

# SupportIT

## Sheet Pile Wall Design Software

www.GTSoft.org

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## **SupportIT: Sheet Pile Wall Design Software**

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# Contents

<b>Chapter 1: Introduction</b> .....	5
Description .....	5
Copy Protection .....	5
Installation .....	5
Starting <b>SupportIT</b> .....	6
Enabling <b>SupportIT</b> .....	6
Using <b>SupportIT</b> .....	7
Databases .....	7
Demonstration Mode .....	7
Upgrading .....	7
Uninstalling <b>SupportIT</b> .....	7
<b>Chapter 2: Getting Started</b> .....	8
Creating a Design .....	8
Shortcuts and Screen Hotspots .....	12
<b>Chapter 3: Main Window</b> .....	13
Side Elevation Page .....	13
Input/Output Page .....	13
Graphs Page .....	13
Tables Page .....	14
Pressure Page .....	14
Plan View Page .....	14
Reports Page .....	14
Summary Page .....	15
Printing Designs .....	15
Customising .....	15
<b>Chapter 4: Creating/Editing Designs</b> .....	16
The Define Box .....	16
Job Page .....	16
Excavation Page .....	17
Soils Page .....	17
Loads/Slope Page .....	18
Wall Page .....	20
Supports Page .....	23
Install Page .....	25
Plan Page .....	26
Pressure Page .....	28
Setup Page .....	32
<b>Chapter 5: Menus and Toolbars</b> .....	34
Menu Bar .....	34
Toolbar .....	35
<b>Chapter 6: Databases</b> .....	37
The Client Database .....	37
The Soil Database .....	38
The Sheet Database .....	38
The Frame Database .....	39

<b>Chapter 7: Pressure Calculation Methods</b> .....	40
Soil Coefficients .....	40
Earth Pressure: Rankine and Coulomb Pressure Models .....	41
Earth Pressure: Terzaghi Pressure Model .....	42
Water Pressure in Cohesive Soils .....	43
Sloping Ground .....	45
Surcharge Loads .....	45
Custom Slope .....	46
<b>Chapter 8: Retaining Wall Calculation Methods</b> .....	47
Cantilever Retaining Wall .....	47
Free Earth Support Retaining Wall .....	48
Fixed Earth Support Retaining Wall .....	49
Linear Load .....	50
Factor of Safety Methods .....	51
Stepped Excavations .....	52
Deflection Calculation .....	52
Rowe's Moment Reduction Theory .....	52
<b>Chapter 9: Soldier Pile and Lagging Walls</b> .....	54
Effective width .....	54
Method 1: Adjustment factor applied to passive side only .....	54
Method 2: Adjustment factor applied to active and passive sides.....	55
AASHTO .....	55
Load Reduction Factor .....	55
Worked Example: Soldier Pile Wall, Method 1 (Metric) .....	56
Worked Example: Soldier Pile Wall, Method 2 (Metric) .....	58
Worked Example: Soldier Pile Wall, Method 1 (Imperial) .....	60
Worked Example: Soldier Pile Wall, Method 2 (Imperial) .....	62
<b>Appendix A: Notation</b> .....	64
<b>Appendix B: Rules of Thumb</b> .....	65
<b>Appendix C: Default Values</b> .....	66
<b>Appendix D: Computer Settings</b> .....	68
<b>Appendix E: References</b> .....	69

# Chapter 1

## Introduction

### Description

**SupportIT** is a design and analysis tool for cantilevered and propped sheet pile and soldier pile retaining walls. Stepped excavations using sheet piles may also be modelled. User-editable databases for customers, soils, sheet piles, soldier piles, lagging and braces are included. Multi-layered excavations may be defined, with different soils on each side of the excavation.

Different pressure models (**Rankine, Coulomb**, etc), sheet pile penetration models (**Free/Fixed Earth**, etc) and factor of safety calculations (**Net/Gross Pressure, Burland-Potts**) give users complete control over a design.

Surface loads, foundations and sloping/irregular ground may be modelled. **SupportIT** can calculate the optimum positions of supporting frames and raked struts and/or soil anchors may be selected. **SupportIT** also generates a method statement for installing a design, and reports on design safety.

Current versions of **SupportIT** operate under **WINDOWS 95** or later.

### Copy Protection

The software is copy protected by one of the following methods, depending on which version of the software has been installed:

#### Product Key

A **Product Key** is provided when the software is purchased. This is in the form of a code which is entered the first time the software is used, and the computer would normally be connected to the internet at this point to use the **Web Based Activation** method.

The protection is checked periodically via the internet, and the **Product Key** method requires occasional internet access by the computer which is running the software. This usually happens about once every seven days. Users are notified when this is about to happen, and only copy protection data relevant to the software is transmitted. Refer to the **Privacy Policy** button when the code is first entered for more information.

It is possible to use the **Manual Activation** method if the software is to be installed on a computer which does not have internet access. However, it is then more difficult to move the software between computers and install upgrades, and it is recommended that **Web Based Activation** is used for maximum flexibility.

The software may be used for a **trial period** if the **Product Key** field is left blank when the software is used for the first time.

#### Key Disk

A **Key Disk** is supplied to enable/disable the copy protection system. The key disk may not be copied and must not be write-protected.

Software protection is provided by a token system on the key disk, and installation is a two stage process. The relevant files are installed as described below, and the software is enabled by transferring the copy protection from the supplied key disk to the hard drive. The software may be installed on more than one computer, but may only be used on more than one computer simultaneously if there are sufficient installation tokens on the key disk. The copy protection token may be moved between different computers using the key disk.

The key disk version of the software works in **demonstration mode** without being activated (see below).

### Installation

**SupportIT** is installed from CD-Rom or an installation file obtained from the website **www.GTsoft.org**. In both cases, the software must be activated using a **Key Disk** or a **Product Key**, as described above.

Install the software by running the **Setup** program on the supplied installation CD or by double clicking the installation file obtained from the website **www.GTSoft.org**.

Make appropriate entries when prompted. If the default entries are accepted, the software will be installed in the directory **C:\Program Files\GTSoft**.

## Starting SupportIT

- Click the **Start** button on the task bar.
- Select **Programs ► GTSoft ► SupportIT**

## Enabling SupportIT

Different versions of the software are available, and each has a different method for unlocking, or enabling, the software:

### Product Key method

For **Web Based Activation**:

- Install **SupportIT**.
- **Connect** to the internet.
- Start **SupportIT** for the first time
- Three options are available:
  - Select "**Install as a standalone program**", enter the **Product Key** and click **OK**. This is for users of a standalone computer, which will be most cases.
  - Select "**Install as a trial**" and click **OK** to install a 2 week trial version.
  - Select "**Install as a network client**", enter the **CopyMinder Network Path** and click **OK**. This option is for network users, and assumes the network administrator has already installed **CopyNet** on the server and has entered a valid **Product Key**.
- Click **OK** again at the next screen. The software will access the internet and the software will be enabled.


For **Manual Activation**:

- Install **SupportIT**.
- **Do not connect** to the internet.
- Start **SupportIT** for the first time
- Select "**Install as a standalone program**" and enter the **Product Key** in the window which opens, then click **OK**.
- Click **OK** again at the next screen.
- Select **Manual Activation** at the next screen (after a short delay).
- Note your **Product Key** and **Installation Code** from the next screen.
- Access the website <http://www.copyminder.com/activate.php> from a different computer and follow the instructions to receive an **Activation Code**. If you do not have internet access at all, your supplier can provide the **Activation Code** if you contact them with your **Product Key** and **Installation Code**.
- Enter the **Activation Code** in the **Manual Activation** screen.

**Note:**

- 1 Leave the **Product Key** field blank to install the software for a **trial period**.
- 2 **Manual Activation** does not permit a trial period.
- 3 It is recommended that you use the **Web Based Activation** method for maximum flexibility.

### Key Disk Method

- Install the software and start it as described above.
- Insert the **SupportIT Key Disk** in the disk drive.
- Click the **Enable/Disable** button on the main **SupportIT** toolbar.
- A window opens showing the current enable status. Click the **Enable** button within this window to enable the software. 
- Click the **Enable** button again, after ensuring that the drive identification label at the top of the window is correct, and the **SupportIT Key Disk** is in that drive.
- Click the **OK** button within the enable/disable window to accept the new protection status after the copy protection has been transferred.

The software is disabled by repeating the above process to transfer the protection token back to the floppy disk.

## Using SupportIT

Full instructions are available in the online **Help** files, which include tutorials to create simple designs.

A simple introduction to the available functions can be obtained by loading the demonstration files which can be found in the **Designs** folder. Open the files in the usual fashion by starting **SupportIT** and selecting:

**File ► Open**

When a design has been opened, double click anywhere in the main window to open the **Define Box**, which is used to edit designs.

## Databases

The software provides a database of customers, soils, sheet piles, soldier piles, lagging and frames (walers/braces).

You should periodically back up your databases. The easiest way to do this is to copy the **Data** directory to another location.

## Demonstration Mode

The **Key Disk** version of **SupportIT** works in **demonstration mode** without being enabled. Demonstration files in the **Designs** folder may be loaded and edited in a limited fashion. The results of calculations may be viewed in the usual way. Restrictions on editing include items such as the depth of an excavation and the number of soil layers.

The soil, sheet pile and frame databases may not be edited while in demonstration mode.

Designs are not printed while in demonstration mode.

## Upgrading

You can upgrade the software by replacing the current **SupportIT.exe** file with a more recent one. However, if you want to completely reinstall the software:

- Disable the existing installation if appropriate (**Key Disk** version only).
- Uninstall the previous version.
- Install the new version.

## Uninstalling SupportIT

If you wish to maintain existing database entries in an existing **SupportIT** installation for use in a new installation, copy the existing **GTSOFT>Data** directory to a temporary location before uninstalling the software (see below), then move the files from the temporary location to the new **GTSOFT\Data** directory after it has been installed. Similarly, if you have any previously saved designs within the **GTSOFT** folder which you want to keep, copy them to a temporary location before uninstalling the software.

To completely uninstall **SupportIT**:

- Disable the existing installation if appropriate (**Key Disk** users only).
- Uninstall by selecting:  
**Start ► Settings ► Control Panel ► Add/Remove Programs**  
Select **SupportIT** from the program list, then select **Add/Remove**
- If you get the message "Not all components could be removed", or similar, delete the folder **c:\Program Files\GTSOFT**.
- Remove any shortcuts, etc relevant to the previous installation.

### IMPORTANT NOTE for KEY DISK USERS only:

Do not uninstall **SupportIT**, or delete the **GTSOFT** folder from your hard drive, without first **Disabling** the software. Otherwise, you will lose your protection token, and will not be able to reinstall the software.

# Chapter 2

## Getting Started

Start **SupportIT** by selecting: **Start ▶ Programs ▶ GTSoft ▶ SupportIT**



Select the **Help** button, or press the **F1** key on your keyboard at any time to view the online **Help** file.



Click the **New** button on the toolbar to open the main design window.



Follow the instructions below to see how easy it is to create a design:

**Step 1: Open Define Box**

Double-click anywhere in the main window to open the **Define Box**. The **Define Box** is used to create and edit your design.

Drag the **Define Box** to the side to let you see what is happening in the main window.

Click the **Excavation** tab of the **Define Box**, and make the entries shown. The main diagram changes after each entry is made.

**Step 2: Select top soil layer**

Click the **Soils** tab of the **Define Box** to define soil layers. Click the arrow beside the **Name** box and select **Loose Fine Sand** from the drop-down list.

**Define**

Install | Plan | Pressure | Setup

Job | Excavation | Soils | Loads/Slope | Wall | Supports

(m) **Passive Side** | (m) **Active Side**

0.00 Loose Fine Sand | 0.00 Loose Fine Sand

depth: 4 m | Name: Dense Fine Sand

$\gamma: 18.60 \text{ kN/m}^3$  |  $C: 0.0 \text{ kN/m}^2$  |  $K_a: 0.27$   
 $\gamma': 10.80 \text{ kN/m}^3$  |  $C_a: 0.0 \text{ kN/m}^2$  |  $K_{ac}: 0.00$   
 $\phi: 35.0 \text{ degrees}$  |  $K_p: 3.69$   
 $\delta: 0.0 \text{ degrees}$  |  $K_{pc}: 0.00$

Editing active and passive sides.

Apply the new layer.

### Step 3: Add new soil layer

Click the **Add Layer** button to add another soil layer.

Enter **4.0** in the **Depth** box, then click the arrow beside the **Name** box and select **Dense Fine Sand** from the drop-down list.

Click the **Apply** button to add the new layer to your design.

**Define**

Install | Plan | Pressure | Setup

Job | Excavation | Soils | Loads/Slope | Wall | Supports

Embedment

Analysis Method

Gross Pressure (CP2)

Net Pressure (BSPH)

Burland-Potts

Penetration

Free Earth

Fixed Earth

Defined FOS

No Toe

Manual

Miscellaneous

Upstand: 0.00 m

Toe: 11.50 m

FOS: 2.0

Rules of thumb

Wall

Type: Sheet Pile Wall

Sheet

Name: Larsen 6W

$E: 2.1E+08 \text{ kN/m}^2$  |  $I: 6459.0 \text{ cm}^4/\text{m}$   
 $f: 200.0 \text{ N/mm}^2$  |  $Z: 610.0 \text{ cm}^2/\text{m}$   
Max. Bending Moment: 122.0 kNm/m

$W: 44.7 \text{ kg/m}$  |  $A: 108.0 \text{ cm}^2/\text{m}$   
 $b: 0.525 \text{ m}$

Soil Factors

$K_a: \times 1.0$  |  $K_p: \times 1.0$  |  Embedment only  
 $C_{as}: \times 1.0$  |  $C_{ps}: \times 1.0$

### Step 4: Define the wall

Click the **Wall** tab of the **Define Box** to define wall properties and calculation methods.

Select **Sheet Pile Wall** in the **Type** box.

Click the arrow beside the **Name** box and select **Larsen 6W** from the drop-down list.

Select **Net Pressure** and **Free Earth**.

**Define**

Install | Plan | Pressure | Setup

Job | Excavation | Soils | Loads/Slope | Wall | Supports

Frames:

	d (m)	t (m)	b (m)
Water	0.55		
Water	3.85		

Load Model

Area Distribution |  Elastic Shear

Hinge Method

Rigid Wall | 1.3 P<sub>x</sub>

Scale frame

Show frame description

Concrete lowest frame

Selected Frame:

Name: | Angle: 0.0 degrees

Type: Water |  Share load

Strut

Anchor

Find Supports

Maximum top support depth: m | SWL: kN/m

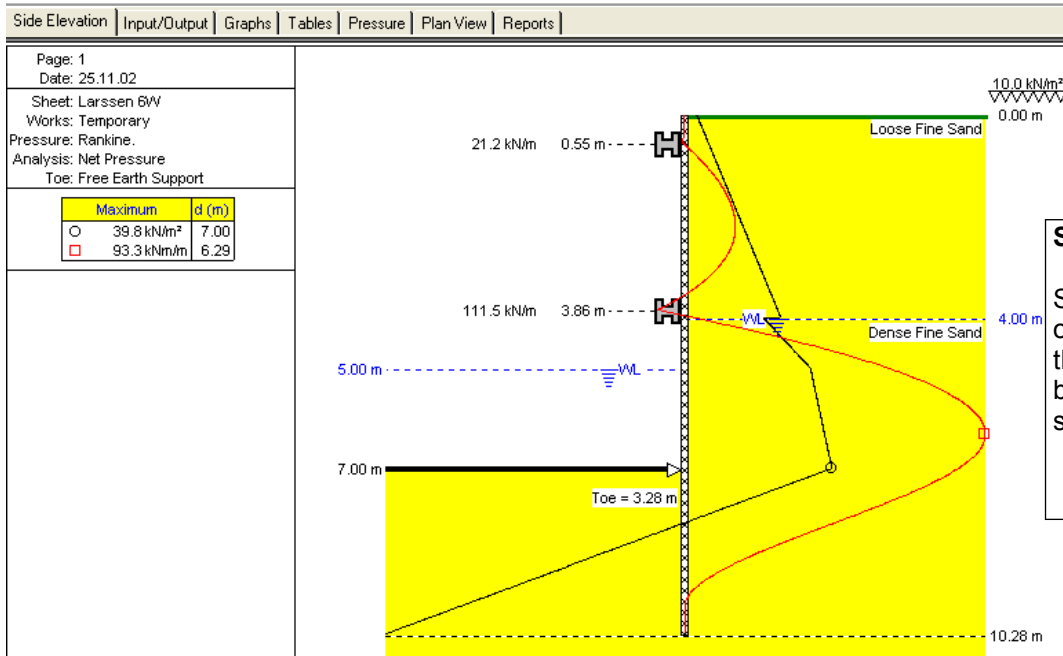
Minimum clearance: m

### Step 5: Define supports

Click the **Supports** tab of the **Define Box** to define support types and positions.

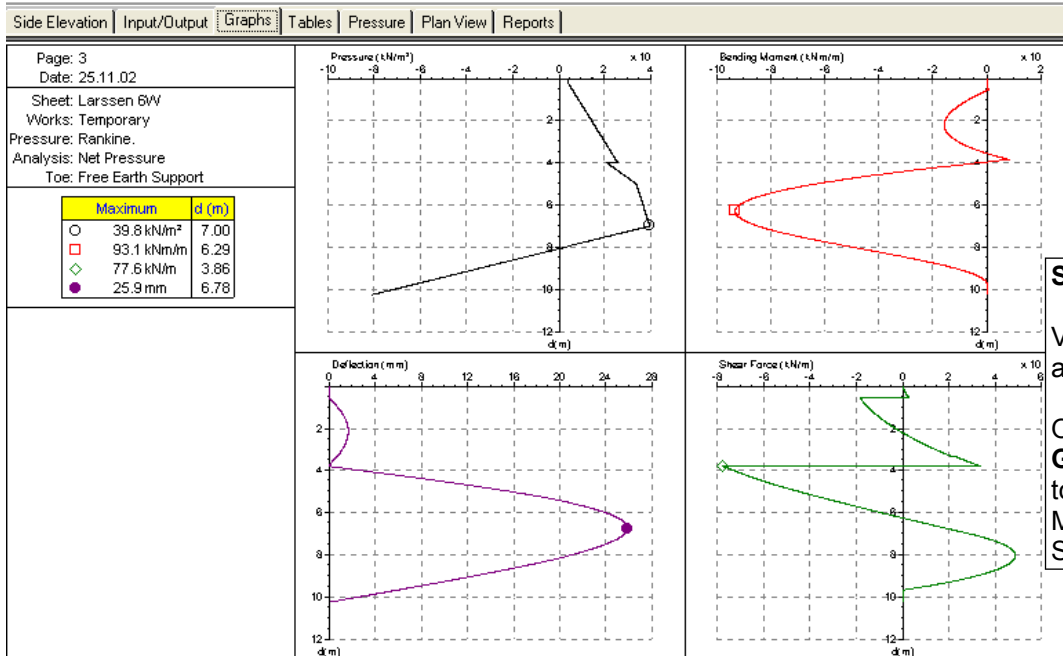
Click the **Find Supports** button to let **SupportIT** find the support positions for you. Click **Yes** when asked if you want to remove any existing supports.

Double click any support on the main diagram to open the **Define Box** at the **Supports** page again. You can edit the calculated support positions in the **Frames** grid at the top left.



**Step 6: Toolbar**

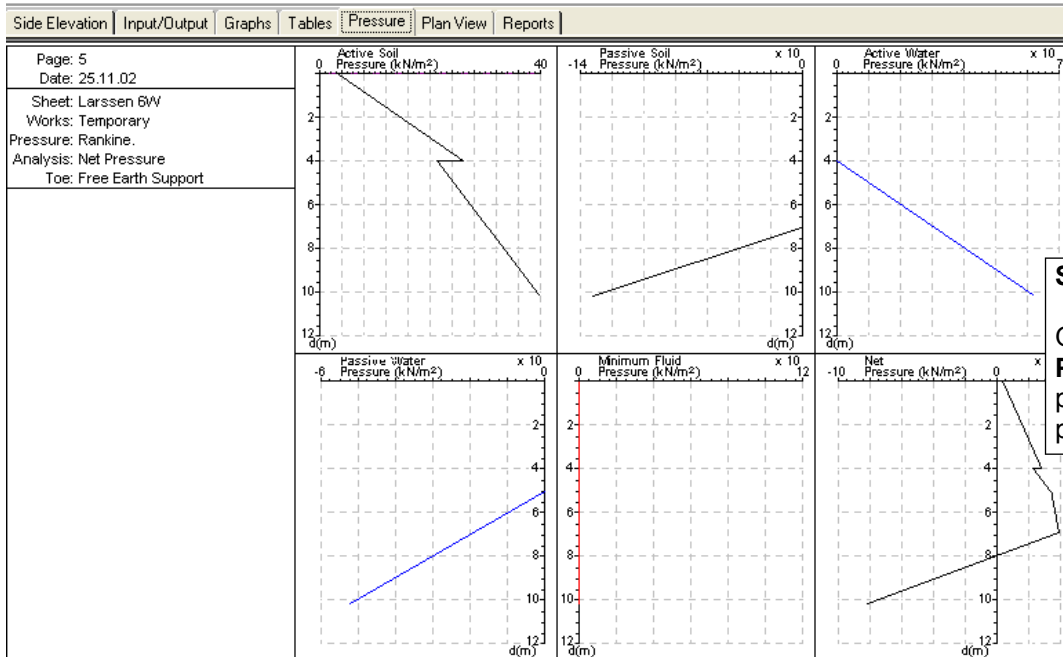
Superimpose various items on the main diagram using the toolbar buttons. Click a button again to remove the superimposed item.



