{db})   min 0.03(rebar dia)fy/f'c$^{(1/2)}$

Modifier 2:
      1)   Horizontal rebar so placed that more than 12'' of fresh concrete is cast in the member below the development length...1.3

Modifier 3:
      1)   Rebar in excess of that required by analysis............................(As req'd/As provided)

Final l_{db} = (Modifier 2)(Modifier 3)(l_{db}) min 12"

Hook Length

Basic l_{hb} = 1200d_b/f'c$^{(1/2)}$ f'c max = 10,000 psi

Modifier 1:
     1)   fy/60000.

Modifier 2:
     1)   RetainWall assumes that concrete side cover is adequate......................................0.7

Modifier 3:
     1)   Rebar in excess of that required by analysis............................(As req'd/As provided)

Final l_{hb} = (Modifier 1)(Modifier 2)(Modifier 3)(Basic l_{hb})   min 8d_b or 6"

UBC '94
b = 12"
vu = Shear/(0.85bd)
vc = 2f'c$^{(1/2)}$

b = 12"
m = fy/(0.85f'c)
Ru = Moment/(0.9bd^2)
rho = [1 - (1-2mRu/fy)$^{1/2}$]/m
As req'd = (rho)bd

If As req'd is less than 200/fy then As req'd is multiplied by 4/3. If this new As req'd is greater than 200/fy then As req'd is set to 200/fy. Finally if As req'd is less than the input % Min Steel then the As req'd is increased to the input minimum.

The As max in the wall sections and footing are calculated as follows:

     For f'c ≤ 4,000 psi
          β1 = 0.85
     For f'c > 4,000 psi
          β1 = 0.85 - 0.05((f'c - 4,000)/1,000) min=0.65

     rho Bal = 0.85β1f'c(87,000/(87,000 + fy))/fy

As max = 0.75(rho Bal)bd

Embedment Length

Basic l_{db} = 0.04$A_b$fy/f'c$^{(1/2)}$ f'c max = 10,000 psi

Modifier 1:
- 1) If the rebar cover is greater than 2(rebar diameter) and the rebar spacing is equal to or greater than 3(rebar diameter) 1.0
- 2) If the rebar cover is equal to or less than the rebar diameter or the rebar spacing is equal to or less than 2(rebar diameter) 2.0
- 3) For all bars not included above 1.4
- 4) If the rebar cover is equal to or greater than 2.5(rebar diameter) and the rebar spacing is equal to or greater than 5(rebar diameter)...0.8

l_{db} = (Modifier 1) (Basic l_{db})   min 0.03(rebar dia)fy/f'c$^{(1/2)}$

Modifier 2:
- 1) Horizontal rebar so placed that more than 12" of fresh concrete is cast in the member below the development length...1.3

Modifier 3:
- 1) Rebar in excess of that required by analysis............................(As req'd/As provided)

Final l_{db} = (Modifier 2)(Modifier 3)(l_{db}) min 12"

Hook Length

Basic l_{hb} = 1200d_b/f'c$^{(1/2)}$ f'c max = 10,000 psi

Modifier 1:
- 1) fy/60000.

Modifier 2:
- 1) RetainWall assumes that concrete side cover is adequate.....................................0.7

Modifier 3:
- 1) Rebar in excess of that required by analysis............................(As req'd/As provided)

Final l_{hb} = (Modifier 1)(Modifier 2)(Modifier 3)(Basic l_{hb})   min 8d_b or 6"

UBC '97
b = 12"
vu = Shear/(0.85bd)
vc = 2f'c$^{(1/2)}$

b = 12"
m = fy/(0.85f'c)
Ru = Moment/(0.9bd^2)
rho = [1 - (1-2mRu/fy)$^{1/2}$]/m
As req'd = (rho)bd

If As req'd is less than the larger of 200/fy or 3(f'c)$^{1/2}$/fy then As req'd is multiplied by 4/3. If this new As req'd is greater than the larger of the above, As req'd is set to the larger of the above. Finally if As req'd is less than the input % Min Steel then the As req'd is increased to the input minimum.