**Step 7: Change view**

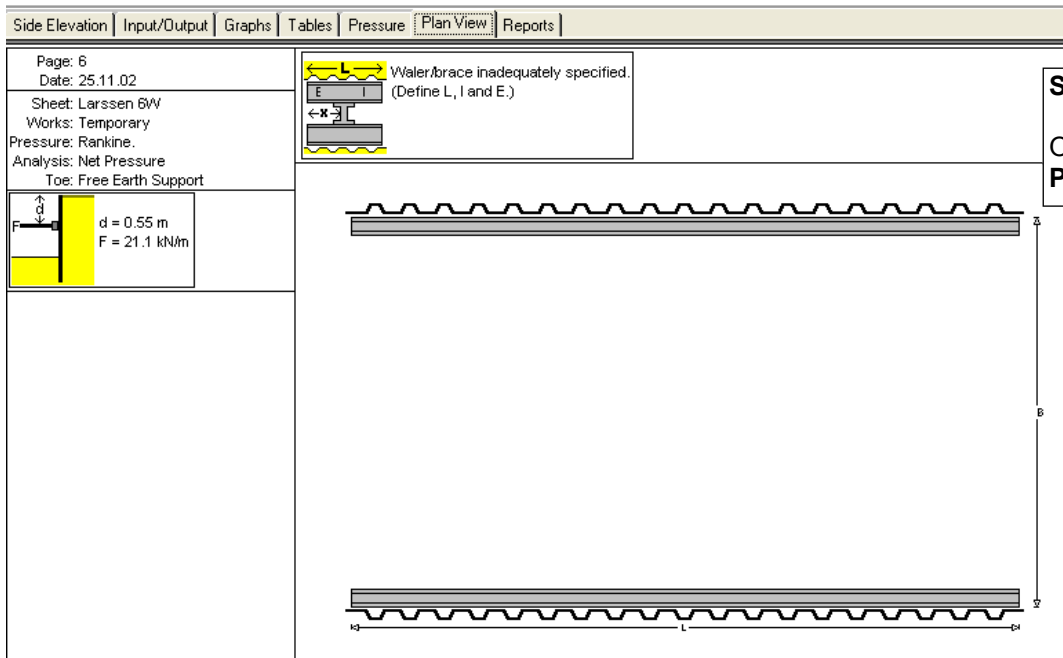
Vary the view using the tabs above the main window.

Open the **Graphs** page to view Pressure, Bending Moment, Deflection and Shear Force graphs.



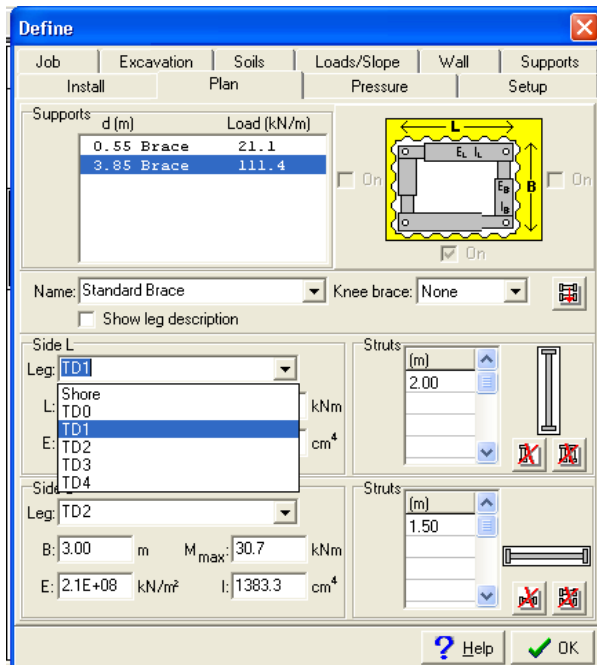
**Step 8: Pressure page**

Open the **Pressure** page to view graphs of each pressure component.



### Step 9: Plan View

Open the Plan View.



### Step 10: Plan view

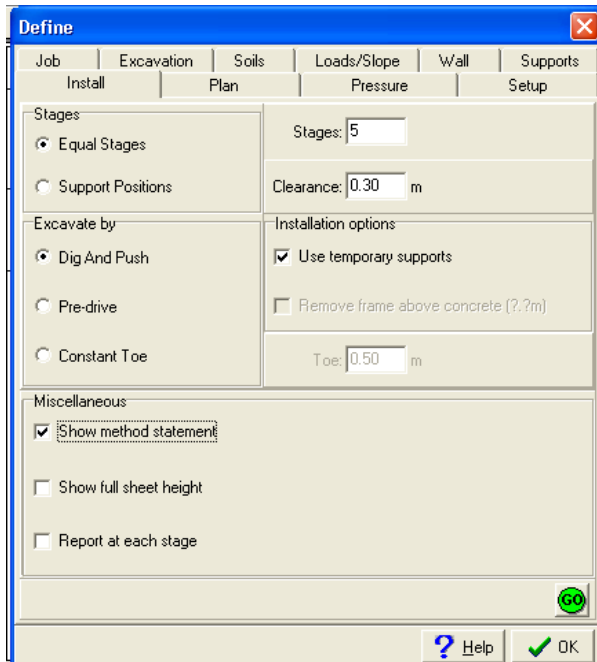
Double click in the main window to open the **Define Box** at the **Plan** page.

Select any brace and leg sizes from the drop-down lists by clicking the arrows beside the **Name** and **Leg** boxes.

Enter **4.0** and **3.0** in the **L** and **B** boxes.

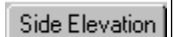
Additional struts may be defined using the **Struts** grids.

The toolbar buttons display reactions, bending moment, etc.



### Step 11: Installation

Change the main window view to **Side Elevation**.



Double click on the main window to open the **Define Box** and select the **Install** page. Select **Equal Stages** and **Dig And Push**.

Click the **Go** button.



Use the controls above the main window to move through the installation stages.



The **Define Box** pages are discussed in greater depth in **Chapter 4**, including those not mentioned in this brief introduction:

The **Job** page is used to enter customer details.

The **Loads/Slope** page is used to define surcharge loads and sloping or irregular ground.

The **Pressure** page is used to select the pressure model being used, or enter manually calculated pressure values.

The **Setup** page is used to enter user contact details, select units and set other various display options. It is also used to quickly reset some common calculation options.

## Shortcuts and Screen Hotspots

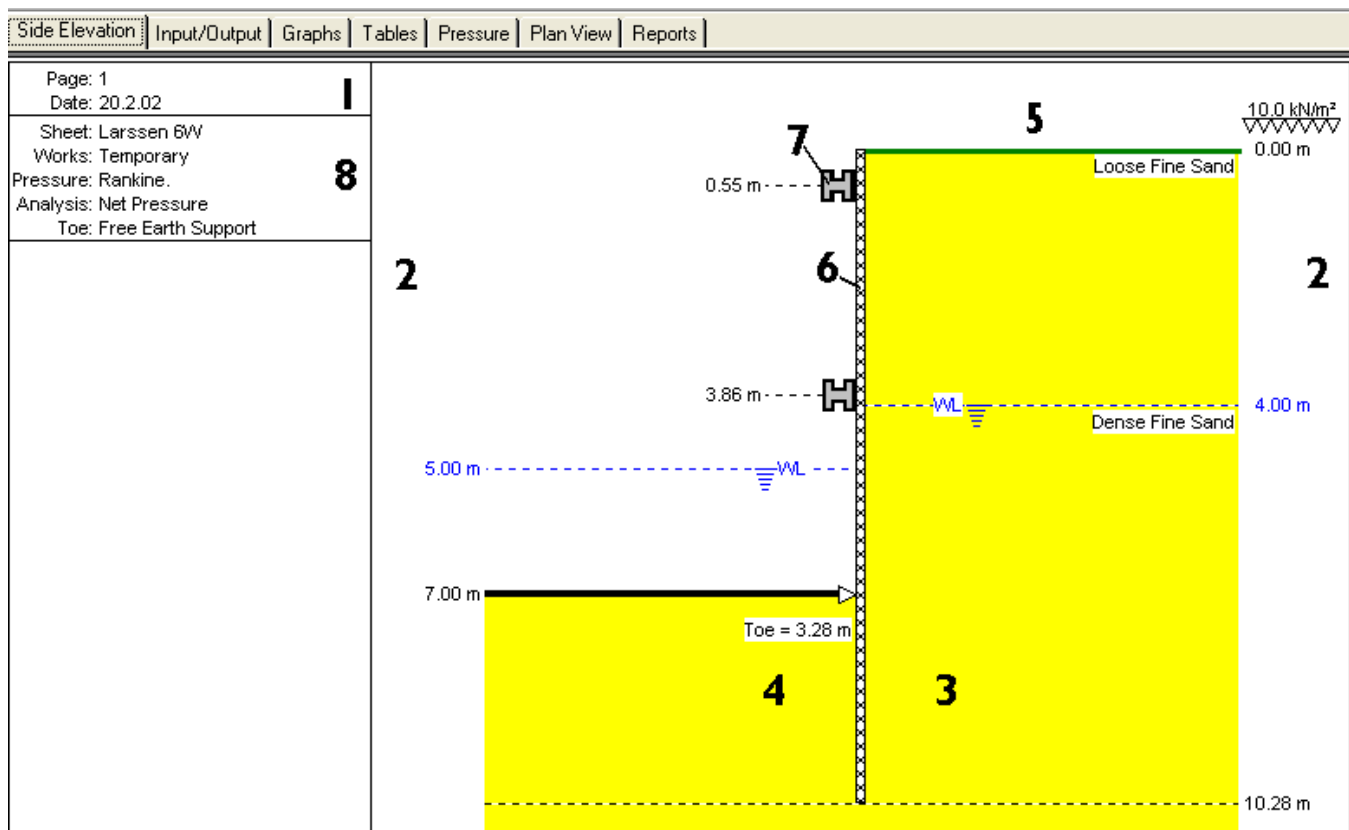
As seen in the preceding pages, the **Define Box** may be opened by double clicking anywhere in the main design window. The relevant page can then be selected using the tabs at the top of the **Define Box**.

The box is opened at the **Plan** page if the **Plan View** is displayed in the main design window and the central drawing area is double clicked.

The box is opened at the **Pressure** page if the **Pressure** page is displayed in the main design window and the central drawing area is double clicked.

Alternatively, the **Define Box** can be opened directly at the desired page by double clicking in one of the zones indicated below:

Zone	Define Box Page
1	The Job page
2	The Excavation page
3	The Soils page (active/passive editing switched on)
4	The Soils page (passive only switched on)
5	The Loads/Slope page
6	The Wall page
7	The Supports page
8	The Setup page



## Chapter 3

### Main Window

A new design can be started by clicking the **New** icon on the toolbar, or select **File ► New** from the menu bar.



A saved design can be loaded by clicking the **Open File** icon on the toolbar, or select **File ► Open** from the menu bar. Some sample files can be found in the designs folder in the install directory



Descriptions of each toolbar button and menu command can be seen in the status bar at the bottom of the main application window. The function of each button is also displayed when the pointer is placed over it.

You may need to adjust your computer's font size and/or screen resolution to optimise your display (see **Appendix D: Computer Settings**)

Load a file (eg. **Demo2** from the **Designs** folder) to view some features of the software.

The tabs at the top of the main design window are used to view various aspects of the design:



#### Side Elevation Page



This page shows the main elements of a design.

**Pressure, linear load, tieback load** (in soldier pile walls), **bending moment, shear force, deflection** and **water pressure** may be calculated and superimposed on the main diagram by selecting the relevant item from the **Superimpose** menu above the main window. Alternatively, click the appropriate toolbar button.

**Factor of safety** may be displayed by selecting from the **Superimpose** menu, or by clicking the relevant toolbar button. The calculation method used may be selected in the **Wall** page of the define box (the default is net pressure). **FOS** is not displayed for "no toe" solutions.

Select **Miscellaneous ► Full Size** or **Miscellaneous ► Fit Screen** from the menu bar to toggle between a full size view and a diagram which fits the VDU. Alternatively, click the appropriate toolbar button.

Select **Miscellaneous ► Report** from the menu bar for a report on the current design. Alternatively, click the appropriate toolbar button. This will list any potential design problems identified by the software. Items considered are bending moment (compared with allowed sheet moment), toe smaller than recommended, danger of rotation in "no toe" designs, water levels and warnings if manual pressure is on or pressure components are switched off. Other checks will be added as they are identified.

#### Input/Output Page



This page lists the input/output data for the design.

Note that the maximum value will be displayed in the **Maxima** table for any quantity which has been calculated. For example, if the deflection graph has not been displayed, no maximum deflection will be shown.

The legibility of this page can be improved by selecting **Miscellaneous ► Full Size** from the menu bar, or clicking the zoom button.

#### Graphs Page



The **Pressure, Bending Moment, Shear Force** and **Deflection** graphs are displayed with axes and maximum values shown.

In stepped excavations the graphs referring to sheet piles in different walls of the excavation may overlap. A key is shown beside the graph to indicate this.



## Tables Page

Tables

This page displays tabulated values of pressure, bending moment, shear force and deflection. Note that a column will be left blank if the relevant quantity has not yet been calculated. For example, if the deflection graph has not been displayed, no data will be shown in the deflection column.

In stepped excavations, the maximum relevant value is shown at depths where sheet piles in different walls of the excavation overlap. A key is shown in the depth column of the table to indicate this.



## Pressure Page

Pressure

This page displays details of the pressure calculation, in graphical or tabular format. The contents and format of the display can be modified using the **Pressure** page of the define box.

## Plan View Page

Plan View

This page displays a plan view of the excavation. The display varies for sheet pile and soldier pile/lagging walls:

### Sheet Pile Walls

The diagram displayed depends on whether a brace or waler has been used at a given depth, and indicates angled struts and/or anchors. Note that the sheet pile outline shown in the plan view is not to scale.

The plan view calculates reactions, bending moment, deflection and shear force on walers and braces. Multiple cross struts and knee braces may be used.

Different sides of the excavation can be displayed or hidden in the case of walings.

A key is displayed on the side bar, indicating the depth of the plan view and the linear load at that depth.

### Soldier Pile Walls

The current version of **SupportIT** assumes any additional supports in soldier pile walls are tiebacks installed at the soldier piles. The plan view does not show the tiebacks, but calculates the bending moment, shear force and deflection of the lagging. The tieback load may be viewed on the **Side Elevation** page.

A future release will allow walers/braces to be used with soldier pile walls.

Different sides of the excavation can be displayed or hidden.

The plan view is modified using the **Plan** page of the define box.

**Reactions, bending moment, deflection and shear force** can be superimposed on the diagram using the toolbar buttons or by selecting appropriately from the **Superimpose** menu, as described for the side elevation.

A table summarising the calculations can be displayed above the plan view, or hidden, by selecting **Superimpose ► Results Table** from the menu bar, or by clicking the appropriate toolbar button. The table is on by default, but the length/breadth, I and E must all be defined for calculations to be performed.

If the results table is switched off, a table is displayed on the side bar to show the maximum values of any graphs currently displayed.

## Reports Page

Reports

This page displays information relating to the safety of a design.

The report lists any potential design problems identified by the software. Items considered include bending moment (compared with allowed sheet moment), toe smaller than recommended, danger of rotation in "no toe" designs, water levels and warnings if manual pressure is on or pressure components are switched off.

Soil densities are examined and a warning is displayed if a submerged density seems large compared with the bulk density. The minimum section modulus, **Z**, required in a design is also displayed.

The same information can be displayed in a message box, by clicking the **Reports** button on the toolbar, and other checks will be added as they are identified.

Note that **Rules of thumb** can be switched on/off in the **Wall** page of the define box. These can improve design safety. Refer to **Appendix B** for details of the rules of thumb.

## Summary Page

Summary

This page is only displayed if the software is in installation mode. The page summarises the pressure, bending moment, deflection, shear force, frame loads, etc which occur at each stage during the installation of a design.

## Printing Designs

Select **File ► Print** (or click the **Print** button on the toolbar).

The paper orientation has been set to landscape by default. It may be changed to portrait using **File ► Print Setup**, in which case output will be scaled to this size.

**Print Range, Copies, Collate**, etc work in the usual **Windows** fashion.

There are a maximum of 8 pages associated with any design, as indicated by the tabs at the top of the design window, i.e. **Side Elevation, Input/Output, Graphs, Tables, Pressure, Plan View, Reports** and **Summary**. The **Summary** page is only displayed during installation stages.

The relevant page number (**1 - 8**) is printed below the design reference in the job description area at the left side of a page. When an installation stage is being viewed (ref: **Chapter 4**), page numbers are prefixed by the installation stage number, eg. the above page numbers would be **2.1 - 2.8** for **Stage 2**.

Page numbers can be switched on/off in the **Job** page of the define box. Page numbers are **on** by default.

### Printing to PDF files

Printing can be directed to a **pdf** file by downloading one of the various free applications from the internet which give you a **pdf** writing facility in the form of a printer driver. A typical driver is the one which can be downloaded from [www.primopdf.com](http://www.primopdf.com).

## Customising

Your company logo or other information may be displayed in the area at the left side of the title bar below the main design area. To use this area, create a bitmap file called **MyLogo**, and replace the current **MyLogo** file in the **Data** folder of the install directory. The bitmap will be plotted in the appropriate area.


The bitmap may be any size as it is scaled to fit the space available. However, as the maximum display area provided is **266 pixels x 70 pixels**, the bitmap should not be much larger than this.

Your company address and other contact details can be displayed in the title bar below a design. They can be altered in the **Setup** page of the define box. Double click anywhere on a design and select the **Setup** tab for this page. Alternatively, double click the relevant hotspot (ref: **Chapter 2**) to open the define box at the **Setup** page.

## Chapter 4

### Creating/Editing Designs

#### The Define Box

To start a new design, click the **New** icon on the toolbar or select **File ► New** from the menu bar. A blank excavation is displayed following the **New** command. 

Alternatively, load a saved design by clicking the **Open File** icon on the toolbar or select **File ► Open** from the menu bar. Some sample files can be found in the "**Designs**" folder in the install directory 

A design is edited using the "**Define Box**". This dialog box is opened by double clicking anywhere on the main diagram. There are several pages in the define dialog box and these are discussed below. Different pages are accessed by selecting the appropriate tab at the top of the define dialog box:



Alternatively, the box may be opened at the appropriate page by double clicking on the relevant hotspot (ref: **Chapter 2**) of the main design diagram, eg. double click the sheet pile to open directly at the **Wall** page of the dialog box or double click a waler/brace to open directly at the **Supports** page of the dialog box.

When the define box is opened, entries may be made to edit boxes and any changes become effective when the "**Enter**" key is pressed, or the mouse is clicked on another control within the dialog box.

In the case of the grids used in some cases (eg. to define frame positions) changes are not applied until the cursor is moved to a different cell in the grid, or leaves the grid. Movement between cells is achieved by clicking a new cell, or by pressing the **Up/Down/Left/Right** cursor arrows, or **(Shift)TAB**. The cursor leaves the grid when "**Enter**" is pressed, or another control is clicked.

In some cases a new item (soil layer, superimposed load, etc) is defined completely, then applied by clicking the "**Apply**" button (the one with the tick) at the bottom of the relevant page in the dialog box. If the **OK** button is clicked before **Apply**, the new item will not appear. At a later date this will be changed to ensure that changes are assumed to be accepted by clicking **OK**.

The status bar at the bottom of the main window describes the function of each object in the define box when the mouse pointer is placed over the object.

The pages of the **Define Dialog Box** are described below.

#### Job Page



Open this page by clicking the **Job** tab when the define box is open, or by double clicking the **Client/Title/Designer** areas at the left of the main window.

Most of the entries in this page are self-explanatory.

A client may be selected from the existing database by selecting from the drop down list which opens when the arrow to the right of the **Code** edit box is clicked. Data retrieved from the database may be edited in the relevant edit boxes. The database may be ignored completely, and entries made directly to the relevant boxes.

The **Show Page Numbers** check box is used to switch page numbering on or off.

The **Note** edit box is used to enter any notes relevant to the current design. Any note entered is displayed in the side panel to the left of the main design. Long notes may not be completely visible when viewing the design in **fit screen** mode, and this is indicated by a red "continue" arrow at the end of the note.



The **Clear Note** button at the bottom right clears the current note entry.

## Excavation Page

Excavation

Open this page by clicking the **Excavation** tab when the define box is open, or by double clicking the right or left margin of the main diagram.

Most of the entries in this page are self-explanatory. Refer to the description in the status bar for more information on any of the entries.

The main diagram is immediately updated when any entry is changed (eg. the depth of the excavation).

Water levels may be defined above ground level by entering **negative depths** in the relevant entry boxes. Water above the datum is indicated by a '+' beside the depth in the main design window.

The **Surcharge** is the standard surcharge at ground level, and the default value is **10kN/m<sup>2</sup>**.

The **Minimum Fluid Density** is used in the **Rankine** pressure model to give a minimum pressure value when soils with a high cohesion are involved. The default value is **5kN/m<sup>3</sup>**.

## Soils Page

Soils

Open this page by clicking the **Soils** tab when the define box is open, or by double clicking any soil layer. Note that the page is opened in a different mode, depending on whether a soil is double clicked on the active or passive side of the excavation (see below).

The **Passive Side** and **Active Side** list boxes at the top of this page list the soils currently present in an excavation. Any layer may be selected using these boxes.

A popup hint is displayed when the cursor is positioned over an edit box or button. A hint is also displayed at the bottom of the main window.

The **depth of the top surface of the layer** should be entered in the **depth** edit box. Note that the thickness of the layer is **not required**.

If a new layer is added or the depth of a layer is changed and an existing layer is at the same depth, the existing layer is moved down.

Edit soil properties by entering values in the appropriate boxes. Note that the density values required are the **Bulk Density** and the **Submerged Density** (i.e. not the **saturated density**).

After editing an entry, press "**Enter**" or click another field to implement it and update the diagram. A soil may be selected from the database by selecting from the drop down list which appears when the arrow to the right of the **Soil Name** box is clicked. Note that changes made in this page do not affect the soils database - only the current layer. The depth of each layer is measured from the top of the excavation - this means the depth of the top layer on the passive side may not equal the depth of the excavation.

Different soils may be defined on the active and passive sides of the excavation. Choose whether you are editing **both sides**, **active side only** or **passive side only** by clicking the relevant button (see below). By default, both sides are being edited simultaneously, and this is the case if the define box is opened by double clicking a soil on the active side. However, if the page is opened by double clicking a soil on the passive side, then **passive side only** is enabled.

The current editing mode is indicated in the panel at the bottom left of the page.

The page buttons are:



Add a new layer by clicking the **New Layer** button. The properties of the new layer should then be defined as described above, before selecting the **Apply** button.



Click the **Apply** button to accept a new layer definition. The new layer is not added to the design until the **Apply** button is clicked.



Cancel a new layer definition by clicking the **Cancel** button. The new layer is not added to the design.



Delete an existing layer by clicking the **Delete Layer** button.



Restrict any changes in soil depth and properties to the passive side of the excavation by clicking the **Edit passive side** only button. Any subsequent changes will not be applied to the active side of the excavation.



Restrict any changes in soil depth and properties to the active side of the excavation by clicking the **Edit active side** only button. Any subsequent changes will not be applied to the passive side of the excavation.



Apply any changes in soil depth and properties to the active **and** passive side of the excavation by clicking the **Edit active and passive sides** button.



Make the passive soil layers identical to the active soil layers at any time by clicking the red "**left arrow**".



Make the active soil layers identical to the passive soil layers at any time by clicking the red "**right arrow**".

## Loads/Slope Page

Loads/Slope

Open this page by clicking the **Loads/Slope** tab when the define box is open, or by double clicking above the excavation on the active side in the main design window.

The top of this page allows various surcharges to be added to a design, while the bottom is used to vary the surface profile. The different sections of the page are:

### Loads

The list box at the top right lists the current loads. A load may be selected from the list for editing.

Select a load **Type (Point/Line/Strip/Area)** from the drop down list, and use the edit boxes to enter the values indicated in the diagram shown beside the edit area. After editing an entry, press "**Enter**" or click another field to implement the change and update the diagram.

The **depth** entry is used to simulate foundations, or loads above the datum with custom slopes (see below). If a custom slope has been selected, loads can be placed above the datum by entering a **negative depth** in the **depth** entry box. A load above the datum is indicated by a '+' beside the depth in the **Input/Output** page of the main window. The effect of placing the load above the datum will be small in many cases, but the diagram will "look correct".

**Yielding Wall** This determines whether the pressure calculated for a strip or area load uses the formula for a yielding or non-yielding wall. The setting has no effect on point or line loads.

The effects of surcharge loads on soil pressure are calculated according to Terzaghi's modification of Boussinesq elastic theory (Ref: "**CIRIA Report 104**", pg 58; "**USS Steel Sheet Piling Design Manual**", pg 14). The calculation methods are summarised in **Chapter 7**.

The load editing buttons are:



Add a new load by clicking the **New Load** button. The properties of the new load should then be defined as described above, before selecting the **Apply** button.



Click the **Apply** button to accept a new load definition. The new load is not added to the design until the **Apply** button is clicked.



Cancel a new load definition by clicking the **Cancel** button. The new load is not added to the design.



Delete an existing load by clicking the **Delete Load** button.

## Ground Profile

This panel is used to define the ground profile on the active and passive sides of the excavation. The buttons in the **Slope** panel are used to define level or sloping ground on each side:

### Level Ground (Active)



The ground surface is set to horizontal on the active side.

### Sloping Ground (Active)



Select the appropriate button to define a positive or negative slope on the active side. The angle of slope,  $\beta$ , should be entered in the box provided.

### Level Ground (Passive)



The ground surface is set to horizontal on the passive side.

### Sloping Ground (Passive)



Select the appropriate button to define a positive or negative slope on the passive side. The angle of slope,  $\beta$ , should be entered in the box provided.

Two methods of analysis are available for sloping ground:

### Modify K Values.

The soil **K** values are recalculated when the ground is changed between level and sloping or the angle of slope is changed, and the **Rankine** or **Coulomb** pressure model has been selected. The **K** values are recalculated using the given angle of slope. Note that the formula used requires that the angle of slope does not exceed the angle of soil friction. If such a condition exists, it is assumed that the angle of friction equals the angle of slope in any soil layer where it occurs, and a warning to this effect is displayed in the message box at the bottom of the page. The message appears, or changes colour, whenever the **K** values are recalculated. The **K** values can always be changed manually in the **Soils** page of the define box.

### Use British Steel Piling Handbook Approximation.

As described in "**BSPH (7th Edition)**" (pg 4/12), it is assumed that soil pressure changes by **5%** for each **5 degrees** of slope. This avoids the problem outlined above. The **BSPH** approximation is always used with the **Terzaghi** pressure model.



## Custom Slope

Select the custom slope button in the **Custom** panel to define irregular ground on the active side. The ground is defined by entering a series of coordinates in the grid provided. Coordinates are measured from the top of the sheet, and may be entered in any order. Positive or negative **y** values may be entered. For example, enter the values:

0, 0	OR	0, 0
2, 0		2, 0
3, 2		3, -2
5, 2		5, -2

When editing the coordinates:



Click the **Apply** button to apply the defined points to the design. The **Apply** button must be clicked to implement any changes to the data.



Click the **Delete Point** button to delete the currently selected row in the table.



Click the **Delete All Points** button to delete all the points in the table.



A number of pre-defined custom slopes are available. Click the appropriate button in the **Pre-defined** panel for a given shape. The values in the grid may be edited.

When a customised slope has been defined, pressure is calculated by treating the slope as a series of superimposed strip loads.

## Wall Page



Open this page by clicking the **Wall** tab when the define box is open, or by double clicking the sheet pile in the main design window (only possible after the excavation depth has been defined).

This page is used to define:

- the method of supporting an excavation (sheet pile wall, soldier pile wall or stepped excavation)
- sheet pile, soldier pile and lagging properties
- the method of wall analysis.

The different sections of the page are:

### Wall

Select the method of excavation support from the drop down list in the **Type** box: **Sheet Pile Wall**, **Stepped Excavation** or **Soldier Pile & Lagging**.

The contents of the remaining sections of the page will change according to the selection made. Note that **Stepped Excavation** assumes that sheet piles will be used for each step. This may be changed in a future release.

Wall			
Type:	Sheet Pile Wall		
Sheet			
Name:	Larssen 6W		
E:	2.1E+08 kN/m <sup>2</sup>	I:	6459.0 cm <sup>4</sup> /m
f:	200.0 N/mm <sup>2</sup>	Z:	610.0 cm <sup>3</sup> /m
Max. Bending Moment:		122.0 kNm/m	
W:	44.7 kg/m	A:	108.0 cm <sup>2</sup> /m
b:	0.525 m		

### Sheet

This panel only appears if **Sheet Pile Wall** or **Stepped Excavation** is selected in the **Wall** panel (above).

Entries and units are the same as those described for the **Sheet** database (**Chapter 6**).

Edit sheet properties by entering new values in the appropriate boxes. After editing an entry, press "**Enter**" or click another field to implement it and update the diagram.

A new sheet may be selected from the database by selecting from the drop down list which appears when the arrow beside the **Name** box is clicked. The **Working Stress** and **Bending Moment** values recalled from the database depend on the **Temporary/Permanent Works** setting in the **Setup** page. Alternatively, enter a new sheet name by typing it directly into the box. Note that changes made in this page do not affect the sheets database - only the sheet in the current design.

### Stepped Excavation

The **Sheet** panel described above is displayed if **Stepped Excavation** is selected in the **Wall** panel (above). There is an additional control which takes the form of a grid used to define the steps of an excavation. The grid is used to define 'D' and 'B' for a number of walls, where 'D' is the depth of the top of a local datum, and 'B' is the offset from the previous wall. These dimensions are shown in the key to the right of the grid.



Click the **Delete Row** button to delete the currently selected row in the table.

Sheet properties for the currently selected wall are defined by entering values in the appropriate boxes of the **Sheet** panel, as described above.

Wall			
Type:	Stepped Excavation		
Sheet			
Name:	Larssen 6W		
E:	2.1E+08 kN/m <sup>2</sup>	I:	6459.0 cm <sup>4</sup> /m
f:	200.0 N/mm <sup>2</sup>	Z:	610.0 cm <sup>3</sup> /m
Max. Bending Moment:		122.0 kNm/m	
W:	44.7 kg/m	A:	108.0 cm <sup>2</sup> /m
b:	0.525 m		

D (m)	B (m)
0.00	0.00
3.00	1.00
7.00	0.00

Each wall is analysed independently in the case of stepped excavations, i.e. it is assumed there is no transfer of load from a wall to an adjacent wall. The user should ensure walls are far enough apart for this to be the case.

A stepped excavation can be viewed in the demonstration file **Demo6**, supplied with **SupportIT**. Open the file then select **Stepped Excavation** in the **Type** box (see above).

### Soldier Pile & Lagging

Two panels are displayed for defining the **Soldier Pile** and **Lagging** properties respectively. These only appear if **Soldier Pile & Lagging** is selected in the **Wall** panel (above). The **Sheet** panel is not displayed.

Edit soldier pile and lagging properties by entering new values in the appropriate boxes. After editing an entry, press "**Enter**" or click another field to implement it and update the diagram.

A new soldier pile or lagging may be selected from the **Frame** database (**Chapter 6**) by selecting from the drop down lists which appear when the arrows beside the **Name** boxes are clicked. Note that changes made in this page do not affect the frames database - only the soldier pile or lagging in the current design.

Most entries and units are the same as those described for the **Frame** database (**Chapter 6**). Some additional entries relevant to the calculation method are required:

- w** the diameter of any preaugered hole for the soldier pile. The minimum value of this is the diameter of the pile.
- s** the distance between the soldier piles.
- A** passive arching factor.
- n** defines the depth over which passive pressure is ignored, as described in **AASHTO**.
- r** the **load reduction factor**, as summarised in **Chapter 9**.

**Apply 'A to both sides**

The passive arching factor, 'A', is applied to both sides (active and passive) of the excavation if this box is checked. 'A' is only applied to the passive side if the box is unchecked. See **Chapter 9** for details.

**Draw to scale**

Soldier piles and lagging are drawn to scale if this box is checked. In some cases the diagram is improved by not having these drawn to scale, as the vertical and horizontal scales usually differ and the dimensions may appear incorrect.

**Show key**

This displays/hides a diagram explaining each of the above. Each term is discussed in detail in **Chapter 9**.

A soldier pile wall can be viewed in the demonstration file **Demo6**, supplied with **SupportIT**. Open the file then select **Soldier Pile & Lagging** in the **Type** box (see above).

**Analysis Method**

The analysis method for factor of safety (**Gross Pressure**, **Net Pressure** or **Burland-Potts**) may be selected by clicking the appropriate radio button. The analysis method is calculated as outlined in the "**British Steel Piling Handbook (7th Edition)**", pg 5/6, and "**CIRIA Report 104**", pp 70 - 72.

The selected method is applied to **all walls** in a **stepped excavation**.

**Penetration**

The method of support (**Free Earth**, **Fixed Earth**, **Defined FOS**, **No Toe**, **Manual**) may be selected by clicking the appropriate radio button. The penetration depth is calculated as outlined in the "**British Steel Piling Handbook (7th Edition)**", pg 5/6, and "**CIRIA Report 104**", pp 70 - 72.

The selected method is applied to **all walls** in a **stepped excavation**.

**Miscellaneous**

**Upstand**

An **Upstand** may be entered in the appropriate edit box. Frames and water may be placed above ground level in the **Supports** page and **Excavation** page respectively, after an upstand has been defined. A different upstand may be defined for each wall in a **stepped excavation**.

**Toe**

If **Manual** is selected in the **Penetration** section, a toe may be entered manually in the edit box provided. A different toe may be defined for each wall in a **stepped excavation**.

## FOS

If **Defined FOS** is selected in the **Penetration** section, then the desired factor of safety should be entered in the edit box provided. The toe will be calculated to provide this factor of safety. The same **FOS** is applied to each wall in a **stepped excavation**.

## R, the Moment Reduction Factor

A factor may be entered to reduce the calculated bending moment and deflection, according to **Rowe's Moment Reduction Theory**. Rowe's theory was developed from empirical evidence gathered under specific conditions (wall type, soil type, etc), and should be used with caution. The value of **R** is usually determined from moment reduction curves. The user should ensure that moment reduction may be applied to the current design, and that the value of **R** is appropriate. Refer to **Chapter 8** for more details.

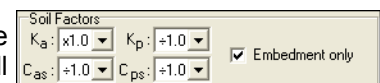
## Rules of thumb

The **Rules of thumb** check box switches a number of **Rules of thumb** on/off. The rules of thumb may make a design safer by applying a larger toe than predicted by theory, or suggesting an alternative support method. They will **never result in a smaller toe** than theory predicts being used. If switched on, the rules of thumb will be applied every time a recalculation is made following a change in design specification (eg. changing a soil parameter). A warning is displayed indicating which rule has been applied, if any. To avoid repeatedly seeing this warning, switch **Rules of thumb** off until the design is completed, then switch it on. Refer to **Appendix B** for details of the rules of thumb.

## Soil Factors

The **Soil Factors** panel allows different factors to be applied to soil parameters to increase the active pressure and/or decrease the passive pressure, as described in the "**British Steel Piling Handbook (7th Edition)**", pg 5/7, "**CIRIA Report 104**" (pp 69 – 70) and the "**Pile Buck Steel Sheet Piling Design Manual**".

The toe is increased when a factor greater than **1.0** is selected. The factor(s) can be applied to the embedment calculation only, or to all calculations:



Soil Factors			
K <sub>a</sub> :	x1.0	K <sub>p</sub> :	+1.0
C <sub>as</sub> :	+1.0	C <sub>ps</sub> :	+1.0
			<input checked="" type="checkbox"/> Embedment only

### K<sub>a</sub>

A factor in the range **1.0 – 2.0** may be selected from the drop down list. The active pressure coefficient, **K<sub>a</sub>**, is multiplied by the selected factor with a resultant increase in the active pressure. **K<sub>ac</sub>** is adjusted accordingly. The factor is only applied if the angle of soil friction in a layer is non-zero (i.e.  $\phi > 0$ ).

### K<sub>p</sub>

A factor in the range **1.0 – 2.0** may be selected from the drop down list. The passive pressure coefficient, **K<sub>p</sub>**, is divided by the selected factor with a resultant decrease in the passive pressure. **K<sub>pc</sub>** is adjusted accordingly. The factor is only applied if the angle of soil friction in a layer is non-zero (i.e.  $\phi > 0$ ).

### C<sub>act</sub>

A factor in the range **1.0 – 2.0** may be selected from the drop down list. The cohesion on the active side is divided by the selected factor with a resultant increase in the active pressure.

### C<sub>pas</sub>

A factor in the range **1.0 – 2.0** may be selected from the drop down list. The cohesion on the passive side is divided by the selected factor with a resultant decrease in the passive pressure.

### Embedment only

The check box defines how the selected soil factors are applied. The factors are only applied during the embedment calculation, as recommended in "**CIRIA 104**", if the check box is selected. The factors are applied to all calculations, as recommended in the "**Pile Buck Steel Sheet Piling Design Manual**", if the check box is unselected. The calculated sheet pile embedment is the same for both settings. The default setting is **on**.

## Note:

1. In some cases the calculated free earth support depth exceeds the calculated fixed earth support depth. This usually occurs (but not always) when there is a cohesive layer at the base of the excavation, and in such cases **SupportIT** assumes that the fixed earth support depth equals the free earth support depth and displays a warning to this effect, i.e. the toe for fixed earth support is increased from the calculated value. The excavation is then assumed to be **Free Earth Support** for all subsequent calculations, i.e.

frame load, moment, etc. This produces larger frame loads, bending moment, etc, and is the safest approach. The toe can still be adjusted manually if desired (see above).

2. **FOS** refers to the stability against rotation about the lowest frame, or toe in the case of a cantilever. By definition, free earth support conditions exist when the passive pressure is sufficient to resist the forward movement of the toe, and the penetration should be sufficient to give a factor of safety of 2 against rotation of the wall about the lowest frame.

Similarly, fixed earth support conditions exist when the penetration of the wall is such that the passive pressure is sufficient to prevent both forward movement and rotation at the toe. As any displayed fos relates to stability about the lowest frame, it tends to be high in cases of fixed earth support, and should be treated with caution.

In cantilever walls, the displayed fos is calculated independently of the 20% correction factor applied to compensate for the simplified method of calculating the toe.

3. When soil factors have been applied, the displayed fos still refers to stability against rotation about the toe (cantilever wall) or the lowest frame (propped wall). The displayed fos does not include the effect of the factored soil parameter(s) as it is calculated using the factored parameter(s). The recommended factor of safety depends on the circumstances and method used, as described in "CIRIA 104", pp 72 – 74. The **Defined FOS** option can be used to enter any desired fos, and **Table 5** in "CIRIA 104" gives recommended values of fos applicable to the various methods.
4. If **Embedment only** is switched **on**, then the pressure graph displayed is only calculated down to the unfactored embedment depth – i.e. it will appear to stop short of the bottom of the sheet. However, the calculated pressure down to the bottom of the sheet will have been used to calculate the indicated toe.
5. There is an anomaly in the **Gross Pressure** method when  $K_a = K_p = 1$ , where it is found that the calculated fos decreases with increasing length of wall beyond a certain depth of penetration (Ref: "British Steel Piling Handbook (7th Edition)", pg 5/6).
6. Sheet penetration can only be calculated if the pressure graph cuts the sheet below ground level. If this is not the case (eg. when the lowest soil layer is very soft clay), then the design reverts to a "no toe" design and an appropriate warning is displayed. In such cases, a penetration can often be calculated by changing the pressure model on the **Pressure** page (eg. by using the **Terzaghi** model).
7. Similarly, in some cases it is not possible to calculate the sheet penetration using the selected analysis method (**Gross Pressure**, **Net Pressure** or **Burland-Potts**). When this occurs, and the selected method is not the **Net Pressure** method, the software tries to find a solution using the **Net Pressure** method and displays an appropriate message if the penetration is calculated successfully. Alternatively, an appropriate message is displayed if no sheet penetration could be calculated, and the design reverts to a "no toe" design.
8. Cantilever embedment is always calculated assuming fixed earth conditions exist at the toe. Selecting **Free Earth Support** will produce the same penetration as **Fixed Earth Support** in a cantilever wall.

## Supports Page



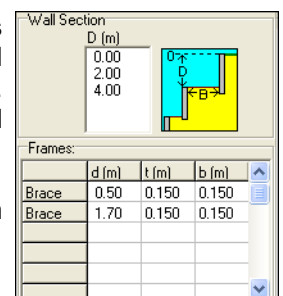
Open this page by clicking the **Supports** tab when the define box is open, or by double clicking any existing support in the main design window.

This page is used to define supporting frames and select a model for calculating the frame load(s). The different panels of the page are:

### Frames

The positions (**d**), widths (**t**) and heights (**b**) of frames are defined using the **Frames** grid. Enter a new value, or edit an existing value in the grid. Changes are applied when the cursor is moved to a different row in the grid, or leaves the edit box - i.e. press the **up/down** cursor key; press **TAB**; press **Enter**; or click on another control within the page.

Select a different frame by clicking it in the grid or by double clicking it in the main design diagram.



An additional control is provided in the case of a **stepped excavation**. The **Wall Section** list box allows each of the walls defined in the **Wall** page to be selected. The frame depth in a stepped excavation should be entered **relative to the local datum**, ie. the depth below the bench at the top of the relevant wall. This is indicated in the graphic displayed beside the **Wall Section** control. The relative and absolute depths (i.e. from the top of the excavation) of frames are displayed in tables in the main display pages.

The grid described above is different in the case of a **soldier pile wall**. Supports are assumed to be tiebacks placed in the position of the soldier piles. The 't' and 'b' columns of the grid are absent and the tieback depth is the only entry required. A tieback cannot be selected from the database (see '**Selected Frame**', below). Some of the other controls described below are also disabled when a soldier pile wall is being designed, eg. '**Scale Frame**', '**Anchor**', etc.

A support can be placed above ground level (or above the local datum in a stepped excavation) by entering a negative 'd' value in the grid. An upstand must have been defined in the **Wall** page beforehand. The frame position must be within the defined sheet length. Frames above ground are indicated by a '+' beside their depth in the main window.

### Selected Frame

A frame description/type can be selected from the database and applied to the current frame position using the **Name** box. This recalls values for the frame type/width/height/E/I, and these are applied to the side elevation and the plan view. The **Name** and frame **Type** of the selected frame can be changed. The frame type can be designated as "waler" or "brace". A different symbol is used for each, and some edit fields and buttons are disabled for "brace".

The **Share load** check box is used to allocate the loads of a frame and the one above equally between the two frames. This can be used, for example, when two frames have been placed close together. A line connecting the two frames is drawn to indicate that this option has been selected.



The **Copy Frame** button is used to copy the selected frame **name**, **type**, 't' and 'b' to all other frames in the design.



The **Delete Frame** button is used to remove a frame.

### Strut

If the frame selected in the grid is a waler, strut angles and soil anchors may be selected using the appropriate boxes.



The **Copy Strut** button is used to copy the selected strut definition to all other struts in the design.

### Find Supports

This section of the page can be used to calculate support positions which will produce a design within the specified maximum allowed sheet bending moment:

The **Maximum top support depth** specifies the lowest depth at which the top support is to be placed. The top frame will not be placed below the specified depth.

The **Minimum clearance** is the depth which must remain free of supports at the bottom of the excavation, for access or other reasons. No frames will be placed lower than the specified depth.

The **SWL** is the maximum allowed linear safe working load of the frames being used. Frames will be placed to ensure that the maximum linear load is less than the value specified.



Enter appropriate values in the above boxes (or leave them blank to use only the allowed pile bending moment), then click the **Find Supports** button. A solution may not be found for the specified criteria in some cases, and a warning to this effect will be displayed.

### Load Model

In single propped walls, frame loads are calculated using the appropriate method for **Free/Fixed Earth Support** (Ref: "**BSPH (7th Edition)**"; "**CIRIA 95**").

With multiple frames, the load calculation model can be set to to **Area Distribution**, **Hinge Method** or **Rigid Wall** (ref: **Chapter 8**).