The As max in the wall sections and footing are calculated as follows:

For f'c ≤ 4,000 psi
  β1 = 0.85
For f'c > 4,000 psi
  β1 = 0.85 - 0.05((f'c - 4,000)/1,000) min=0.65

rho Bal = 0.85β1f'c(87,000/(87,000 + fy))/fy
As max = 0.75(rho Bal)bd

Embedment Length

Basic l$_{db}$ = (3/40)(fy/(f'c)$^{1/2}$)(bar dia)   f'c max = 10,000 psi

Modifier 1:
   5)   Horizontal rebar so placed that more than 12" of fresh concrete is cast in the member below the development length...1.3
   6)   Otherwise 1.0

Modifier 2:
   5)   No. 6 and smaller bars 0.8
   6)   Otherwise 1.0

Modifier 3:
   1)   Spacing or cover dimension

Modifier 4:
   3)   Rebar in excess of that required by analysis............................(As req'd/As provided)

Final l_{db} = (Modifier 1)(Modifier 2)(Modifier 4)(l_{db})/(Modifier2/bar dia)   min 12"

Hook Length

Basic l_{hb} = $1200d_b/f'c^{(1/2)}$ f'c max = 10,000 psi

Modifier 1:
    3)   fy/60000.

Modifier 2:
    3)   RetainWall assumes that concrete side cover is adequate......................................0.7

Modifier 3:
    3)   Rebar in excess of that required by analysis............................(As req'd/As provided)

Final l_{hb} = (Modifier 1)(Modifier 2)(Modifier 3)(Basic l_{hb})   min $8d_b$ or 6"

BOCA '93
b = 12"
vu = Shear/(0.85bd)
vc = $2f'c^{(1/2)}$

b = 12"
m = fy/(0.85f'c)
Ru = Moment/(0.9bd^2)
rho = $[1 - (1-2mRu/fy)^{1/2}]/m$
As req'd = (rho)bd

If As req'd is less than 200/fy then As req'd is multiplied by 4/3. If this new As req'd is greater than 200/fy then As req'd is set to 200/fy. Finally if As req'd is less than the input % Min Steel then the As req'd is increased to the input minimum.

The As max in the wall sections and footing are calculated as follows:

    For f'c ≤ 4,000 psi
        β1 = 0.85
    For f'c > 4,000 psi
        β1 = 0.85 - 0.05((f'c - 4,000)/1,000) min=0.65

    rho Bal = 0.85β1f'c(87,000/(87,000 + fy))/fy

As max = 0.75(rho Bal)bd

Embedment Length

Basic $l_{db} = 0.04A_b fy/f'c^{(1/2)}$ f'c max = 10,000 psi

Modifier 1:
1) If the rebar cover is greater than 2(rebar diameter) and the rebar spacing is equal to or greater than 3(rebar diameter) 1.0
2) If the rebar cover is equal to or less than the rebar diameter or the rebar spacing is equal to or less than 2(rebar diameter) 2.0
3) For all bars not included above 1.4
4) If the rebar cover is equal to or greater than 2.5(rebar diameter) and the rebar spacing is equal to or greater than 5(rebar diameter) 0.8

l_{db} = (Modifier 1) (Basic l_{db})   min 0.03(rebar dia)$fy/f'c^{(1/2)}$

Modifier 2:
1) Horizontal rebar so placed that more than 12" of fresh concrete is cast in the member below the development length...1.3

Modifier 3:
1) Rebar in excess of that required by analysis...........................(As req'd/As provided)

Final l_{db} = (Modifier 2)(Modifier 3)(l_{db}) min 12"

Hook Length

Basic $l_{hb} = 1200d_b/f'c^{(1/2)}$ f'c max = 10,000 psi

Modifier 1:
1) fy/60000.

Modifier 2:
1) RetainWall assumes that concrete side cover is adequate.....................................0.7

Modifier 3:
1) Rebar in excess of that required by analysis...........................(As req'd/As provided)

Final l_{hb} = (Modifier 1)(Modifier 2)(Modifier 3)(Basic l_{hb})   min $8d_b$ or 6"

SBCCI '91
b = 12"
vu = Shear/(0.85bd)
vc = 2f'c$^{(1/2)}$

b = 12"
m = fy/(0.85f'c)
Ru = Moment/(0.9bd^2)
rho = [1 - (1-2mRu/fy)$^{1/2}$]/m
As req'd = (rho)bd

If As req'd is less than 200/fy then As req'd is multiplied by 4/3. If this new As req'd is greater than 200/fy then As req'd is set to 200/fy. Finally if As req'd is less than the input % Min Steel then the As req'd is increased to the input minimum.

The As max in the wall sections and footing are calculated as follows:

> For f'c ≤ 4,000 psi
> > β1 = 0.85
>
> For f'c > 4,000 psi
> > β1 = 0.85 - 0.05((f'c - 4,000)/1,000)   min=0.65

> rho Bal = 0.85β1f'c(87,000/(87,000 + fy))/fy
> As max = 0.75(rho Bal)bd

Embedment Length

Basic l$_{db}$ = 0.04A$_b$fy/f'c$^{(1/2)}$ f'c max = 10,000 psi

Modifier 1:
> 1)   If the rebar cover is greater than 2(rebar diameter) and the rebar spacing is equal to or greater than 3(rebar diameter) 1.0
> 2)   If the rebar cover is equal to or less than the rebar diameter or the rebar spacing is equal to or less than 2(rebar diameter) 2.0
> 3)   For all bars not included above 1.4
> 4)   If the rebar cover is equal to or greater than 2.5(rebar diameter) and the rebar spacing is equal to or greater than 5(rebar diameter)...0.8

l$_{db}$ = (Modifier 1) (Basic l$_{db}$)   min 0.03(rebar dia)fy/f'c$^{(1/2)}$

Modifier 2:
> 1)   Horizontal rebar so placed that more than 12" of fresh concrete is cast in the member below the development length...1.3

Modifier 3:
      1)   Rebar in excess of that required by analysis............................(As req'd/As provided)

Final l_{db} = (Modifier 2)(Modifier 3)(l_{db}) min 12"

Hook Length

Basic l_{hb} = $1200d_b/f'c^{(1/2)}$ f'c max = 10,000 psi

Modifier 1:
      1)   fy/60000.

Modifier 2:
      1)   RetainWall assumes that concrete side cover is adequate......................................0.7

Modifier 3:
      1)   Rebar in excess of that required by analysis............................(As req'd/As provided)

Final l_{hb} = (Modifier 1)(Modifier 2)(Modifier 3)(Basic l_{hb})   min $8d_b$ or 6"

SBCCI '94
b = 12"
vu = Shear/(0.85bd)
vc = $2f'c^{(1/2)}$

b = 12"
m = fy/(0.85f'c)
Ru = Moment/($0.9bd^2$)
rho = $[1 - (1-2mRu/fy)^{1/2}]/m$
As req'd = (rho)bd

If As req'd is less than 200/fy then As req'd is multiplied by 4/3. If this new As req'd is greater than 200/fy then As req'd is set to 200/fy. Finally if As req'd is less than the input % Min Steel then the As req'd is increased to the input minimum.

The As max in the wall sections and footing are calculated as follows:

      For f'c ≤ 4,000 psi
             $\beta 1 = 0.85$
      For f'c > 4,000 psi

$$\beta 1 = 0.85 - 0.05((f'c - 4{,}000)/1{,}000) \quad min{=}0.65$$

rho Bal $= 0.85\beta 1 f'c(87{,}000/(87{,}000 + fy))/fy$
As max $= 0.75(\text{rho Bal})bd$

Embedment Length

Basic $l_{db} = 0.04A_b fy/f'c^{(1/2)}$ $\qquad\qquad$ f'c max $= 10{,}000$ psi

Modifier 1:
1) If the rebar cover is greater than 2(rebar diameter) and the rebar spacing is equal to or greater than 3(rebar diameter) 1.0
2) If the rebar cover is equal to or less than the rebar diameter or the rebar spacing is equal to or less than 2(rebar diameter) 2.0
3) For all bars not included above 1.4
4) If the rebar cover is equal to or greater than 2.5(rebar diameter) and the rebar spacing is equal to or greater than 5(rebar diameter)..0.8

$l_{db} = (\text{Modifier 1}) (\text{Basic } l_{db})$ $\qquad\qquad$ min $0.03(\text{rebar dia})fy/f'c^{(1/2)}$

Modifier 2:
1) Horizontal rebar so placed that more than 12" of fresh concrete is cast in the member below the development length...1.3

Modifier 3:
1) Rebar in excess of that required by analysis...........................(As req'd/As provided)

Final $l_{db} = (\text{Modifier 2})(\text{Modifier 3})(l_{db})$ min 12"

Hook Length

Basic $l_{hb} = 1200d_b/f'c^{(1/2)}$ $\qquad\qquad$ f'c max $= 10{,}000$ psi

Modifier 1:
1) fy/60000.