If **Elastic Shear** is switched on, moment transfer is used to adjust the calculated loads. **Elastic Shear** is only available with the **Area Distribution** model.

The earth pressure mobilisation factor for the rigid wall method may be entered in the **P x** box.

#### Other check boxes

Select **Concrete lowest frame** to indicate concrete below the lowest frame position (the frame type, i.e. **waler** or **brace**, will be ignored). Frame positions may be adjusted after setting **Concrete lowest** - it is always the lowest frame which is concreted.

The **Hanging chains** check box is used to display/hide hanging chains on the side elevation diagram.

The **Scale frame** check box is used to draw frames to scale. The selected setting is applied to the side elevation and the plan view. Note that the vertical and horizontal scales may differ, and it is often better not to draw frames to scale.

The **Show frame description** check box is used to display/hide the frame description on the side elevation diagram.

## Install Page



Open this page by clicking the **Install** tab when the define box box is open.

The software can be used to simulate the installation of the support system and generate a method statement. The installation process is defined by selecting the relevant properties:

#### Stages

The installation can be completed by excavating in a number of **Equal Stages**, or by excavating to **Support Positions**. If the former is selected, the number of stages required should be entered in the **Stages** edit box. The default number of stages is **5**. This method is unavailable with a stepped excavation.

If **Support Positions** is selected, installation is achieved by excavating to successive support positions.

**Clearance** is the clearance required below a support for it to be installed. The default value is **300mm**.

#### Excavate by

Sheet installation can be by **Dig And Push**, **Pre-drive** or **Constant Toe**. The last option uses a constant toe throughout the installation process, and the value of this toe should be entered in the **Toe** edit box.

#### Installation options

If **Use temporary supports** is **On**, then a temporary support will be inserted in some cases to ensure stability, and an instruction will be given in a later stage that the temporary support should be moved down. This option is only available when **Equal Stages** has been selected.

If **Remove frame above concrete** is **On**, then an extra installation stage will be added to remove the frame immediately above any concrete slab which has been defined. The option is only available if **Concrete lowest frame** has been selected in the **Supports** page, and if there is at least one frame above the concrete. The option counts as one of the 5 allowed "user-defined" stages (see below) if selected.

#### Other page controls

##### Show method statement

A computer generated method statement is displayed in the side bar beside the main diagram. This method statement is not user-editable. However, the **Note** field (defined in the **Job** page) may be used to provide more information. A different note may be used for each stage.

The method statement is only printed on the **Side Elevation** page The stage number is indicated on the other pages if **Method Statement** is switched on. The stage number is also indicated by the page number, eg **2.1**, **3.1**, etc.

### Show full sheet height

The full length of the sheet pile is shown during excavation. This results in the lower part of the diagram being smaller. If this option is not selected, a faint image of the sheet is shown above the excavation to indicate that the sheet is longer than shown to scale.

### Report at each stage

Reports on each stage automatically using a message box. This can be left off, and a report requested at each stage in the usual way.



After selecting the options above, click the **GO** button to start the installation process. A control panel appears beside the page tabs at the top of the main window:



Click to move back to the first stage.



Click to move back to the previous stage.



Click to stop the installation procedure.



Click to move to the next stage.



Click to move to the last stage which has already been viewed, i.e. it will not jump to stage 5, if you have only viewed up to stage 3.



Click to add a new "user-defined" stage. A maximum of 5 such stages may be added, and the option described above for removing a frame above concrete is counted as an extra stage. The button can only be selected when you are viewing the current last stage, and creates a new stage in which you can make your own changes, eg. you can dewater, add/delete frames or loads, etc. The **Note** field in the **Job** page can be used for giving additional instructions.



Click to switch the method statement on/off.

### Summary

An extra page, **Summary**, is available during installation. The **Summary** page shows three tables relating to the installation. One table shows the depth, frame loads, maximum pressure, maximum bending moment, etc at each stage, while the other tables show the maximum value of each quantity during the installation, and the stage numbers where they occur. A stage is only included in the tables if it has already been viewed.

During installation, most of the normal functions are available. For example, graphs can be superimposed/plotted in the usual way, supports may be moved or added, etc. However, some functions are disabled during installation - eg. only the **Note** edit box is available in the **Job** page; only the **Show Method Statement** and **Show Installation Summary** selections may be changed in the **Install** page; the **Units** may not be changed.

### Plan Page

#### Plan

Open this page by clicking the **Plan** tab when the define box is open, or by double clicking anywhere on the main diagram when the **Plan View** is displayed.

### Sheet Pile Walls and Stepped Excavations

When first viewed, the plan view refers to the most recently selected frame (i.e. the last frame to be double clicked, or selected in the **Supports** page). If no frame has been selected, the default plan view is for the frame which bears the greatest load. A plan view can be viewed for any other frame by double clicking it then opening the plan view, or by selecting it from the lists displayed at the top of the **Plan** and **Supports** pages of the define box, as described below.

d (m)	Load (kN/m)
1.00 Waler	26.1
4.00 Waler	98.8

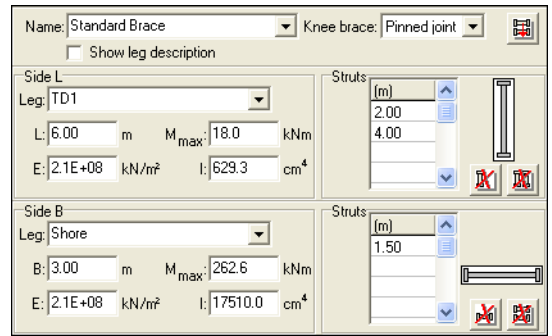
The list box in the **Supports** panel at the top of the **Plan** page shows the current support positions and the linear load at each depth. Click a support to show the plan view at that depth.

d (m)	Load (kN/m)
0.50 Brace	33.9
1.80 Brace	60.4

In **stepped excavations**, a second list box is displayed in the **Supports** panel to allow each of the walls defined in the **Wall** page to be selected. This list box

will not be displayed in single sheet pile or soldier pile and lagging walls. The frames listed in the frames box (see above) will be those for the selected wall.

The **Name** box is used in the same way as the **Name** box in the **Supports** page, i.e. a description of the frame can be entered directly into the box, or a frame can be selected from the database. When a brace is selected from the database, the relevant leg types for the brace are added to the **Leg** boxes in the **Side L** and **Side B** panels below. The leg types displayed in each list are those specified for the selected brace in the frames database.



Note that selecting a new frame will affect some values/settings in the **Supports** page.

The brace leg types are displayed on the **Side Elevation** and **Input/Output** pages of the main window if **Show leg description** is selected. These leg types are added to the frame description, if **Show description** is also switched on in the **Supports** page.

The **Knee brace** control is used to select **no** knee braces, **fixed joint** knee braces or **pinned joint** knee braces. The setting will have no effect unless struts have been defined in the side **L** and **B** **strut grids** (see below). If struts have been defined, then any selected knee braces are drawn between the first and last defined struts on each side.



The **Copy Plan** button copies the currently defined plan to all other frame positions. Items copied include the frame name, frame type, frame dimensions, cross struts and knee braces. Note that the frame name, frame type and frame dimensions can also be copied to different depths using the **Copy Frame** button on the **Supports** page.

The **Side L** and **Side B** panels are used to specify the length and breadth of the excavation, and properties of the frame used. The excavation length and breadth should be entered in the '**L**' and '**B**' boxes in each panel. **If a brace is being used**, the leg type and properties (i.e. **E**, **I** and **M<sub>max</sub>**, the maximum bending moment) for each dimension may be selected from the **Leg** drop down lists. **M<sub>max</sub>**, **E** and **I** values can also be entered directly into the appropriate boxes.

The **Leg** boxes are disabled if a waler is being used, and **M<sub>max</sub>**, **E** and **I** are disabled for side **B** if walings have been used and neither side is closed (see below).

Different dimensions may be entered at each frame depth. This is particularly useful in **stepped excavations**.

Different sides of the excavation may be shown/hidden in the main diagram using the **On** check boxes beside the diagram at the top right of this page. These controls are disabled if a brace is being viewed, as all sides are then closed.

Additional struts along sides **L** and **B** are defined using the grids on the right of the page. The **Side B** grid is disabled if walings are being used and either side is not closed. In these strut definition areas:

The grid shows current strut positions, if any. Enter or edit strut positions by clicking on a grid cell. Changes are not applied until the cursor leaves the grid - this is achieved by pressing "**Enter**", or clicking on another control within the page.



Delete a strut by selecting it in the grid then clicking the **Delete Strut** button beside the grid.



Delete all struts in a grid by clicking the **Delete All Struts** button beside the grid.

A database of struts will be available in a future release of **SupportIT**. The **Note** feature in the **Job** page may be used in the meantime to describe strut details in the side margin.

**Reactions**, **Bending Moment**, **Shear Force** and **Deflection** are displayed above the plan diagram, if the **Results Table** is switched on.

## Soldier Pile and Lagging Walls

The plan view is always at the depth where the maximum lagging bending moment occurs, i.e. the depth of maximum pressure. No selection may be made from the **Supports** panel.

The only controls used on the **Plan** page are the plan dimensions, 'L' and 'B', and the 'On' boxes for showing/hiding different sides of the excavation.

Note that in the plan diagram the length, 'L', of the excavation is always assumed to be an integral number of soldier pile separations, as specified in the **Wall** page. This is to ensure a soldier pile is placed at each end of side L, and may cause the dimension shown in the plan diagram to differ from the value entered in the **Plan** page. For example, if a soldier pile separation of **2.5m** is specified in the **Wall** page and **12.0m** in the **Plan** page, then the length displayed in the plan diagram will be **10m**. In side 'B', the diagram may show a smaller span than that entered in the **Wall** page at one or both ends of side 'B', to give the same dimension as specified in the **Plan** page.

The maximum **Pressure**, **Bending Moment**, **Shear Force** and **Deflection** are displayed above the plan diagram, if the **Results Table** is switched on. The **minimum section modulus** required for the lagging is also displayed above the plan diagram. The displayed values include any load reduction factor entered in the **Wall** page.

## Pressure Page



Open this page by clicking the **Pressure** tab when the define box is open, or by double clicking anywhere on the main diagram when the **Pressure** page is being viewed in the main window.

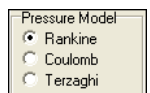
This page has five basic functions, and can be used to:

- select different pressure models.
- turn passive softening on or off.
- change the way hydrostatic pressure is modelled in cohesive soils.
- change the format of the **Pressure** page of the main design window.
- view details of the pressure calculation.
- enter manually calculated pressure values.

Different components of the page are described below:

### Pressure Model

The pressure model used in the design may be varied:



#### Rankine

Pressure is calculated as outlined in the "**British Steel Piling Handbook (7th Edition)**", Ch. 4. The net pressure is calculated by finding the sum of the **Active Soil Pressure ( $P_{as}$ )**, **Passive Soil Pressure ( $P_{ps}$ )**, **Active Water Pressure ( $P_{aw}$ )**, and **Passive Water Pressure ( $P_{pw}$ )**. The calculated net pressure may be negative in cohesive layers with a high **C**, and in such cases the pressure is assumed to be the value of the **minimum fluid pressure** which is the pressure due to an equivalent fluid of **5kN/m<sup>3</sup>** density. The value of the minimum fluid density may be changed in the **Excavation** page. Alternative methods may be used to calculate pressure in cohesive soils - see "**Cohesive Soils: Active Side**" and "**Cohesive Soils: Passive Side**" below.

#### Coulomb

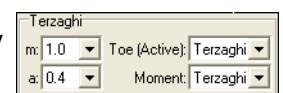
Pressure is calculated as above, using modified **K** values (ref: **Chapter 7**).

#### Terzaghi

**Active Soil ( $P_{as}$ )** pressure is calculated using an appropriate envelope, as described in "**CIRIA Special Publication 95: The Design And Construction of Sheet-Piled Cofferdams**". If there is more than one soil type present, the software selects the envelope which will produce the maximum pressure, assuming one soil throughout the excavation.

**Active/Passive Water** pressure is added to find the net pressure. **Minimum Fluid Pressure ( $P_{mf}$ )**, is not relevant to this pressure model. Alternative methods are provided for modelling hydrostatic pressure in cohesive soils with the **Terzaghi** pressure model - see "**Cohesive Soils: Active Side**" and "**Cohesive Soils: Passive Side**" below.

Additional settings are available in the "**Terzaghi**" panel, which is only available when the **Terzaghi** pressure model has been selected:



## m and a

The values of 'm' and 'a' used in the **Terzaghi** pressure model may be selected in the appropriate boxes.

## Toe (Active)

**Active Soil ( $P_{as}$ )** pressure is calculated using **Terzaghi** above the excavation depth, i.e. formation level. **Passive Soil ( $P_{ps}$ )** pressure is calculated using **Rankine**. **Toe (Active)** determines how **SupportIT** calculates the active pressure below the excavation depth:

### Rankine

**Active Soil ( $P_{as}$ )** pressure below the excavation depth is calculated using **Rankine**.

### Terzaghi

**Active Soil ( $P_{ps}$ )** pressure below the excavation depth is calculated by extending the appropriate **Terzaghi** pressure envelope below formation level.

## Moment

Frame loads and sheet penetration are calculated using the **Terzaghi** pressure envelope. The **Moment** setting determines how **SupportIT** calculates the sheet bending moment:

### Rankine

The bending moment is calculated using the **Rankine** pressure values. The **Terzaghi** pressure graph is still shown on graphs.

### Terzaghi

The bending moment is calculated using the **Terzaghi** pressure values.

The effect of the above settings can be viewed by examining the relevant graphs in the **Pressure** and **Side Elevation** pages of the main design window.

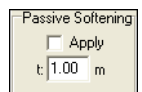
In each of the above models, the effects of superimposed loads ( $P_{sur}$ ) and custom slopes ( $P_{cus}$ ) are added to the other pressure components to find the net pressure. In the **Rankine/Coulomb** models, the effect of minimum fluid pressure is considered after all other pressure sources have been considered.

The **K** values of each soil are recalculated if **Rankine/Coulomb** is selected, using the current angle of slope. Note that the formula used demands that the angle of slope does not exceed the angle of soil friction. If such a condition exists, it is assumed that the angle of friction equals the angle of slope in any soil layer where it occurs, and a warning to this effect is displayed.

The **K** values can always be changed manually in the **Soils** page.

## Passive Softening

This panel controls whether passive softening is to be applied, and the depth over which it is to be applied. Click the **Apply** check box to switch passive softening on or off, and enter the thickness of the passive softening layer in the appropriate box. The default value of the latter is **1m**. Changing the **Apply** setting, or the **thickness** value will only have an effect if there is a cohesive layer within the appropriate depth from the excavation base.



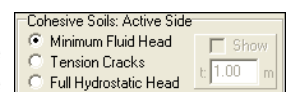
If passive softening is applied, then the cohesion of the passive side is assumed to increase linearly from zero to the full value over the passive softening depth entered.

## Cohesive Soils: Active Side

The panel contents differ depending on whether **Rankine**, **Coulomb** or **Terzaghi** has been selected:

### Rankine/Coulomb

The panel controls how **SupportIT** deals with active side cohesive soils in the **Rankine** or **Coulomb** pressure models, where the calculated net active pressure can have a negative value when high cohesion values are involved:



### Minimum Fluid Head

The minimum pressure in cohesive layers is assumed to be the **MEFP** i.e. the pressure due to an equivalent fluid of density **5kN/m<sup>3</sup>** (Ref: "**BSPH (7th Edition)**"; "**CIRIA Report 104**").

The value of this **Minimum Fluid Density (MEFD)** can be changed in the **Excavation** page of the define box.

### Tension Cracks

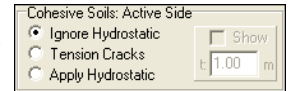
Tension cracks are assumed to exist to the depth specified in the tension crack depth edit box, 't'. The net active pressure within the tension cracks is the maximum of the calculated soil pressure and water pressure at that depth. **MEFP** is applied at depths greater than the tension crack depth.

### Full Hydrostatic Head

Full hydrostatic pressure is applied in cohesive layers from the water table down to formation level, and added to the calculated active soil pressure.

### Terzaghi

The panel controls how hydrostatic pressure is dealt with in active side cohesive soils in the **Terzaghi** pressure model:



### Ignore Hydrostatic

No hydrostatic pressure is applied in cohesive soils on the active side, even when a water table has been defined.

### Tension Cracks

Tension cracks are assumed to exist to the depth specified in the tension crack depth edit box, 't'. The net active pressure within the tension cracks is the maximum of the calculated soil pressure and water pressure at that depth. This may have no effect with the **Terzaghi** pressure model.

### Apply Hydrostatic

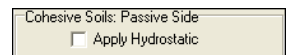
Hydrostatic pressure is applied in cohesive soils on the active side if a water table has been defined.

The **Show** check box gives a visual indication on the main diagram if **Tension Cracks** or **Full Hydrostatic Head** are selected. In the case of **Full Hydrostatic Head**, a blue line is drawn vertically beside the sheet pile, in cohesive layers below the water table and above formation level

The pressure calculated by the above options is shown in the **P<sub>mf</sub>** or **P<sub>aw</sub>** columns of the **Pressure Grid** (see below).

### Cohesive Soils: Passive Side

This determines how **SupportIT** deals with hydrostatic pressure in passive side cohesive soils. Hydrostatic pressure is applied in cohesive soils on the passive side if the box is checked. Hydrostatic pressure is not applied in cohesive soils on the passive side when the box is not checked. The default setting of this control is **OFF**. When selected, the option results in a smaller toe in excavations with cohesive soils below the excavation depth (and the water table). When it has not been selected, **SupportIT** may fail to calculate a toe in, for example, very soft clays. A warning is displayed in the **Reports** page if the option has been selected.



### Display

The display mode of the **Pressure** page of the main window may be varied:



#### Graphs (Common Scale)

A graph is displayed for each pressure component (see above) and the net pressure, using the same scale for each graph.

#### Graphs (Unique Scales)

A graph is displayed for each pressure component (see above) and the net pressure, using an appropriate scale for each graph. This is the default display.

#### Table

A table is displayed for each pressure component (see above) and the net pressure. Note that **P<sub>net</sub>** may not equal the sum of the other columns for a variety of reasons, including: the method of applying hydrostatic pressure in cohesive soils, **MEFP** being applied to the net active pressure, or rounding errors. Blank entries in the **Pressure Grid** are treated differently in different columns (see below).

## Pressure Grid

The grid in the lower part of the page shows the pressure due to the sources outlined above at various significant depths, and the net pressure. The depths used include:

**Any soil interface.** Two depths are shown - one at the bottom of the layer above the interface, and one just inside the layer below the interface.

**Active/Passive water tables.**

**The bottom of the excavation.** Two depths are shown - one at the bottom of the excavation, and one just inside the first passive layer.

**The bottom of the sheet** (i.e. the toe).

**The limit of minimum fluid pressure/water pressure in cohesive layers.** This is only used for cohesive layers and for the **Rankine** or **Coulomb** pressure models.

**The limit of passive softening** (if applied).

The values of each pressure component, and the net pressure, are displayed in the appropriate columns in the grid. A value will only be displayed in the  $P_{mf}$  column if it has been used - i.e. if  $P_{mf}$  exceeds the net pressure calculated from the other sources at a depth.

Any **superimposed/custom slope** pressure is shown to the left of the depth column as they cannot be edited (see below).

Different components may be removed from the net pressure calculation, and their effects assessed, using the **Include** panel below the grid. An item is included if it is ticked. This panel is disabled if the manual pressure option is used (see below).

## Manual Pressure Values

The grid is user-editable, allowing manually calculated pressure values to be used. The values of any depths or pressures (except  $P_{sur}$  and  $P_{cus}$ ) may be changed, and the net pressure shown in the grid will be recalculated appropriately. Values may be entered directly into the  $P_{net}$  column and these will ignore other pressures at that depth. Any changes in the table will not be implemented in the design until manual pressure has been selected by applying the grid (see below).

There are three buttons below the pressure grid:



The **Apply** button applies the current net pressure column to the design. The pressure model is set to **Manual**, and the pressure is **not recalculated** after any of the changes which usually affect it (eg. excavation depth, soil parameters, etc).



The **Delete Row** button deletes the the current row from the pressure grid and the resultant net pressure column is applied to the design. The pressure model is set to **Manual**, and the pressure is **not recalculated** after any of the changes which usually affect it (eg. excavation depth, soil parameters, etc).



The **Reset** button resets the pressure model (to **Rankine**, **Coulomb** or **Terzaghi**) and recalculates the pressure accordingly. Any manually entered values are lost. Normal operation following changes to excavation depth, soil parameters, etc is resumed.

The **Automatic Recalculation** check box controls how changes to the grid are applied. When the manual pressure model has been applied, and automatic recalculation is **On** (the default), then any changes to the grid are applied to the design immediately. If automatic recalculation is **Off**,  $P_{net}$  is updated in the grid following relevant changes, but the **Apply** button must be clicked to apply the net pressure to the design. It may be useful to set automatic recalculation to **Off** if a large number of changes are being made.

Blank entries in the pressure grid are "undefined", and are treated differently according to the column. Blank entries in the  $P_{aw}$ ,  $P_{pw}$  and  $P_{mf}$  columns are treated as zero and no values are shown in these

depth	$P_{as}$	$P_{ps}$	$P_{aw}$	$P_{pw}$	$P_{mf}$	$P_{net}$
[m]	[kN/m <sup>2</sup> ]	[kN/m <sup>2</sup> ]	[kN/m <sup>2</sup> ]	[kN/m <sup>2</sup> ]	[kN/m <sup>2</sup> ]	[kN/m <sup>2</sup> ]
0.00	3.3	0.0				3.3
4.00	26.0	0.0	0.0			26.0
4.01	21.3	0.0	0.1			21.4
5.00	24.1	0.0	9.8	0.0		33.9
7.00	30.0	0.0	29.4	-19.6		39.8
7.01	30.0	-0.4	29.5	-19.7		39.4
10.97	41.6	-158.2	68.3	-58.5		-106.8

Include:   $P_{as}$    $P_{ps}$    $P_{aw}$    $P_{pw}$    $P_{mf}$    $P_{sur}$    $P_{cus}$

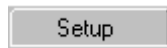
Automatic Recalculation

columns in the table display of the **Pressure** page of the main window. Blank entries in the  $P_{as}$ ,  $P_{ps}$  and  $P_{net}$  columns are ignored when the pressure values in these columns of the table display are being calculated, and the pressure is found assuming a linear relationship between the non-blank values above and below the undefined values. To set zero pressure over a selected depth (eg. in a layer of rock), enter **0** explicitly for the relevant depths. For example, set  $P_{net}$  at **3m** to **0**, and  $P_{net}$  at **3.5m** to **0**.