Modifier 2:
1) RetainWall assumes that concrete side cover is adequate.....................................0.7

Modifier 3:
1) Rebar in excess of that required by analysis...........................(As req'd/As provided)

Final l_{hb} = (Modifier 1)(Modifier 2)(Modifier 3)(Basic l_{hb})   min $8d_b$ or 6"

ACI 318-89
b = 12"
vu = Shear/(0.85bd)
vc = $2f'c^{(1/2)}$

b = 12"
m = fy/(0.85f'c)
Ru = Moment/$(0.9bd^2)$
rho = $[1 - (1-2mRu/fy)^{1/2}]/m$
As req'd = (rho)bd

If As req'd is less than 200/fy then As req'd is multiplied by 4/3. If this new As req'd is greater than 200/fy then As req'd is set to 200/fy. Finally if As req'd is less than the input % Min Steel then the As req'd is increased to the input minimum.

The As max in the wall sections and footing are calculated as follows:

> For f'c ≤ 4,000 psi
> $\beta 1 = 0.85$
> For f'c > 4,000 psi
> $\beta 1 = 0.85 - 0.05((f'c - 4,000)/1,000)$ min=0.65

> rho Bal = $0.85\beta 1f'c(87,000/(87,000 + fy))/fy$
> As max = 0.75(rho Bal)bd

Embedment Length

Basic l_{db} = $0.04A_bfy/f'c^{(1/2)}$ f'c max = 10,000 psi

Modifier 1:
1) If the rebar cover is greater than 2(rebar diameter) and the rebar spacing is equal to or greater than 3(rebar diameter) 1.0
2) If the rebar cover is equal to or less than the rebar diameter or the rebar spacing is equal to or less than 2(rebar diameter) 2.0
3) For all bars not included above 1.4
4) If the rebar cover is equal to or greater than 2.5(rebar diameter) and the rebar spacing is equal to or greater than 5(rebar diameter) 0.8

l_{db} = (Modifier 1) (Basic l_{db})   min 0.03(rebar dia)fy/f'c$^{(1/2)}$

Modifier 2:
      1)   Horizontal rebar so placed that more than 12" of fresh concrete is cast in the member below the development length...1.3

Modifier 3:
      1)   Rebar in excess of that required by analysis............................(As req'd/As provided)

Final l_{db} = (Modifier 2)(Modifier 3)(l_{db}) min 12"

Hook Length

Basic $l_{hb} = 1200d_b/f'c^{(1/2)}$ f'c max = 10,000 psi

Modifier 1:
      1)   fy/60000.

Modifier 2:
      1)   RetainWall assumes that concrete side cover is adequate.....................................0.7

Modifier 3:
      1)   Rebar in excess of that required by analysis............................(As req'd/As provided)

Final l_{hb} = (Modifier 1)(Modifier 2)(Modifier 3)(Basic l_{hb})   min $8d_b$ or 6"

ACI 318-95
b = 12"
vu = Shear/(0.85bd)
vc = $2f'c^{(1/2)}$

b = 12"
m = fy/(0.85f'c)
Ru = Moment/($0.9bd^2$)
rho = $[1 - (1-2mRu/fy)^{1/2}]/m$
As req'd = (rho)bd

If As req'd is less than the larger of 200/fy or $3(f'c)^{1/2}/fy$ then As req'd is multiplied by 4/3. If this new As req'd is greater than the larger of the above, As req'd is set to the larger of the above. Finally if As req'd is less than the input % Min Steel then the As req'd is increased to the input minimum.

The As max in the wall sections and footing are calculated as follows:

For f'c ≤ 4,000 psi
$$\beta1 = 0.85$$
For f'c > 4,000 psi
$$\beta1 = 0.85 - 0.05((f'c - 4,000)/1,000) \quad min=0.65$$

rho Bal = $0.85\beta1f'c(87,000/(87,000 + fy))/fy$
As max = 0.75(rho Bal)bd

Embedment Length

Basic l_{db} = $(3/40)(fy/(f'c)^{1/2})$(bar dia)   f'c max = 10,000 psi

Modifier 1:
1) Horizontal rebar so placed that more than 12" of fresh concrete is cast in the member below the development length..1.3
2) Otherwise 1.0

Modifier 2:
1) No. 6 and smaller bars 0.8
2) Otherwise 1.0

Modifier 3:
1) Spacing or cover dimension

Modifier 4:
1) Rebar in excess of that required by analysis............................(As req'd/As provided)

Final l_{db} = (Modifier 1)(Modifier 2)(Modifier 4)(l_{db})/(Modifier2/bar dia)   min 12"

Hook Length

Basic l_{hb} = $1200d_b/f'c^{(1/2)}$ f'c max = 10,000 psi

Modifier 1:
1) fy/60000.