**Note:**

1. Most controls on the page are switched **OFF** when manual pressure has been selected.
2. A value is only shown in the  $P_{mf}$  column when it is being applied, i.e. when the **MEFP** exceeds the calculated net pressure.
3. When the grid is applied manually, a linear pressure relationship is assumed between each defined depth, except in the cases of  $P_{sur}$  and  $P_{cus}$  (see below).
4.  $P_{sur}$  and  $P_{cus}$  are not user-editable. These are non-linear, and are applied after the net pressure of the other pressure sources has been calculated. To use manual pressure with these switched off (eg. you may want to show a custom slope or surcharge in the design diagram, but enter your own pressure values), switch them **off** in the **Include** panel before applying the manual pressure.
5. If a manual pressure is being entered, **SupportIT** does not amend it at each installation stage. The responsibility for this lies with the user.
6. In some cases, the net pressure above excavation level can be negative (eg. when the passive water level is less than the excavation depth). In such instances, the net pressure is assumed to be zero.

## Setup Page



Open this page by clicking the **Setup** tab when the define box is open, or by double clicking the **Sheet/Works/Pressure** area of the panel to the left of the main design window, or the title bar below the main design diagram.

This page allows various options to be changed. The page panels are:

### Quick Setup

Provides simultaneous access to several functions which are normally set on other pages:

#### Analysis Method

Normally set on the **Wall** page.

#### Penetration

Normally set on the **Wall** page.

#### Load Model

Normally set on the **Supports** page.

#### Pressure

Normally set on the **Pressure** page.

Indication is given when additional settings relevant to the above can be found on other pages. For example, further changes may be made to the pressure model on the **Pressure** page.



The **Restore Defaults** button is used to restore all **SupportIT** settings to their **Default Values** (ref: **Appendix C**).

### Miscellaneous

Controls various software settings:

#### Units

**Metric** or **Imperial** units may be selected.

#### Works

**Temporary** or **Permanent** works may be selected. This controls the allowed sheet bending moment when a sheet is recalled from the database.

### Display/Shading

The **Soil Layers** check box turns the soil layer shading in the side elevation view **on** or **off**.

The **Frame Symbols** check box turns the shading of frames **on** or **off**. The selected setting is applied to the side elevation and the plan view.

The **Table Headings** check box turns the shading in the top line of tables **on** or **off**.

The **Print Colour Graphs** check box turns the colours of plotted graphs **on** or **off** when they are printed. Graphs are black when printed if the setting is switched off.

The **Vertical Scale** and **Horizontal Scale** check boxes turn vertical and horizontal scales **on** or **off**. The vertical and horizontal scales may differ. A horizontal scale is only shown if surcharge(s), custom slope or excavation width have been defined.

The **Show Both Sides** check box shows both sides of the excavation in the main diagram when checked, if the excavation width has been defined. Both sides are only shown if the excavation width has been defined and there is no slope on the passive side. Only one side of the excavation is shown in **stepped excavations**.

### User Details

The user's contact details may be added and are displayed in the title bar below the main diagram.

## Chapter 5

### Menus and Toolbars

#### Menu Bar

A number of menus perform the usual **Windows** function (eg. **New/Open/Save/Print** etc), and these are not described here.

The menu options displayed at any time depend on the display mode (eg. **Side Elevation** or **Plan View**), and the menus unique to **SupportIT** are:

Menu	Function
Superimpose	Superimposes graphs and results on main diagrams.
Miscellaneous	Gives design reports and changes display size.
Database	Opens database window.
Reference	Opens reference window.
Protection	This menu item only appears for <b>Key Disk</b> users (Ref: <b>Chapter 1</b> ). It enables/disables <b>SupportIT</b> , or opens the <b>Tools</b> utility for amending <b>Key Disks</b> . Your supplier will provide further information on the latter if this is required.

#### Superimpose Menu

This menu superimposes calculation results (often in the form of a graph) on the **Side Elevation** and **Plan** views. The contents of the menu depend on the current view, and the result is superimposed on that view, i.e. the **Plan View** or the **Side Elevation**. A tick beside the menu item indicates whether the item is on or off.

Each menu function can also be performed using the relevant toolbar button.

The menu items, and the relevant toolbar buttons are:

#### Pressure (Side Elevation only)



Superimposes the earth pressure graph on the side elevation.

#### Linear Load (Side Elevation only)



Displays the linear load on the frames in a sheet pile wall, or the tieback load in a soldier pile wall.

#### Bending Moment



Superimposes the bending moment graph on the side elevation or plan view.

#### Deflection



Superimposes the deflection graph on the side elevation or plan view.

#### Shear Force



Superimposes the shear force graph on the side elevation or plan view.

#### Water Pressure (Side Elevation only)



Superimposes the water pressure graph on the side elevation.

#### Factor Of Safety



Indicates the current design factor of safety in the left margin.

#### Results Table (Plan View only)



Shows a diagram key and table of maximum values above the plan view.

#### Reactions (Plan View only)



Superimposes strut loads on the plan view.

## Miscellaneous Menu

The menu items, and the relevant toolbar buttons are:

### Report



Provides a report on the safety and other aspects of the design.

### Full Size/Fit Screen



Changes the size of the main diagram. **Fit Screen** is often better for viewing **Side Elevation** or **Plan View** diagrams, while **Full Size** improves the legibility of text (eg. in the **Input/Output** page).

## Database Menu



Opens **SupportIT** databases for editing. Refer to **Chapter 6** for more information.

## Reference Menu

Opens reference window. Useful data may be viewed by selecting appropriately from the drop-down list box at the top right corner of the window. More information may be added to this display at a later date.

## Protection Menu (Key Disk users only)

The menu items, and the relevant toolbar buttons are:

### Enable/Disable



Opens **Enable/Disable** window. Refer to **Chapter 1** for more information.

### Tools

Opens a utility for amending key discs. Your supplier will provide further information if this is required.

## Help Menu

Opens **Windows** online **Help** file or displays program information.

## Toolbar

The speed buttons on the toolbar are used for quick access to menu functions, and the buttons displayed at any time depend on the current view (eg. **Side Elevation** or **Plan View**). The buttons can be used to switch an effect (eg. a graph) on or off. The function of each button is displayed when the pointer is placed above it.

A number of these buttons perform the usual **Windows** function (eg. **Print**), and these are not described here. The buttons unique to **SupportIT** are:

### Basic Tool Bar

*Visible in all views.*



**Database:** Opens database window. Refer to **Chapter 6** for more information.



**Reference:** Opens reference window. See above for details.



**Enable/Disable:** Enables or disables **SupportIT**. This button only appears for **Key Disk** users (Ref: **Chapter 1**).



**About:** Displays program information.



**Quit:** Quits **SupportIT**.

### Main Tool Bar

*Visible in all design views except **Plan View**.*



**Pressure:** Superimposes the earth pressure graph on the side elevation.



**Linear/Tieback Load:** Displays the linear load on the frames in a sheet pile wall, or the tieback load in a soldier pile wall.



**Bending Moment:** Superimposes the moment graph on the side elevation.



**Deflection:** Superimposes the deflection graph on the side elevation.



**Shear Force:** Superimposes the shear force graph on the side elevation.



**Water Pressure:** Superimposes the water pressure graph on the side elevation.



**Factor Of Safety:** Indicates the current design factor of safety in the left margin.



**Report:** reports on the safety and other aspects of the design. Refer to “**Reports Page**”, **Chapter 3** for more details.



**Zoom:** Changes size of display.

### Plan View Tool Bar

*Visible in Plan View.*



**Results Table:** Shows a key and table of maximum values for the plan view.



**Reactions:** Superimposes strut loads on the plan view.



**Bending Moment:** Superimposes the moment graph on the plan view.




**Deflection:** Superimposes the deflection graph on the plan view.



**Shear Force:** Superimposes shear force graph on the plan view.


## Chapter 6


### Databases


A database is provided for clients, sheets, soils and frames. To access the database, select **Database** on the menu bar, or click the **Database** button (i.e. the "card index") on the toolbar. 


The database window is a "modal" window, i.e. no other actions can be performed until it has been closed.


Data may be entered directly to the table, or in the edit area above the table. Some fields are recalculated when relevant values are modified **in the edit area** above the table. For example, the **K** values of soils are recalculated if a soil's **angle of friction** is changed in the edit area. Calculated fields **are not recalculated** if a value (eg. **angle of friction**) is changed **in the table**.

Navigate the database using the control panel: 

To enter a new record, click: 

To delete a record click: 

To cancel a change click: 

To post a change click: 

New records are not valid until another record has been clicked, or the post button is clicked. An amendment has not been "posted" if there is an asterisk shown beside it in the table.

Click the **Printer** icon to print the current database.

Click **OK** to accept the current entries.

The client, sheet, soil or frame database is selected by clicking the appropriate tab at the top of the dialog box:

**Tab**

Client	Sheet	Soil	Frame
--------	-------	------	-------

Client  
Sheet  
Soil  
Frame

**Database**

Customer contact details.  
Sheet pile specification.  
Soil properties.  
Supports specification.

#### Note:

You should periodically back up your customer, sheet, soil and frame databases. The easiest way to do this is to copy the **Data** directory from the install directory to another location.

#### Client Database

<i>Field Name</i>	<i>Field Description</i>	<i>Characters</i>
<b>Code</b>	A unique customer code is required for each customer. If the same customer appears more than once (eg. for different sites), distinguish them by using an amendment to the code (eg. ABC123a and ABC123b).	8
<b>Name</b>	Company name.	50
<b>Site/Office</b>	Location.	30
<b>FAO</b>	For the Attention Of.	30
<b>Tel</b>	Telephone number.	20
<b>Fax</b>	Fax number.	20
<b>Note</b>	Miscellaneous notes.	100

## Soil Database

<i>Field Name</i>	<i>Field Description</i>	<i>Units</i>
<b>Name</b>	Description of the soil. Maximum characters = 30.	
<b>Type</b>	Soil type (sand, clay, etc). For information only. Maximum characters = 5.	
$\gamma$	Bulk density of soil.	kN/m <sup>3</sup> ; pcf
$\gamma_s$	Submerged density of soil.	kN/m <sup>3</sup> ; pcf
<b>C</b>	Cohesion of soil.	kN/m <sup>2</sup> ; psf
<b>C<sub>a</sub></b>	Adhesion between soil and piles. For information only.	kN/m <sup>2</sup> ; psf
$\phi$	Angle of internal friction of soil.	degrees
$\delta$	Angle of friction between soil and piles.	degrees
<b>K<sub>a</sub></b>	Active pressure coefficient for cohesionless soils.	
<b>K<sub>ac</sub></b>	Active pressure coefficient for cohesive soils.	
<b>K<sub>p</sub></b>	Passive pressure coefficient for cohesionless soils.	
<b>K<sub>pc</sub></b>	Passive pressure coefficient for cohesive soils.	

Calculated fields are recalculated when a relevant value is modified **in the edit area** above the table. For example, the **K** values are recalculated if a soil's **angle of friction** is changed in the edit area. Calculated fields are **not recalculated** if a value (eg. **angle of friction**) is changed **in the table**.

Note that the **K** values are not automatically recalculated if the **C<sub>a</sub>** value is changed. Users should enter appropriate **K** values to account for variations in **C<sub>a</sub>**.

## Sheet Database

<i>Field Name</i>	<i>Field Description</i>	<i>Units</i>
<b>Name</b>	Description of the sheet. Maximum characters = 30.	
<b>E</b>	Elastic Modulus (i.e. Young's modulus). Required for deflection calculations.	kN/m <sup>2</sup> ; psi
<b>I</b>	Moment of Inertia. Required for deflection calculations.	cm <sup>4</sup> /m; in <sup>4</sup> /ft
<b>Z</b>	Section Modulus.	cm <sup>3</sup> /m; in <sup>3</sup> /ft
<b>f</b>	Working Stress.	N/mm <sup>2</sup> ; psi
<b>BM<sub>max</sub></b>	Maximum allowed bending moment (= <b>fZ</b> ).	kNm/m; ftlb/ft
<b>b</b>	Sheet width. For information only.	m; in
<b>A</b>	Sheet area per unit length of wall. For information only.	cm <sup>2</sup> /m; in <sup>2</sup> /ft
<b>W</b>	Sheet weight per unit length of pile. For information only.	kg/m; lb/ft

Two entries are available for **Working Stress** and **Bending Moment**. Use **Working Stress (temp)** and **Bending Moment (temp)** for temporary works, and **Working Stress (perm)** and **Bending Moment (perm)** for permanent works. The relevant values will be recalled from the database when defining the sheet pile in the **Wall** page of the define box.

The **Working Stress (temp)** and **Working Stress (perm)** entries in the supplied database are based on **Table 1.2** of the "**British Steel Piling Handbook (7th Edition)**", i.e. they are 65% of the minimum yield strength of mild steel. These are for guidance only, and should be checked against current codes of practice.

Calculated fields are recalculated when a relevant value is modified **in the edit area** above the table. For example, **Max. Moment (temp)** is recalculated if **Z** or **Working Stress (temp)** is changed in the edit area. Calculated fields **are not recalculated** if a value (eg. **Z**) is changed **in the table**.

**Frame Database**

<b>Field Name</b>	<b>Field Description</b>	<b>Units</b>
<b>Name</b>	Description of the component. Maximum characters = 50.	
<b>Type</b>	Type of entry: Brace, (B), Lagging (L), Waler (W). Maximum characters = 1.	
<b>Leg</b>	Leg type or size. Only used if <b>Type</b> is specified as <b>B</b> . Maximum characters = 20.	
<b>E</b>	Elastic Modulus (i.e. Young's modulus). Required for deflection calculations.	kN/m <sup>2</sup> ; psi
<b>I</b>	Moment of Inertia. Required for deflection calculations.	cm <sup>4</sup> ; in <sup>4</sup>
<b>Z</b>	Section Modulus.	cm <sup>3</sup> ; in <sup>3</sup>
<b>f</b>	Working Stress.	N/mm <sup>2</sup> ; psi
<b>BM<sub>max</sub></b>	Maximum allowed bending moment (= <b>fZ</b> ).	kNm; ftlb
<b>t</b>	"Horizontal" dimension of component. See displayed image for key.	m; ft
<b>b</b>	"Vertical" dimension of component. See displayed image for key.	m; ft

The name of each system should be entered in the **Name** field and "**B**", "**L**" or "**W**" should be entered in the **Type** field to indicate brace, lagging or waler. If a brace is being defined, the leg type/size should be entered in the **Leg** field.

A **soldier pile** should be entered as type **W** (waler).

The sample database illustrates how different leg types can be defined for a particular brace using several entries:

Make the same entry (eg. *Standard Brace* and *B*) in the **Name** and **Type** fields for each leg type.

Enter the leg type (eg. *TD0*, *TD1*, etc) in the **Leg** field.

Enter the remaining leg properties (**E**, **I**, etc).

The defined leg types will be available for use in the **Plan View**, when the relevant brace has been selected.

The entries in the supplied database are for illustration purposes only, and do not relate to any specific products.

Calculated fields are recalculated when a relevant value is modified **in the edit area** above the table. For example, **Max. Moment** is recalculated if **Z** or **Stress** is changed in the edit area. Calculated fields **are not recalculated** if a value (eg. **Z**) is changed **in the table**.

## Chapter 7

### Pressure Calculation Methods

The notation used in these pages is listed in **Appendix A**.

#### Soil Coefficients

The soil coefficients used in earth pressure calculations are calculated according to the pressure model being used:

##### Rankine

Active and passive earth pressure coefficients are given by:

$$K_a = \cos \beta \frac{\cos \beta - \sqrt{\cos^2 \beta - \cos^2 \phi}}{\cos \beta + \sqrt{\cos^2 \beta - \cos^2 \phi}} \quad K_{ac} = 2\sqrt{K_a}$$
$$K_p = \cos \beta \frac{\cos \beta + \sqrt{\cos^2 \beta - \cos^2 \phi}}{\cos \beta - \sqrt{\cos^2 \beta - \cos^2 \phi}} \quad K_{pc} = 2\sqrt{K_p}$$

In the case of level backfill (i.e.  $\beta = 0$ ), the  $K_a$  and  $K_p$  equations become:

$$K_a = \tan^2(45 - \phi/2)$$
$$K_p = \tan^2(45 + \phi/2)$$

The effect of **wall friction** on active and passive pressures is determined by using modified **K** values, based on **Tables 4.6.1** and **4.6.2** in "**British Steel Piling Handbook (7th Edition)**".

##### Coulomb

Active and passive earth pressure coefficients are given by:

$$K_a = \frac{\cos^2 \phi}{\cos \delta \left[ 1 + \sqrt{\frac{\sin(\phi + \delta) \sin(\phi - \beta)}{\cos \delta \cos \beta}} \right]^2} \quad K_{ac} = 2\sqrt{K_a}$$
$$K_p = \frac{\cos^2 \phi}{\cos \delta \left[ 1 - \sqrt{\frac{\sin(\phi + \delta) \sin(\phi + \beta)}{\cos \delta \cos \beta}} \right]^2} \quad K_{pc} = 2\sqrt{K_p}$$

##### Wall adhesion

Wall adhesion,  $C_a$ , is not taken into account when calculating **K** values in current versions of **SupportIT**, and displayed values of  $C_a$  are for information only. Wall adhesion can be taken into account by manually modifying the **K** values (Ref: **Tables 4.8.1** and **4.8.2** in "**BSPH (7th Edition)**").

The **K** values of each soil in an excavation are recalculated using the current angle of slope if any relevant soil parameters (eg. angle of friction) are changed, or if **Coulomb/Rankine** is selected. Note that the formula used demands that the angle of slope does not exceed the angle of soil friction. If such a condition exists, it is assumed that the angle of slope equals the angle of friction in any soil layer where it occurs, and a warning to this effect is displayed.

The **K** values calculated in the database window assume the Rankine equations, zero slope and zero wall friction. When a soil is first introduced into a design from the database, the initial **K** values will be those stored in the database, ignoring any current slope or wall friction. The recalled values can be modified to take account of slope and/or wall friction by switching to level ground, then back to sloping ground.

The **K** values can always be changed manually in the **Soils** page.

**Note:** The **Coulomb** pressure model will give the same results as **Rankine** if

$$\delta = \beta = 0$$

## Earth Pressure: Rankine and Coulomb Pressure Models

Pressure is calculated as outlined in the “**British Steel Piling Handbook (7th Edition)**”, Ch. 4 (“**BSPH**”). Different active and passive pressure coefficients are used for the **Rankine** and **Coulomb** models, as described above.

The net pressure is calculated by finding the sum of the active and passive earth and water pressures:

### Active and Passive Earth Pressure

Active and passive earth pressures are given by:

$$p_a = \gamma \cdot h \cdot K_a - K_{ac} \cdot C$$

$$p_p = \gamma \cdot h \cdot K_p + K_{pc} \cdot C$$

It is recommended that a minimum standard surcharge of **10kN/m<sup>2</sup>** be applied to the surface of the retained soil in the design of all retaining walls (Ref: “**BS 8002: 1994**”). This is the default in **SupportIT**, but the value may be changed in the **Excavation** page of the define box. Additional loading due to vehicle movement, foundations, etc can be modelled by increasing the standard surcharge or by applying point, line, strip and area loads in the **Loads/Slope** page of the define box.

### Water pressure

Water pressure at any depth, **d**, is given by:

$$p_w = (d - d_w) \gamma_w$$

In the earth and water pressure equations:

**Granular soils** ( $C = 0$ ;  $\phi > 0$ ): bulk and submerged densities are used above and below the water table respectively. Water pressure is then calculated within each soil layer.

**Cohesive soils** ( $C > 0$ ;  $\phi = 0$ ): bulk density is used above and below the water table. The limit of water pressure in cohesive strata is assumed to be the depth at which the water pressure equals the earth pressure. Tension cracks may be applied in the **Pressure** page of the define box.

**Mixed soils** ( $C > 0$ ;  $\phi > 0$ ): treated in the same way as cohesive soils on the active side. Hydrostatic pressure is applied as in granular soils on the passive side.

### Minimum equivalent fluid pressure (MEFP)

The calculated net pressure can have a negative value when soils with high cohesion exist in an excavation, and the pressure is then assumed to be zero.

Allowance may be made for the intrusion of water between the soil and the sheet piles by applying full hydrostatic pressure. Full hydrostatic pressure may be selected in the **Pressure** page of the define box.

Where ground water is unlikely to be present, an alternative substitution for zero net pressure in cohesive soils is to assume a pressure due to an equivalent fluid of density **5kN/m<sup>3</sup>** (Ref: “**BSPH (7th Edition)**”; “**CIRIA Report 104**”). The value of this **Minimum Fluid Density (MEFD)** can be changed in the **Excavation** page of the define box.

The **MEFP** is applied after all other pressure sources (eg. superimposed loads, custom slopes, etc) have been applied. The **MEFP** can be ignored by setting the minimum fluid density to **0kN/m<sup>3</sup>**. Alternatively, it can be switched off in the **Include** panel of the **Pressure** page of the define box.

### Tension Cracks

Water may penetrate to considerable depths in cohesive soils via tension cracks. These may open in the immediate short term to a depth given by: **(2C - Q)/γ**

Tension cracks in cohesive soils may be defined to a specified depth in the **Pressure** page of the define box. Tension cracks may be defined above the water table, in which case it is assumed that rainwater or ice may be present in the cracks. When tension cracks are applied, the net active pressure is the maximum of calculated soil pressure and water pressure within the tension crack, and the maximum of calculated soil pressure and **MEFP** below the tension crack.

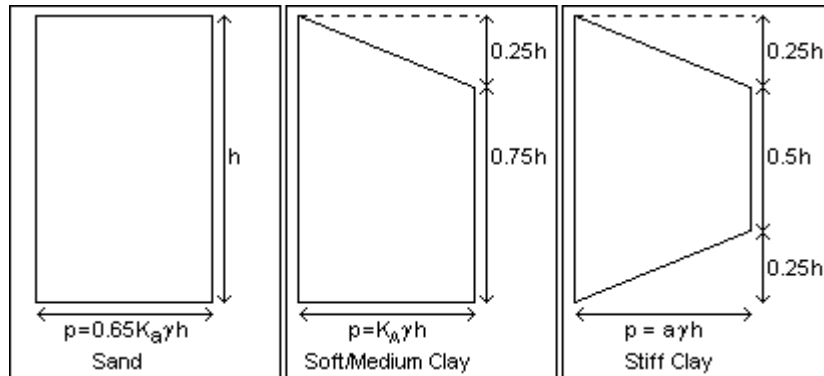
### Passive softening

Passive softening can occur when soft cohesive soils exist at dredge or excavation levels (Ref: “**BSPH (7th Edition)**”, pg 5/8). Passive softening can be switched on/off in the **Pressure** page of the define box.

If passive softening is applied, then the cohesion of the passive side is assumed to increase linearly from zero to the full value over the passive softening depth entered. The default value of the passive softening depth is 1m, but this may be varied.

## Earth Pressure: Terzaghi Pressure Model

This is an empirically derived pressure envelope method (Ref: "CIRIA Special Publication 95"):



### Sand

A rectangular pressure envelope is used, with maximum pressure given by:

$$p = 0.65K_a \gamma h$$

### Clay

A trapezoidal pressure envelope is used. The shape and maximum pressure of the envelope are determined by:

$$N = \gamma h / C$$

### Soft to medium clay

A soft to medium clay is defined as having  $N \geq 5$ . The envelope has the shape shown above, with maximum pressure:

$$p = K_A \gamma h \quad \text{where: } K_A = 1 - 4m/N$$

$m = 1$  usually  
 $m = 0.4$  when cut is underlain by deep soft consolidated clay.

### Stiff clays

A stiff clay is defined as having  $N \leq 4$ . The envelope has the shape shown above, with maximum pressure:

$$p = a \gamma h \quad \text{where: } a = 0.2 \text{ for very short term}$$

$a = 0.4$  for longer term

If  $4 < N < 5$ , then the envelope which results in the larger pressure is adopted.

The values of  $m$  and  $a$  above can be selected in the **Pressure** page of the define box.

### Surcharge

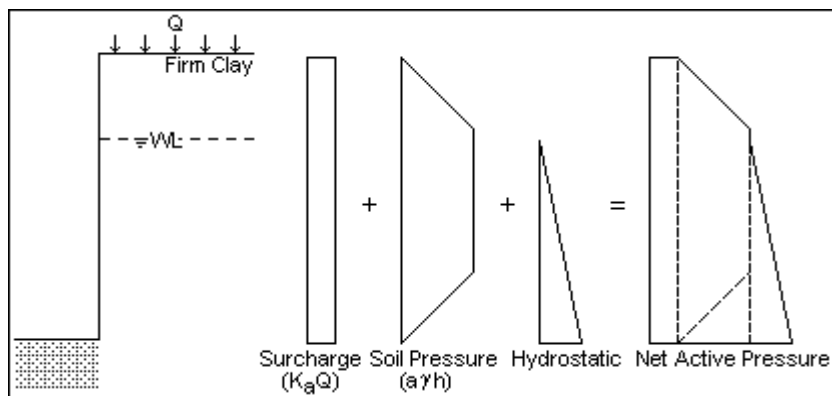
The pressure due to a standard surcharge,  $Q$ , is added net to the design envelope calculated as described above. This is done by adding  $K_a \cdot Q$  to the pressure envelope. The appropriate value of  $K_a$  is used at each depth in excavations with several different soil types.

### Water

Hydrostatic pressure is always added to a granular pressure envelope if a water table has been defined.

"USS Steel Sheet Piling Design Manual" (pg 58) suggests that hydrostatic pressure should also be added to a cohesive pressure envelope if a water table has been defined. However, as this can result in very large pressures (and frame loads), the user can choose to ignore or apply hydrostatic pressure in cohesive soils with the Terzaghi method in the **Cohesive Soils (Hydrostatic)** panel of the **Pressure** page of the define box. Tension cracks may also be selected with the Terzaghi pressure model in this panel, but are unlikely to have any significant effect.

For example, the net active pressure in an excavation in stiff clay with the hydrostatic pressure option switched on is calculated as shown below:



The surcharge envelope may not be rectangular in excavations with several soil types due to a different  $K_a$  being used in each layer (see **Surcharge**, above).

### Toe calculation

When the Terzaghi model is used with a toe, the appropriate pressure envelope is applied to formation level, and Rankine is used for the passive pressure. The user can choose to apply Rankine to the active side below formation level, or to extend the Terzaghi pressure envelope indefinitely on the active side, in the **Toe (Active)** panel of the **Pressure** page of the define box.

### Bending moment calculation

As described in “**CIRIA Special Publication 95**” (pg 57), some references (eg. “**BS8002**”) do not recommend the use of pressure envelopes for the calculation of bending moment in sheet piles, while others suggest that the wall can be designed using two-thirds of the Terzaghi pressure envelope. The user can choose to use either Rankine or Terzaghi for the bending moment calculation in the **Moments** panel of the **Pressure** page of the define box. Alternatively, the Terzaghi pressure envelope may be reduced manually using the pressure grid in the **Pressure** page of the define box.

If Terzaghi is used for pressure and load calculation and Rankine for bending moment, then Rankine is also used for shear force and deflection.

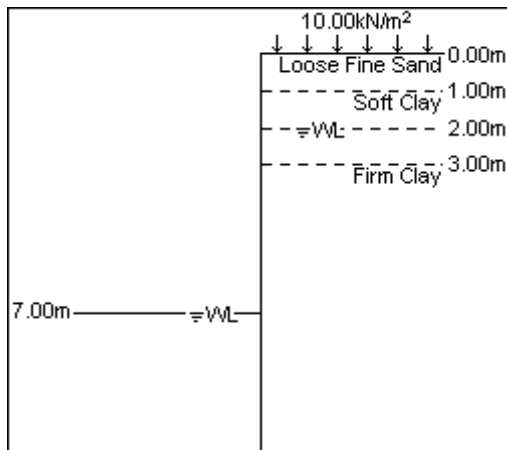
**Note:** In excavations with several different soil types, the envelope which results in the greater total load is adopted.

The total loads represented by the envelopes shown exceed that of the Rankine method by a factor in the range **1.3 - 1.75**, depending on the envelope used.

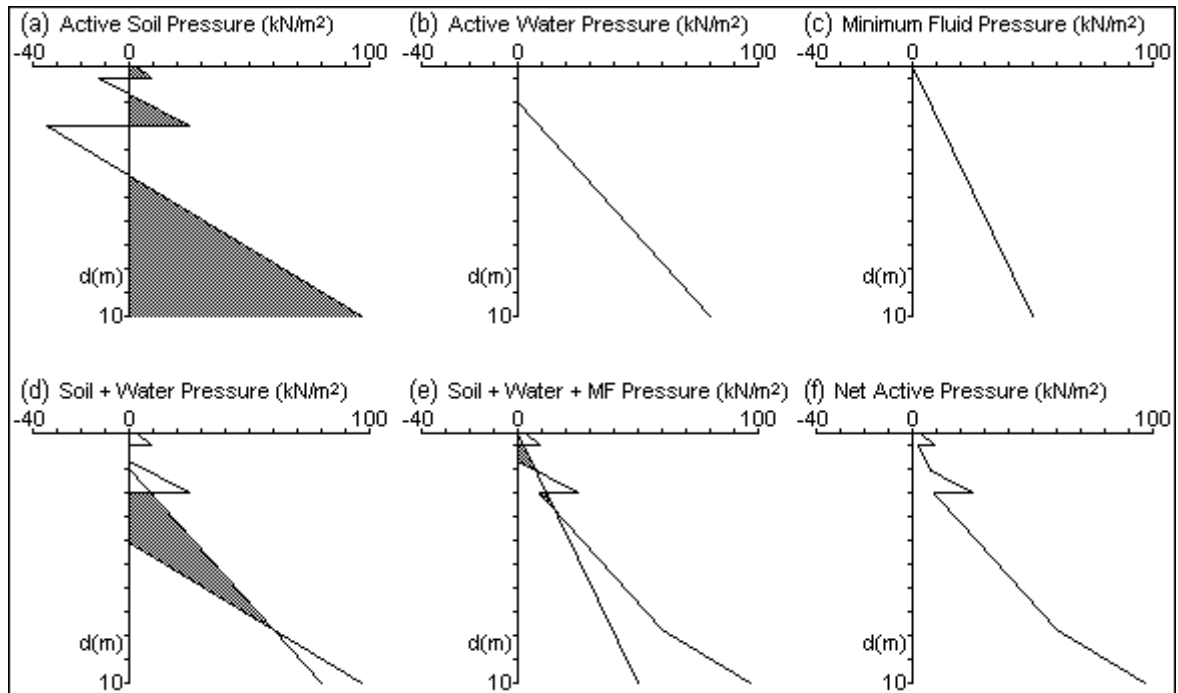
## Water Pressure in Cohesive Soils

(Ref: “**British Steel Piling Handbook (7th Edition)**”, “**CIRIA Report 104**”, “**CIRIA Special Publication 95**”)

### Rankine and Coulomb Pressure Models



When a water table has been defined above or within a cohesive layer as shown, the limit of water pressure in the cohesive layers is the point at which water pressure equals the active pressure (“**BSPH (7th Edition)**”, pg 4/15). The calculation of net active pressure is illustrated below:



- (a) The active earth pressure envelope is calculated. The calculated net pressure can have a negative value when soils with high cohesion are present, and the pressure is then assumed to be zero, i.e. the unshaded area is ignored.
- (b) The active water pressure envelope is calculated.
- (c) The MEFP envelope is calculated.
- (d) The active water pressure envelope, (b), is combined with the active earth pressure envelope, (a). Water pressure exceeds soil pressure in the shaded area, and this is added to the net pressure envelope.
- (e) The MEFP envelope, (c), is combined with the net pressure envelope, (d). MEFP exceeds net pressure in the shaded area, and this is added to the net pressure envelope.
- (f) The net active pressure envelope.

Three options may be selected in the **Pressure** page of the define box for modelling water pressure in cohesive soils with the Rankine and Coulomb pressure models:

#### Minimum Fluid Head

Net active pressure is calculated as shown above, i.e. the active pressure within a cohesive layer is assumed to be the larger of soil pressure and water pressure. The result is then compared with the **MEFP** i.e. the pressure due to an equivalent fluid of density **5kN/m<sup>3</sup>** (Ref: "**BSPH (7th Edition)**"; "**CIRIA Report 104**"), and replaced by the **MEFP** if this is larger. The value of the **Minimum Fluid Density (MEFD)** can be changed in the **Excavation** page of the define box.

#### Tension Cracks

Tension cracks are assumed to exist to the depth specified in the tension crack depth edit box, 't'. Tension cracks may be defined above the water table, in which case it is assumed that rainwater or ice may be present in the cracks. The net active pressure within the tension cracks is the maximum of the calculated soil pressure and water pressure at that depth. **MEFP** and pressure due to any water table are applied as shown above at depths greater than the tension crack depth.

#### Full Hydrostatic Head

"**CIRIA Report 104**", pg 63 states that "it may be found that the line of full hydrostatic pressure plus effective pressure extends nearly to the base of the wall". The **Full Hydrostatic Head** option assumes the net active pressure down to formation level is the sum of soil pressure (assumed to be zero if negative) and any water pressure. **MEFP** and pressure due to any water table are applied as shown above at depths below formation.

Water pressure can be ignored in cohesive layers even though a water table has been defined, by switching  $P_{aw}$  off in the **Pressure Grid** on the **Pressure** page of the define box. Minimum fluid head will still be applied unless  $P_{mf}$  is also switched off in the **Pressure Grid**.

### Terzaghi Pressure Model

Several options may be selected in the **Pressure** page of the define box for modelling water pressure in cohesive soils with the Terzaghi pressure model:

#### Ignore Hydrostatic

No hydrostatic pressure is applied in cohesive soils, even when a water table has been defined.

#### Tension Cracks

Tension cracks are assumed to exist to the depth specified in the tension crack depth edit box, 't'. Tension cracks may be defined above the water table, in which case it is assumed that rainwater or ice may be present in the cracks. The net active pressure within the tension cracks is the maximum of the calculated soil pressure and water pressure at that depth. This may have no effect with the **Terzaghi** pressure model.

#### Apply Hydrostatic

Hydrostatic pressure is applied in cohesive soils if a water table has been defined.

### Passive Side Cohesive Soils

Hydrostatic pressure can be switched on/off in cohesive soils on the passive side using the **Apply Hydrostatic** control in the **Pressure** page of the define box

## Sloping Ground

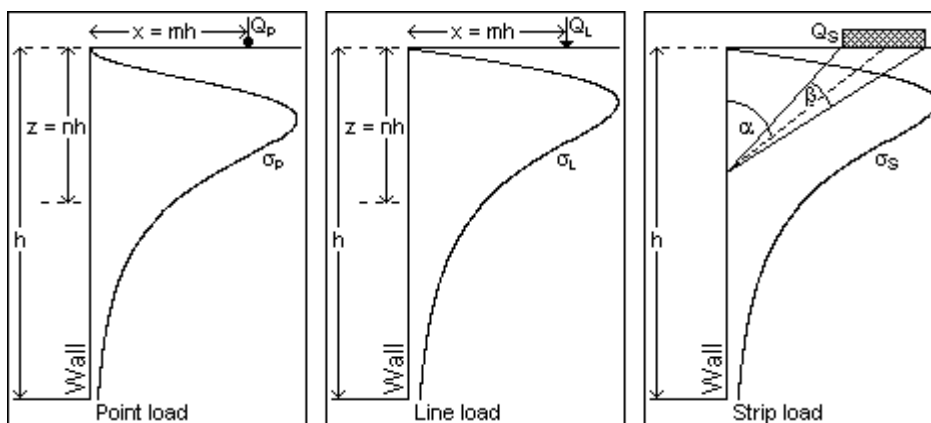
In the Rankine and Coulomb pressure models, the effect of upward or downward sloping ground is determined by modifying the **K** values based on the angle of slope or using the **British Steel Piling Handbook Approximation**. The **K** values are recalculated when the direction or angle of slope is changed in the **Loads/Slope** page of the define box.

In the Terzaghi pressure model, the **BSPH** approximation is used to determine the effect of sloping ground. **K** values are not recalculated when sloping ground is used with the Terzaghi pressure model.

The pressure due to irregular ground conditions is determined by treating the surface as a series of applied strip loads, as described below.

## Surcharge Loads

The lateral pressure due to point, line and area loads are calculated using the appropriate Boussinesq equations (Ref: "CIRIA Report 104"; "USS Steel Sheet Piling Design Manual"; "US Army Corps Of Engineers: Retaining And Flood Walls"):



### Point load

The lateral pressure at any depth,  $z$ , due to a point load a distance  $x$  from the sheet pile wall is given by:

$$\sigma_p = 0.28 \frac{Q_p}{h^2} \frac{n^2}{(0.16 + n^2)^3} \text{ for } m \leq 0.4$$

$$\sigma_p = 1.77 \frac{Q_p}{h^2} \frac{m^2 n^2}{(m^2 + n^2)^3} \text{ for } m > 0.4$$

### Line load

The lateral pressure at any depth,  $z$ , due to a line load a distance  $x$  from the sheet pile wall is given by:

$$\alpha_L = 0.20 \frac{Q_L}{h} \frac{n}{(0.16 + n^2)^2} \text{ for } m \leq 0.4$$

$$\alpha_L = 1.28 \frac{Q_L}{h} \frac{m^2 n}{(m^2 + n^2)^2} \text{ for } m > 0.4$$

### Strip load

The lateral pressure at any depth,  $z$ , due to a strip load is given by:

for non-yielding walls:

$$\alpha_S = \frac{2Q_S}{\pi} (\beta - \sin \beta \cos 2\alpha)$$

for yielding walls (walls at failure):

$$\alpha_S = \frac{Q_S}{\pi} (\beta - \sin \beta \cos 2\alpha)$$

### Area load

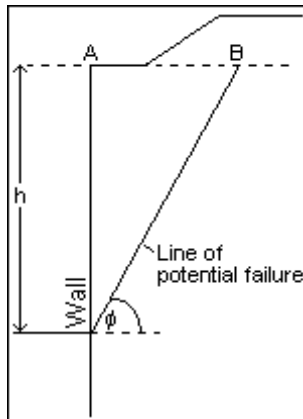
The lateral pressure at any depth due to an area load is calculated as for a strip load, but reduced to account for the finite length of the area load:

$$\alpha_A = \frac{\alpha_S}{(2x/w + 1)}$$

where  $w$  is the length of the load parallel to the wall and  $x$  is the distance between the wall and the nearest edge of the load.

### Custom slope

Pressure due to a customised slope is calculated by treating the slope as a series of superimposed strip loads. The extent of the irregular surface is assumed to be the active failure zone behind the main wall:



The pressure of the customised slope is considered to act in the region between the wall and point **B** in the diagram above. Everything beyond point **B** is ignored (Ref: "**British Steel Piling Handbook (7th Edition)**", Ch. 5).

The worst case occurs when **B** is as far as possible from the wall:

In multi-layered excavations, point **B** is determined using the minimum non-zero angle of friction in the excavation,  $\phi$ , and  $AB = h/\tan(\phi)$ .

**AB** is assumed to be  $1.2 \times h$  from the wall when only cohesive soils are present (i.e.  $\phi$  is zero in all layers).

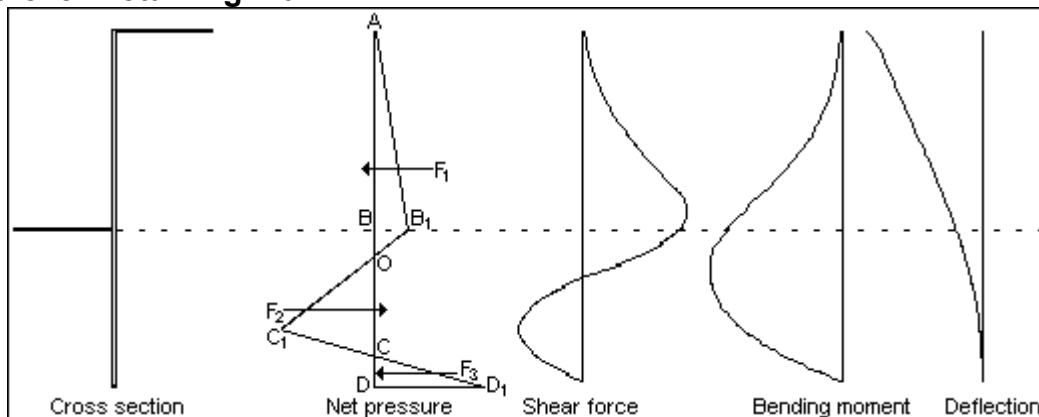
**AB** is assumed to be the maximum value of  $h/\tan(\phi)$  and  $1.2 \times h$ , when a mixture of soils is present ( $\phi > 0$  and  $\phi = 0$ ).

## Chapter 8

### Retaining Wall Calculation Methods

The notation used in these pages is listed in **Appendix A**.

#### Cantilever Retaining Wall

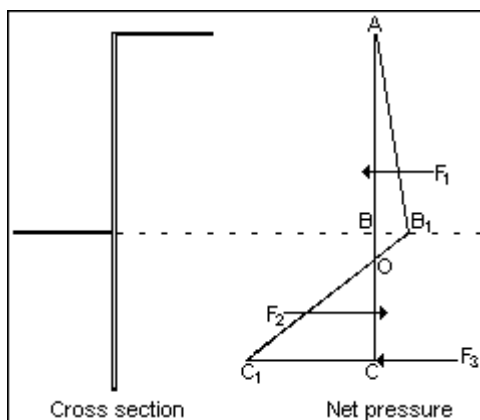


(Ref: "**British Steel Piling Handbook (7th Edition)**", Ch. 5)

Assuming the net pressure is calculated using one of the pressure models available, the forces acting on the wall can be represented as shown above. Each force is assumed to act through the centre of gravity of the given areas:

- $F_1$  = area AOB<sub>1</sub> = total net active pressure
- $F_2$  = area OCC<sub>1</sub> = total net passive pressure
- $F_3$  = area CDD<sub>1</sub> = total net passive pressure required to fix toe of wall

Line C<sub>1</sub>CD<sub>1</sub> may be considered to be horizontal, and force  $F_3$  to act at point C, to simplify calculations:



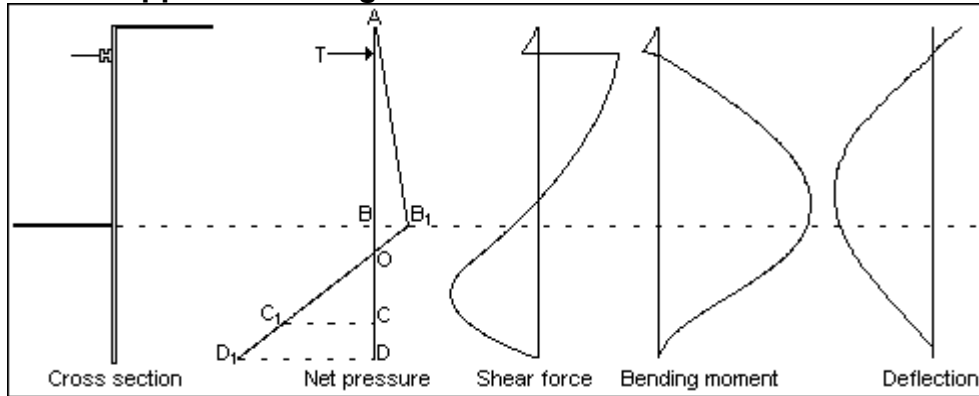
A correction factor is applied to the calculated toe to compensate for this approximation.