Modifier 2:
1) RetainWall assumes that concrete side cover is adequate.....................................0.7

Modifier 3:
1) Rebar in excess of that required by analysis............................(As req'd/As provided)

Final l_{hb} = (Modifier 1)(Modifier 2)(Modifier 3)(Basic l_{hb})   min $8d_b$ or 6"

ACI 318-99
b = 12"
vu = Shear/(0.85bd)
vc = $2f'c^{(1/2)}$

b = 12"
m = fy/(0.85f'c)
Ru = Moment/($0.9bd^2$)
rho = [1 - $(1-2mRu/fy)^{1/2}$]/m
As req'd = (rho)bd

If As req'd is less than the larger of 200/fy or $3(f'c)^{1/2}$/fy then As req'd is multiplied by 4/3. If this new As req'd is greater than the larger of the above, As req'd is set to the larger of the above. Finally if As req'd is less than the input % Min Steel then the As req'd is increased to the input minimum.

The As max in the wall sections and footing are calculated as follows:

> For f'c ≤ 4,000 psi
> $\quad$ β1 = 0.85
> For f'c > 4,000 psi
> $\quad$ β1 = 0.85 - 0.05((f'c - 4,000)/1,000) min=0.65

> rho Bal = 0.85β1f'c(87,000/(87,000 + fy))/fy
> As max = 0.75(rho Bal)bd

Embedment Length

Basic l_{db} = (3/40)(fy/$(f'c)^{1/2}$)(bar dia)   f'c max = 10,000 psi

Modifier 1:
> 3) $\quad$ Horizontal rebar so placed that more than 12" of fresh concrete is cast in the member below the development length..1.3
> 4) $\quad$ Otherwise 1.0

Modifier 2:
> 3) $\quad$ No. 6 and smaller bars 0.8
> 4) $\quad$ Otherwise 1.0

Modifier 3:
> 1) $\quad$ Spacing or cover dimension

Modifier 4:
   2)   Rebar in excess of that required by analysis...........................(As req'd/As provided)

Final l_{db} = (Modifier 1)(Modifier 2)(Modifier 4)(l_{db})/(Modifier2/bar dia)   min 12"

Hook Length

Basic $l_{hb} = 1200d_b/f'c^{(1/2)}$ f'c max = 10,000 psi

Modifier 1:
   2)   fy/60000.

Modifier 2:
   2)   RetainWall assumes that concrete side cover is adequate.....................................0.7

Modifier 3:
   2)   Rebar in excess of that required by analysis...........................(As req'd/As provided)

Final l_{hb} = (Modifier 1)(Modifier 2)(Modifier 3)(Basic l_{hb})   min $8d_b$ or 6"

Effective Area (in^2)

Grout spacing	Nominal unit thickness (inch)			
	6	**8**	**10**	**12**
Solid Grout	5.6	7.6	9.6	11.6
Grout @ 16" oc	4.5	5.8	7.2	8.5
24" oc	4.1	5.2	6.3	7.5
32" oc	3.9	4.9	5.9	7.0
40" oc	3.8	4.7	5.7	6.7
48" oc	3.7	4.6	5.5	6.5

Radius of Gyration (inch)

Grout spacing	Nominal unit thickness (inch)			
	6	8	10	12
Solid Grout	1.62	2.19	2.77	3.34
Grout @ 16" oc	1.79	2.43	3.04	3.67
24" oc	1.87	2.53	3.17	3.82
32" oc	1.91	2.59	3.25	3.91
40" oc	1.94	2.63	3.30	3.97
48" oc	1.96	2.66	3.33	4.02

Rebar Depth

Nominal thickness (in)	Center (in)	Edge (in)
6	2.8125	3.50
8	3.8125	5.25
10	4.8125	7.25
12	5.8125	9.00

Light Weight Block (lbs/ft)

Grout spacing	Nominal unit thickness (inch)			
	6	8	10	12
Solid Grout	52	75	93	118
Grout @ 16" oc	41	60	69	88
24" oc	37	55	61	79
32" oc	36	52	57	74
40" oc	35	50	55	71
48" oc	34	45	53	69