The depth OC is such that the moments of forces  $F_1$  and  $F_2$  about  $F_3$  (i.e. point C) are in equilibrium. The calculated toe is increased by **0.2 x OC**, to compensate for the simplified method. (see **Note** below for **gross pressure** and **Burland-Potts** methods).

**Note:** The factor of safety against rotational failure for cantilever walls is given by the ratio of the restoring moments about point C to the disturbing moments about point C. The displayed factor of safety is calculated **before** the distance OC is increased by 20% to compensate for the simplified method. Similarly, if "**Defined FOS**" is selected or a manual toe is entered in the **Wall** page of the define box, the fos is calculated independently of the 20% correction.

The solution outlined above uses the **net pressure** method. In the **gross pressure** and **Burland-Potts** methods, it is the depth **BC** rather than **OC** which is increased by 20%.

## Free Earth Support Retaining Wall



(Ref: "**British Steel Piling Handbook (7th Edition)**", Ch. 5)

The Free Earth Support condition ensures that the penetration of the piles is sufficient to prevent forward movement of the toe, but not sufficient to prevent rotation.

Assuming the net pressure is calculated using one of the pressure models available, the forces acting on the wall can be represented as shown above. Each force is assumed to act through the centre of gravity of the given areas:

- Area  $AOB_1$  = total net active pressure
- Area  $OCC_1$  = total net passive pressure (factor of safety = 1)
- Area  $ODD_1$  = total net passive pressure (factor of safety = 2)

For stability, the moments of  $AOB_1$  and  $OCC_1$  about the support should be in equilibrium.

The factor of safety with free earth support is given by the ratio of the restoring moments about point T to the disturbing moments about T, and the toe (i.e. BD) should give a factor of safety of 2 against rotation about the support. That is, the moment of area  $ODD_1$  is twice the moment of  $AOB_1$  about the support depth.

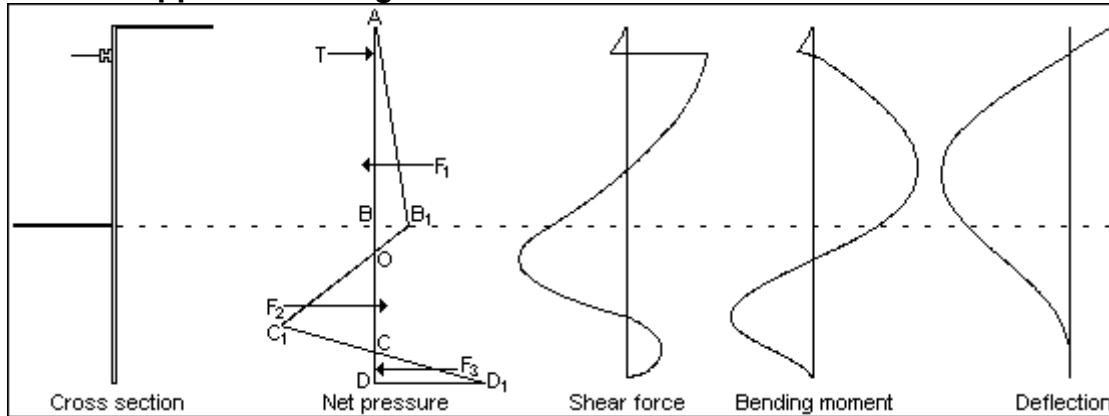
The force T at the support level is given by:

$$T = \text{Area } AOB_1 - \text{Area } OCC_1$$

### Multiple propped wall

When more than one support is present, the toe and load on the lowest frame are found by considering the lowest span as a singly supported wall (Ref: "**British Steel Piling Handbook (7th Edition)**", pg 5/12). Loads on frames above the lowest are found using the current load model.

## Fixed Earth Support Retaining Wall

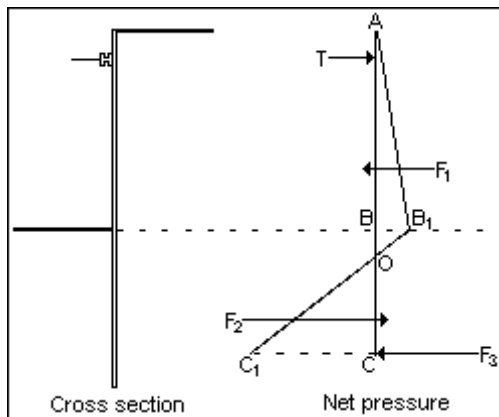


(Ref: "British Steel Piling Handbook (7th Edition)", Ch. 5)

Assuming the net pressure is calculated using one of the pressure models available, the forces acting on the wall can be represented as shown above. Each force is assumed to act through the centre of gravity of the given areas:

- $F_1$  = area  $AOB_1$  = total net active pressure
- $F_2$  = area  $OCC_1$  = total net passive pressure
- $F_3$  = area  $CDD_1$  = total net passive pressure required to fix toe of wall
- $T$  = load on support

As in the case of a cantilevered wall line,  $C_1CD_1$  may be considered to be horizontal, and force  $F_3$  to act at point C to simplify calculations:



A correction factor is applied to the calculated toe to compensate for this approximation.

The depth  $OC$  is such that the moments of forces  $T$ ,  $F_1$  and  $F_2$  about  $F_3$  (i.e. point  $C$ ) are in equilibrium. The calculated toe is increased by **0.2 x OC**, to compensate for the simplified method (see **Note** below for **gross pressure** and **Burland-Potts** methods).

The force  $T$  at the support level is found by taking moments of area  $AOB_1$  about  $O$ .

### Multiple propped wall

When more than one support is present, the toe and load on the lowest frame are found by considering the lowest span as a singly supported wall (Ref: "British Steel Piling Handbook (7th Edition)", pg 5/12). Loads on frames above the lowest are found using the current load model.

**Note:** The displayed factor of safety with fixed earth support walls is the ratio of the restoring moments about point **T** to the disturbing moments about **T**. It is **not the factor of safety against rotational failure about point C**. The fos is calculated independently of the 20% correction compensation factor for the simplified method.

The solution outlined above uses the **net pressure** method. In the **gross pressure** and **Burland-Potts** methods, it is the depth **BC** rather than **OC** which is increased by 20%.

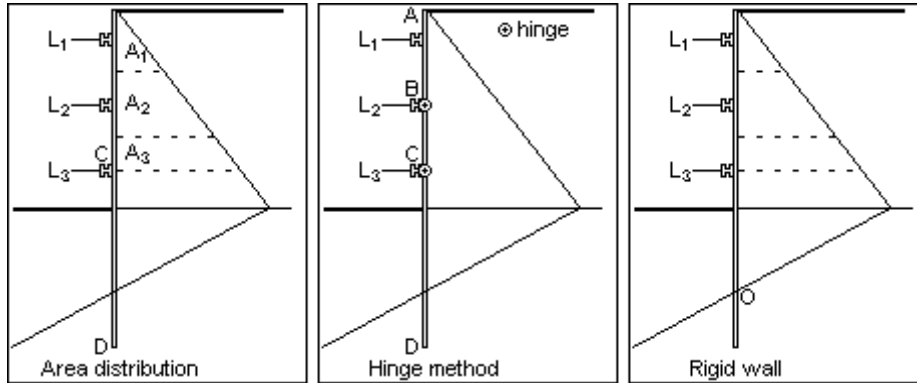
## Linear Load

### Single propped wall

In a wall supported by one level of frames, the frame load is calculated using the appropriate method for Free/Fixed Earth Support (Ref: "BSPH (7th Edition)"; "CIRIA 95").

### Multiple propped wall

In a wall supported by more than one level of frames, the load on the lowest frame is found by treating the span below the lowest frame as a single propped wall and using the appropriate method for Free/Fixed Earth Support. The loads on frames above the lowest are found using the currently selected load model:



#### Area Distribution

The loads on frames above the lowest are found by load distribution. The top frame load is the total load between the top of the excavation and the midpoint between the top frame and the frame below. The load on other frames above the lowest is the total load between the midpoints between each frame and the frames immediately above and below. The load on the lowest frame is found by a combination of the area distribution method and the value obtained by treating the span below the lowest frame as a single propped wall and using the appropriate method for Free/Fixed Earth Support. For example, in the diagram above:

- $L_1$  = load on top support = area  $A_1$
- $L_2$  = load on middle support = area  $A_2$
- $L_3$  = load on lowest support = area  $A_3$  + load obtained by solving span CD as a single propped Free/Fixed earth support wall.

If **Elastic Shear** is switched on, moment transfer is used to adjust the calculated loads. **Elastic Shear** is only available with the **Area Distribution** model.

#### Hinge Method

The loads on frames above the lowest are found using the hinge method (Ref: "BSPH (7th Edition)", pg 5/12; "BS 8002"). A hinge is assumed to exist at each frame except the the top one, and the spans between frames above the lowest are considered as simply supported beams. The load on each frame is the sum of the loads found by analysing each of these simply supported beams. The load on the lowest frame is found by a combination of the hinge method and the value obtained by treating the span below the lowest frame as a single propped wall and using the appropriate method for Free/Fixed Earth Support (Ref: "BSPH (7th Edition)"; "CIRIA 95"). For example, in the diagram above:

- $L_1$  = load on top support; obtained by solving simply supported span AB
- $L_2$  = load on middle support; obtained by adding the values obtained by solving simply supported spans AB and BC.
- $L_3$  = load on lowest support; obtained from the sum of the value obtained by solving simply supported span BC, and the load obtained by solving span CD as a single propped Free/Fixed earth support wall.

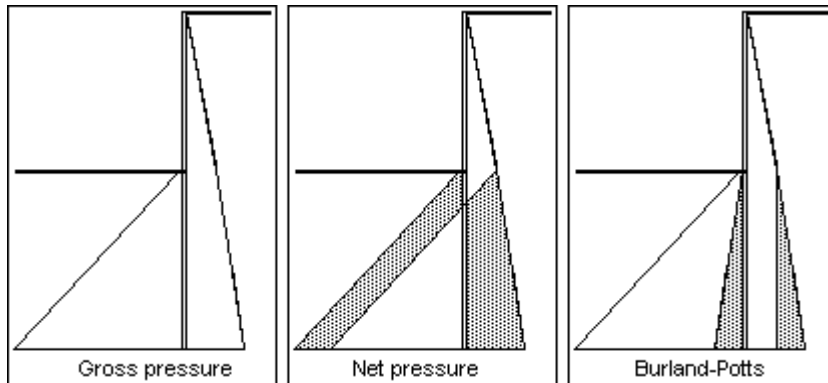
**Note:** No hinge is assumed at the lowest frame position in "No toe" designs, and the Hinge Method gives the same frame loads as the Rigid Wall Method in "No toe" designs with only 2 frames defined.

#### Rigid Wall

The wall is assumed to act as a vertical beam subjected to a pressure distribution with reactions at support points, as outlined in the "**British Steel Piling Handbook (7th Edition)**", pg 5/14. This method recommends that the minimum mobilised earth pressure is **1.3** times the calculated value. This factor may be edited in the **P x** edit box in the **Supports** page of the define box. The pressure values displayed in graphs and tables remain as calculated, i.e. the mobilisation factor is only used during the calculation of linear load, bending moment, etc.

Note that the rigid wall method assumes that the bottom of the beam is determined by the point at which the net active pressure falls below zero (i.e. point **O** in the diagram above). This results in identical reactions/moments being calculated for free/fixed earth cases.

## Factor of Safety Methods



(Ref: “**British Steel Piling Handbook (7th Edition)**”, Ch. 5; “**CIRIA Report 104**”).

### Gross pressure

Also referred to as **CP2**, this method consists of only factoring the gross pressure diagram:

$$\text{fos} = \text{restoring moments}/\text{overturning moments}$$

There is an anomaly in this method in undrained conditions where  $K_a = K_p = 1$ , as it is found that the calculated fos decreases with increasing length of wall beyond a certain depth of penetration.

### Net pressure

The fos is applied to the net passive pressure diagram. This is obtained by subtracting the active earth and water pressures from the passive earth and water pressures, as shown by the unshaded area in the diagram above:

$$\text{fos} = \text{Moment of net passive pressure}/\text{Moment of net active pressure}$$

This method tends to give a higher fos than other methods.

### Burland-Potts

Also referred to as the **Revised Method**, this method eliminates some of the balancing loads from the moment equilibrium equation. It consists of applying the fos to the moment of the net available passive resistance, which is the difference between the gross passive pressure and the components of the active pressure which result from the weight of soil below dredge level, as shown by the unshaded area in the diagram above:

$$\text{fos} = \text{Moment of net available passive resistance}/\text{Moment of retained material}$$

### Parameter values factored (Factor on strength method)

This approach involves factoring the strength parameters of the soil to increase the active pressure and/or decrease the passive pressure, as described in the “**British Steel Piling Handbook**”, “**CIRIA Report 104**” and “**Pile Buck Steel Sheet Piling Design Manual**”.

Factors may be applied in the **Wall** page of the define box:

#### $K_a$

A factor in the range **1.0 – 2.0** may be applied. The active pressure coefficient,  $K_a$ , is multiplied by the selected factor with a resultant increase in the active pressure.  $K_{ac}$  is adjusted accordingly.

#### $K_p$

A factor in the range **1.0 – 2.0** may be applied. The passive pressure coefficient,  $K_p$ , is divided by the selected factor with a resultant decrease in the passive pressure.  $K_{pc}$  is adjusted accordingly.

**C<sub>act</sub>**

A factor in the range **1.0 – 2.0** may be applied. The cohesion on the active side is divided by the selected factor with a resultant increase in the active pressure.

**C<sub>pas</sub>**

A factor in the range **1.0 – 2.0** may be applied. The cohesion on the passive side is divided by the selected factor with a resultant decrease in the passive pressure.

**Embedment only**

The check box defines how the selected soil factors are applied. The factors are only applied during the embedment calculation, as recommended in the “**British Steel Piling Handbook**” and “**CIRIA 104**”, if the check box is selected. The factors are applied to all calculations, as recommended in the “**Pile Buck Steel Sheet Piling Design Manual**”, if the check box is unselected. The default setting is **on**.

**Note:**

1. Only free earth support conditions are relevant to stability calculations in propped walls (Ref: “**CIRIA Report 104**”, pg 66).
2. The displayed fos for cantilever and fixed earth support walls is calculated independently of the 20% correction factor applied to compensate for the simplified method of calculating the toe.
3. The **Gross pressure**, **Net pressure** and **Burland-Potts** methods give the same depth of penetration for a factor of safety of 1.0. However, the final penetration displayed differs as the 20% correction is being added to depth **OC** when net pressure is used, and the depth **BC** when **gross pressure** or **Burland-Potts** are used.
4. When soil factors have been applied, the displayed fos still refers to stability against rotation about the toe (cantilever wall) or the lowest frame (propped wall). The displayed fos does not include the effect of the factored soil parameter(s) as it is calculated using the factored parameter(s). The recommended factor of safety depends on the circumstances and method used, as described in “**CIRIA 104**”, pp 72 – 74. The **Defined FOS** option can be used to enter any desired fos, and **Table 5** in “**CIRIA 104**” gives recommended values of fos which apply with the various methods.

**Stepped Excavations**

Each wall is analysed independently in the case of stepped excavations, i.e. it is assumed there is no transfer of load from a wall to an adjacent wall. The user should ensure walls are far enough apart for this to be the case.

**Deflection Calculation**

Sheet and frame deflections are calculated by finding the bending moment then solving the second order differential equation:

$$\frac{d^2v}{dx^2} = \frac{M}{EI}$$

(Ref: “**The Steel Designer's Handbook**”, pg 82)

**Rowe's Moment Reduction Theory**

(Ref: “**Pile Buck Steel Sheet Piling Design Manual**”; “**Investigation of Wall Friction, Surcharge Loads, and Moment Reduction Curves for Anchored Sheet-Pile Walls**”; “**Engineering and Design - Design of Sheet Pile Walls**”, Ch 6).

A moment reduction factor may be applied to a **SupportIT** design in the **Wall** page of the define box.

**Rowe's Moment Reduction Theory** compensates for the fact that the **Free Earth Support** method overestimates the maximum bending moment and deflection of sheet piles, and establishes a relationship between the flexibility of an anchored wall and the reduction of the actual bending moment, **M<sub>max</sub>**.

The reduced bending moment for a design is given by:

$$M = R \cdot M_{max}$$

where **R** is the reduction factor and depends on wall geometry, wall flexibility and soil characteristics.

**R** is usually determined using moment reduction curves, which are reproduced in “**Pile Buck Steel Sheet Piling Design Manual**” and other references.

As a general guide:

**$0.2 < R \leq 1$  in granular soils.**

**$0.4 < R \leq 1$  in cohesive soils.**

A summary of the theory and sample moment reduction curves are given in “**Investigation of Wall Friction, Surcharge Loads, and Moment Reduction Curves for Anchored Sheet Pile Walls**”. The document can be downloaded from <http://www.vulcanhammer.net/download/itl-tr-01-4.pdf>.

**Note:**

Rowe’s moment reduction curves apply to very specific conditions:

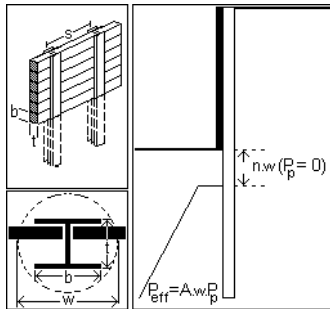
1. Soil layers are homogeneous.
2. The curves are for single anchored walls, not multiple anchors. They do not apply to cantilevers.
3. The curves are for **Free Earth Support** walls. They do not apply to **Fixed Earth** designs.
4. There are restrictions on anchor position, etc.
5. The curves are for steel sheet piling, not aluminium or vinyl.

**SupportIT does not check** that moment reduction may be applied to a design, or that the reduction factor used is appropriate. **The user should ensure** that moment reduction may be applied, and that the value of **R** is appropriate to the design.

# Chapter 9

## Soldier Pile and Lagging Walls

The notation used in these pages is listed in **Appendix A**.



### Effective Width

The effective width of a soldier pile is assumed to be the width of the pile parallel to the wall (**b**), or the diameter of any preaugered hole used for the installation of the pile (**w**). The pile width is indicated below by '**w**'.

Experimental observations indicate that the passive resistance of cohesionless soils acts over a width greater than the actual width of the soldier pile. A passive soil wedge develops below the excavation depth as the pile rotates about its bottom, increasing in width with increasing distance from the pile. This is taken into account by applying an **adjustment** (or **passive arching**) factor, **A**, calculated from:

$$A = 0.08 \phi \quad \text{where } 1.0 \leq A \leq 3.0$$

i.e.  $w_{\text{eff}} = Aw$

The final adjusted effective width should not exceed the pile spacing, i.e.

$$w_{\text{eff}} < s$$

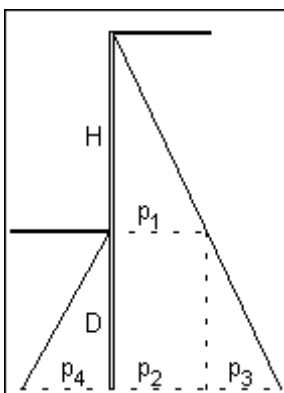
Soil pressures are calculated in the usual way.

The adjusted effective width is sometimes used only on the passive side of the excavation. Alternatively, it may also be used for the active loading. **SupportIT** provides alternative methods for modeling soldier pile and lagging walls, as summarised below.

### Method 1: Adjustment factor applied to passive side only

(Ref: "New York Department of Transportation: Flexible Wall Systems").

**Apply 'A' to both sides** should be unchecked in the **Wall** page to use this method.



Soldier pile penetration is calculated by assuming the loads on the wall are:

$$\begin{aligned} \text{Active load above excavation depth} &= p_1 \cdot s \cdot H/2 \\ \text{Active load below excavation depth} &= p_2 \cdot w \cdot D + p_3 \cdot w \cdot D/2 \\ \text{Passive load} &= p_4 \cdot Aw \cdot D/2 \end{aligned}$$

## Method 2: Adjustment factor applied to active and passive sides

(Ref: "California Trenching and Shoring Manual").

**Apply 'A' to both sides** should be checked in the **Wall** page to use this method.

Soldier piling can be analysed in the same way as sheet piling, if the active loaded width is assumed to equal the passive loaded width below excavation depth. The soldier pile effective width is adjusted to allow results to be calculated on a per metre (foot) basis of wall, as in a sheet piling analysis.

This can be achieved by calculating an **arching factor, f**, as shown below:

$$f = A.w/s \quad \text{where } f \leq 1.0$$

All equations below the excavation depth are factored by **f**, and the final answers multiplied by **s**.

This method usually results in a greater penetration depth than **Method 1**.

## AASHTO

**AASHTO** recommends that passive resistance be ignored for depths below excavation level less than **1.5** times the effective pile width.

This can be implemented by entering an appropriate value of **n** ( $0 < n < 2.0$ ) in the **Wall** page. If a value greater than **0** is entered, then passive pressure is ignored for a depth **nw**, and an increased pile penetration will result. Note that the passive pressure is ignored over the specified depth during the toe calculation, although it will be shown as non-zero in pressure graphs and tables.

**Note: AASHTO** also recommends that the computed pile depth be increased by **50%** for permanent flexible cantilever walls, and by **30%** for temporary works. **SupportIT** does not apply either of these factors, although the user can increase the calculated toe using the **Manual** toe option in the **Wall** page.