Medium Weight Block (lbs/ft)

Grout spacing	Nominal unit thickness (inch)			
	6	**8**	**10**	**12**
Solid Grout	58	78	98	124
Grout @ 16" oc	47	63	80	94
24" oc	43	58	72	85
32" oc	42	55	68	80
40" oc	41	53	66	78
48" oc	40	49	64	75

Normal Weight Block (lbs/ft)

Grout spacing	Nominal unit thickness (inch)			
	6	**8**	**10**	**12**
Solid Grout	63	84	104	133
Grout @ 16" oc	52	66	86	103
24" oc	48	61	78	94
32" oc	47	58	74	89
40" oc	46	56	72	86
48" oc	45	55	70	83

Compressive Strength of Masonry Units

Compressive Strength of Masonry f'm (psi)	Compressive Strength of Masonry Units (psi)
1,000	1,250
1,500	1,900
2,000	2,800
2,500	3,750
3,000	4,800

Em for ACI, SBCCI, and BOCA Building Codes

Compressive Strength of Masonry Units (psi)	Em (psi x 10^6)
6,000 and greater	3.5
5,000	3.2
4,000	2.9
3,000	2.5
2,500	2.4
2,000	2.2
1,500	1.6

DEFINITIONS

% Min Concrete Steel   Minimum percentage of reinforcing steel to be used in the concrete design.

As   Area of concrete tension reinforcement.

b   Effective width of rectangular member.

Concrete Weight   Density of concrete.

csr   Combined stress ratio for masonry calculated as fa/Fa + fb/Fb.

d   Distance from the compression face of the element to the centerline of the tension reinforcement.

D   Dead Load.

DL   Dead Load.

Em   Modulus of elasticity of masonry.

Es   Modulus of elasticity of reinforcing steel.

f'c   Compressive strength of concrete.

f'm   Compressive strength of masonry.

fa   Actual axial stress calculated as shown in the TECHNICAL DISCUSSION section.

Fa   Allowable axial stress calculated as shown in the TECHNICAL DISCUSSION section.

fb   Actual bending stress calculated as shown in the TECHNICAL DISCUSSION section.

Fb   Allowable bending stress calculated as shown in the TECHNICAL DISCUSSION section.

FL   Floor Live Load.

FLL   Floor Live Load.

fs	Input allowable tensile stress of masonry reinforcing steel. Also, actual tensile stress in masonry rebar calculated as shown in the TECHNICAL DISCUSSION section.
Fs	Allowable tensile stress of the masonry reinforcing steel.
fv	Actual shear stress of the masonry calculated as shown in the TECHNICAL DISCUSSION section.
Fv	Allowable shear stress of the masonry calculated as shown in the TECHNICAL DISCUSSION section.
fy	Minimum yield strength of the concrete reinforcing steel.
h'	Effective height of a wall section.
j	The ratio of the distance between the centroid of the flexural compressive forces and the centroid of the tensile forces to depth.
k	The ratio of depth of the compressive stress in a flexural member to the depth.
Mu	Actual factored moment.
n	Modular ratio.
OTM	Overturning Moment.
p	Ratio of the area of flexural tensile reinforcement to the area.
Pa	Active pressure.
Pp	Passive pressure.
Rebar CL	Distance from the tension face of the element to the centerline of the tension reinforcement.
rho	Percentage of tension reinforcement.
RL	Roof Live Load.
RLL	Roof Live Load.

RM   Resisting Moment.

Ru   Coefficient of resistance calculated as shown in the TECHNICAL DISCUSSION section.

SE   Seismic Load.

SEL   Seismic Load.

SF OTM   Safety factor against overturning calculated as shown in the TECHNICAL DISCUSSION section.

SF Slide   Safety factor against sliding calculated as shown in the TECHNICAL DISCUSSION section.

SN   Snow Load.

SNL   Snow Load.

SO   Soil Load.

Soil/Footing Friction   Coefficient of friction between the soil and the bottom of the footing.

SOL   Soil Load.

Thickness   Total thickness of the element.

Unit Wt   Density of soil.

vc   Maximum ultimate factored shear stress calculated as shown in the TECHNICAL DISCUSSION section.

Vu   Actual factored shear.

vu   Actual factored shear stress calculated as shown in the TECHNICAL DISCUSSION section.

W   Wind Load.

WL   Wind Load.