Following the adjustments outlined above, soldier pile penetration is calculated in both methods as for a sheet pile, using the methods described for **Cantilever**, **Free Earth Support** or **Fixed Earth Support** retaining walls in **Chapter 8**.

## Load Reduction Factor

(Ref: "California Trenching and Shoring Manual").

Soil arching causes lagging to flex outwards and induces a redistribution of soil pressure away from the centre of the lagging towards the soldier piles. To account for this, the design load on the lagging may be taken as **0.6** times the theoretical pressure based on a simple span.

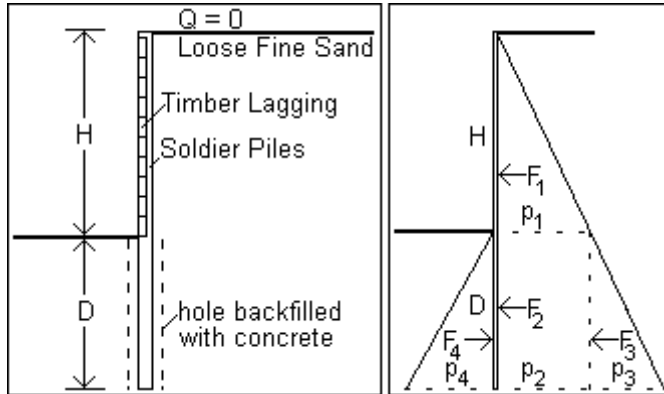
A load reduction factor, **r** ( $0.6 \leq r \leq 1.0$ ), may be applied in the **Wall** page. The effect of the load reduction factor may be seen in the minimum lagging section modulus displayed in the **Plan View**. The load reduction factor is also used in the maximum pressure, bending moment, shear force and deflection displayed in the **Plan View**.

Studies have shown that a maximum lagging pressure of **400psf** may be expected in the absence of surcharges. No provision is made for this in **SupportIT**.

A soldier pile wall can be viewed in the demonstration file **Demo6**, supplied with **SupportIT**. Open the file then select **Soldier Pile & Lagging** in the **Type** box. Manual solutions of this design using the 2 methods described above are outlined in the next few pages.

## Worked Example: Soldier Pile Wall, Method 1 (Metric units)

Calculate the soldier pile penetration required for the excavation below using gross pressure and applying the arching factor, 'A', to the passive side only.



Loose Fine Sand:  $H = 5\text{m}$   
 $\gamma = 18.0\text{kN/m}^3$   
 $\phi = 30^\circ$   
 $K_a = 0.33$   
 $K_p = 3.0$

Soldier pile width,  $b = 0.5\text{m}$   
 Soldier pile separation,  $s = 2.5\text{m}$   
 Hole diameter,  $w = 0.6\text{m}$

Effective pile width,  $w = \text{hole diameter}$   
 $= 0.6\text{m}$

Adjustment factor,  $A = 0.08 \phi$   
 $= 2.4$

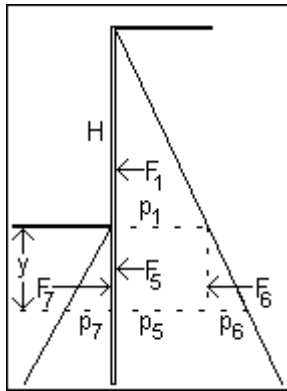
Calculate soil pressure from Rankine, then use the simplified method for cantilever walls:

Pressure	Load	Moment Arm	Moment
$p_1 = \gamma.H.K_a$ $= 29.70\text{kN/m}^2$	$F_1 = p_1.s.H/2$ $= 185.63\text{kN}$	$D + 5/3$	$185.63D + 309.38$
$p_2 = p_1$	$F_2 = p_2.w.D$ $= 17.82D$	$D/2$	$8.91D^2$
$p_3 = \gamma.D.K_a$ $= 5.94D$	$F_3 = p_3.w.D/2$ $= 1.78D^2$	$D/3$	$0.59D^3$
$p_4 = \gamma.D.K_p$ $= 54.00D$	$F_4 = -p_4.Aw.D/2$ $= -38.88D^2$	$D/3$	$-12.96D^3$

Sum of bending moments about toe,  $\Sigma M = 0$   
 $309.38 + 185.63D + 8.91D^2 - 12.37D^3 = 0$   
 $\Rightarrow D = 4.86\text{m}$

Increase **D** by **20%** to compensate for simplified method.  
 $\Rightarrow \mathbf{D = 5.83m}$

Assume the point of zero shear and maximum bending moment occurs a distance **y** below excavation depth:



Pressure	Load	Moment Arm	Moment
$p_1 = 29.70 \text{ kN/m}^2$	$F_1 = 185.63 \text{ kN}$	$y + 5/3$	$185.63y + 309.38$
$p_5 = p_1$	$F_5 = p_5 \cdot w \cdot y$ $= 17.82y$	$y/2$	$8.91y^2$
$p_6 = \gamma \cdot y \cdot K_a$ $= 5.94y$	$F_6 = p_6 \cdot w \cdot y/2$ $= 1.78y^2$	$y/3$	$0.59y^3$
$p_7 = \gamma \cdot y \cdot K_p$ $= 54.00y$	$F_7 = -p_7 \cdot Aw \cdot y/2$ $= -38.88y^2$	$y/3$	$-12.96y^3$

$$\Sigma F = 0$$

i.e.  $F_1 + F_5 + F_6 + F_7 = 0$

$$37.10y^2 - 17.82y - 185.63 = 0$$

$\Rightarrow$   **$y = 2.49 \text{ m}$**

i.e. zero shear, and maximum bending moment, occur at **7.49m**

Maximum moment,  $M_{\max} = \Sigma M$

$$= 309.38 + 185.63y + 8.91y^2 - 12.37y^3$$

$$= \mathbf{635.9 \text{ kNm}}$$

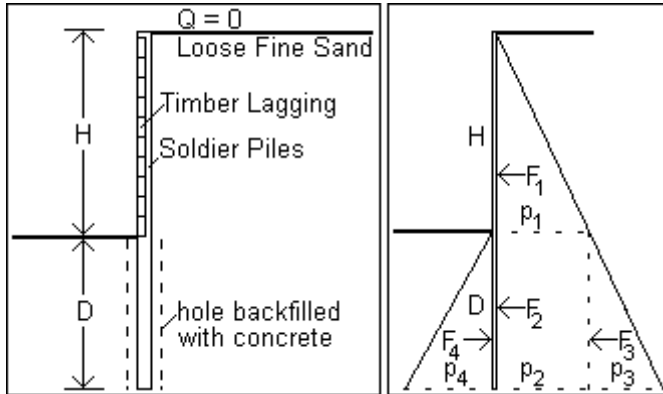
Results from **SupportIT**, with **Apply 'A' to both sides** switched **OFF**, are:

$D = 5.84 \text{ m}$

$M_{\max} = 637.2 \text{ kNm at } 7.49 \text{ m}$

## Worked Example: Soldier Pile Wall, Method 2 (Metric units)

Calculate the soldier pile penetration required for the excavation below using gross pressure and applying the arching factor, 'A', to the passive AND active sides.



Loose Fine Sand:  $H = 5\text{m}$   
 $\gamma = 18.0\text{kN/m}^3$   
 $\phi = 30^\circ$   
 $K_a = 0.33$   
 $K_p = 3.0$

Soldier pile width,  $b = 0.5\text{m}$   
 Soldier pile separation,  $s = 2.5\text{m}$   
 Hole diameter,  $w = 0.6\text{m}$

Effective pile width,  $w = \text{hole diameter}$   
 $= 0.6\text{m}$

Adjustment factor,  $A = 0.08 \phi$   
 $= 2.4$

Arching factor,  $f = A.w/s$   
 $= 0.576$

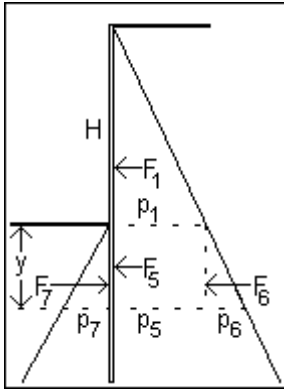
Calculate soil pressure from Rankine and apply **f** below the excavation depth, then use the simplified method for cantilever walls:

Pressure	Load	Moment Arm	Moment
$p_1 = \gamma.H.K_a$ $= 29.70\text{kN/m}^2$	$F_1 = p_1.H/2$ $= 74.25\text{kN}$	$D + 5/3$	$74.25D + 123.75$
$p_2 = fp_1$ $= 17.11\text{kN/m}^2$	$F_2 = p_2.D$ $= 17.11D$	$D/2$	$8.56D^2$
$p_3 = f\gamma.D.K_a$ $= 3.42D$	$F_3 = p_3.D/2$ $= 1.71D^2$	$D/3$	$0.57D^3$
$p_4 = f\gamma.D.K_p$ $= 31.10D$	$F_4 = -p_4.D/2$ $= -15.55D^2$	$D/3$	$-5.18D^3$

Sum of bending moments about toe,  $\Sigma M = 0$   
 i.e.  $123.75 + 74.25D + 8.56D^2 - 4.61D^3 = 0$   
 $\Rightarrow D = 5.59\text{m}$

Increase **D** by **20%** to compensate for simplified method.  
 $\Rightarrow \underline{\underline{D = 6.71\text{m}}}$

Assume the point of zero shear and maximum bending moment occurs a distance **y** below excavation depth:



Pressure	Load	Moment Arm	Moment
$p_1 = 29.70 \text{ kN/m}^2$	$F_1 = 74.25 \text{ kN}$	$y + 5/3$	$74.25y + 123.75$
$p_5 = fp_1$ $= 17.11 \text{ kN/m}^2$	$F_5 = p_5 \cdot y$ $= 17.11y$	$y/2$	$8.56y^2$
$p_6 = f_\gamma \cdot y \cdot K_a$ $= 3.42y$	$F_6 = p_6 \cdot y/2$ $= 1.71y^2$	$y/3$	$0.57y^3$
$p_7 = f_\gamma \cdot y \cdot K_p$ $= 31.10y$	$F_7 = -p_7 \cdot y/2$ $= -15.55y^2$	$y/3$	$-5.18y^3$

$$\Sigma F = 0$$

i.e.  $F_1 + F_5 + F_6 + F_7 = 0$

$$13.84y^2 - 17.11y - 74.25 = 0$$

$\Rightarrow$   $\mathbf{y = 3.02m}$

i.e. zero shear, and maximum bending moment, occur at **8.02m**

Maximum moment,  $M_{\max} = s \Sigma M$

$$= 2.5(123.75 + 74.25y + 8.56y^2 - 4.61y^3)$$

$$= \mathbf{747.7 \text{ kNm}}$$

(Nb: final answers multiplied by **s**)

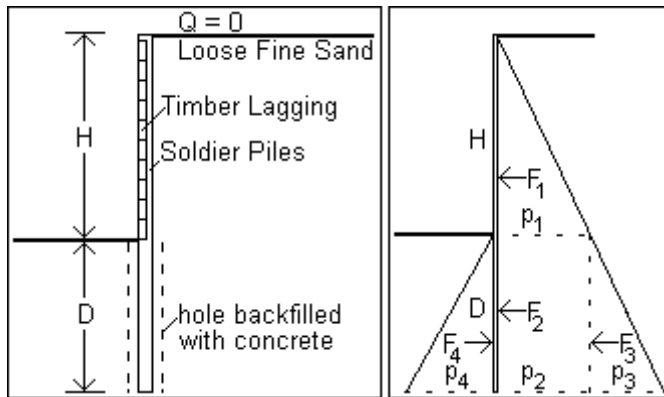
Results from **SupportIT**, with **Apply 'A' to both sides** switched **ON**, are:

$$D = \mathbf{6.69m}$$

$$M_{\max} = \mathbf{747.6 \text{ kNm at } 8.02m}$$

## Worked Example: Soldier Pile Wall, Method 1 (Imperial units)

Calculate the soldier pile penetration required for the excavation below using gross pressure and applying the arching factor, 'A', to the passive side only.



	H = 16.40ft
Loose Fine Sand:	$\gamma = 114.6\text{pcf}$
	$\phi = 30^\circ$
	$K_a = 0.33$
	$K_p = 3.0$
Soldier pile width,	b = 1.64ft
Soldier pile separation,	s = 8.20ft
Hole diameter,	w = 1.97ft
Effective pile width,	w = hole diameter
	= 1.97ft
Adjustment factor,	A = 0.08 $\phi$
	= 2.4

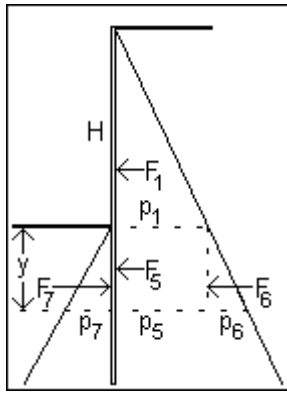
Calculate soil pressure from Rankine, then use the simplified method for cantilever walls:

Pressure	Load	Moment Arm	Moment
$p_1 = \gamma \cdot H \cdot K_a$ = 620.2psf	$F_1 = p_1 \cdot s \cdot H/2$ = 41703.3lb	D + 16.4/3	41703.3D + 227977.9
$p_2 = p_1$	$F_2 = p_2 \cdot w \cdot D$ = 1221.8D	D/2	610.9D <sup>2</sup>
$p_3 = \gamma \cdot D \cdot K_a$ = 37.8D	$F_3 = p_3 \cdot w \cdot D/2$ = 37.3D <sup>2</sup>	D/3	12.4D <sup>3</sup>
$p_4 = \gamma \cdot D \cdot K_p$ = 343.8D	$F_4 = -p_4 \cdot A \cdot w \cdot D/2$ = -812.7D <sup>2</sup>	D/3	-270.9D <sup>3</sup>

$$\begin{aligned} \text{Sum of bending moments about toe, } \Sigma M &= 0 \\ 227977.9 + 41703.3D + 610.9D^2 - 258.5D^3 &= 0 \\ \Rightarrow D &= 15.95\text{ft} \end{aligned}$$

Increase **D** by **20%** to compensate for simplified method.  
 $\Rightarrow \underline{\underline{D = 19.14\text{ft}}}$

Assume the point of zero shear and maximum bending moment occurs a distance **y** below excavation depth:



Pressure	Load	Moment Arm	Moment
$p_1 = 620.2 \text{ psf}$	$F_1 = 41703.3 \text{ lb}$	$y + 16.4/3$	$41703.3y + 227977.9$
$p_5 = p_1$	$F_5 = p_5 \cdot w \cdot y$ $= 1221.8y$	$y/2$	$610.9y^2$
$p_6 = \gamma \cdot y \cdot K_a$ $= 37.8y$	$F_6 = p_6 \cdot w \cdot y/2$ $= 37.3y^2$	$y/3$	$12.4y^3$
$p_7 = \gamma \cdot y \cdot K_p$ $= 343.8y$	$F_7 = -p_7 \cdot A_w \cdot y/2$ $= -812.7y^2$	$y/3$	$-270.9y^3$

$$\Sigma F = 0$$

i.e.  $F_1 + F_5 + F_6 + F_7 = 0$

$$775.4y^2 - 1221.8y - 41703.3 = 0$$

∴  $y = 8.16 \text{ ft}$

i.e. zero shear, and maximum bending moment, occur at **24.56ft**

Maximum moment,  $M_{\max} = \Sigma M$

$$= 227977.9 + 41703.3y + 610.9y^2 - 258.5y^3$$

$$= \mathbf{468501.0 \text{ ft lb}}$$

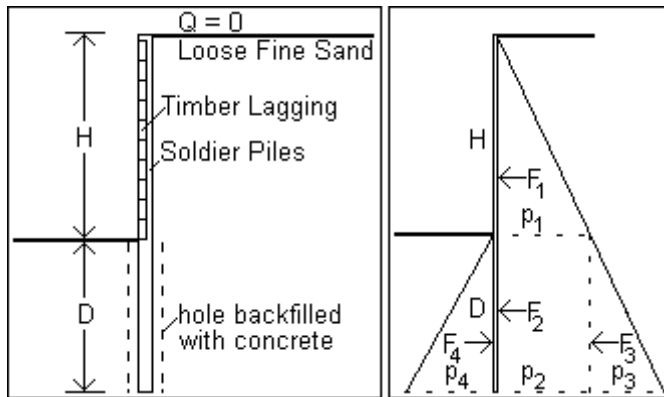
Results from **SupportIT**, with **Apply 'A' to both sides** switched **OFF**, are:

D = **19.16ft**

$M_{\max} = \mathbf{469818.3 \text{ ft lb}}$  at **24.57ft**

## Worked Example: Soldier Pile Wall, Method 2 (Imperial units)

Calculate the soldier pile penetration required for the excavation below using gross pressure and applying the arching factor, 'A', to the passive AND active sides.



	$H = 16.40\text{ft}$
Loose Fine Sand:	$\gamma = 114.6\text{pcf}$
	$\phi = 30^\circ$
	$K_a = 0.33$
	$K_p = 3.0$
Soldier pile width,	$b = 1.64\text{ft}$
Soldier pile separation,	$s = 8.20\text{ft}$
Hole diameter,	$w = 1.97\text{ft}$
Effective pile width,	$w = \text{hole diameter}$
	$= 1.97\text{ft}$
Adjustment factor,	$A = 0.08 \phi$
Arching factor,	$f = A.w/s$
	$= 0.576$

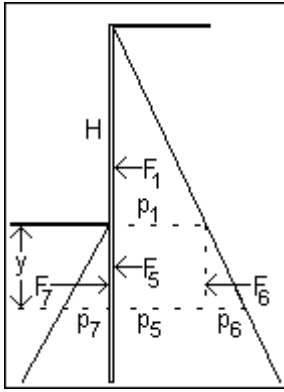
Calculate soil pressure from Rankine and apply  $f$  below the excavation depth, then use the simplified method for cantilever walls:

Pressure	Load	Moment Arm	Moment
$p_1 = \gamma.H.K_a$ $= 620.2\text{psf}$	$F_1 = p_1.H/2$ $= 5085.8\text{lb/ft}$	$D + 16.4/3$	$5085.8D + 27802.2$
$p_2 = fp_1$ $= 357.2\text{psf}$	$F_2 = p_2.D$ $= 357.2D$	$D/2$	$178.6D^2$
$p_3 = f\gamma.D.K_a$ $= 21.8D$	$F_3 = p_3.D/2$ $= 10.9D^2$	$D/3$	$3.6D^3$
$p_4 = f\gamma.D.K_p$ $= 198.0D$	$F_4 = -p_4.D/2$ $= -99.0D^2$	$D/3$	$-33.0D^3$

Sum of bending moments about toe,  $\Sigma M = 0$   
 i.e.  $27802.2 + 5085.8D + 178.6D^2 - 29.4D^3 = 0$   
 $\Rightarrow D = 18.33\text{ft}$

Increase  $D$  by **20%** to compensate for simplified method.  
 $\Rightarrow \underline{D = 22.00\text{ft}}$

Assume the point of zero shear and maximum bending moment occurs a distance  $y$  below excavation depth:



Pressure	Load	Moment Arm	Moment
$p_1 = 620.2 \text{ psf}$	$F_1 = 5085.8 \text{ lb/ft}$	$y + 16.4/3$	$5085.8y + 27802.2$
$p_5 = fp_1$ $= 357.2 \text{ psf}$	$F_5 = p_5 \cdot y$ $= 357.2y$	$y/2$	$178.6y^2$
$p_6 = f_y \cdot y \cdot K_a$ $= 21.8y$	$F_6 = p_6 \cdot y/2$ $= 10.9y^2$	$y/3$	$3.6y^3$
$p_7 = f_y \cdot y \cdot K_p$ $= 198.0y$	$F_7 = -p_7 \cdot y/2$ $= -99.0y^2$	$y/3$	$-33.0y^3$

$$\Sigma F = 0$$

i.e.  $F_1 + F_5 + F_6 + F_7 = 0$

$$88.1y^2 - 357.2y - 5085.8 = 0$$

$\Rightarrow$   **$y = 9.89 \text{ ft}$**

i.e. zero shear, and maximum bending moment, occur at **26.29ft**

Maximum moment,  $M_{\max} = \Sigma M$

$$= 8.2(27802.2 + 5085.8y + 178.6y^2 - 29.4y^3)$$

$$= \mathbf{550462.5 \text{ ft lb}}$$

(Nb: final answers multiplied by s)

Results from **SupportIT**, with **Apply 'A' to both sides** switched **ON**, are:

$$D = 21.96 \text{ ft}$$

$$M_{\max} = 551223.2 \text{ ft lb at } 26.31 \text{ ft}$$

# Appendix A

## Notation

Symbol	Quantity	Units	
$\gamma$	Bulk density of soil	kN/m <sup>3</sup>	pcf
$\gamma_s$	Submerged density of soil	kN/m <sup>3</sup>	pcf
$\gamma_w$	Density of water	kN/m <sup>3</sup>	pcf
$\phi$	Angle of internal friction of soil	degrees	
$\delta$	Angle of friction between soil and piles	degrees	
$\beta$	Angle of slope of backfill	degrees	
$\sigma_p$	Pressure due to point load	kN/m <sup>2</sup>	psf
$\sigma_L$	Pressure due to line load	kN/m <sup>2</sup>	psf
$\sigma_s$	Pressure due to strip load	kN/m <sup>2</sup>	psf
$\sigma_A$	Pressure due to area load	kN/m <sup>2</sup>	psf
A	Soldier pile passive arching factor		
b	Soldier pile (or frame) width	m	ft
C	Cohesion of soil	kN/m <sup>2</sup>	psf
$C_a$	Adhesion between soil and piles	kN/m <sup>2</sup>	psf
d	Depth	m	ft
D	Sheet (soldier) pile penetration	m	ft
$d_w$	Depth of water	m	ft
E	Young's modulus	kN/m <sup>2</sup>	psi
f	Working stress	N/mm <sup>2</sup>	psi
f	Soldier pile arching factor		
h	Height of soil above a level	m	ft
H	Excavation depth	m	ft
I	Moment of Inertia - sheet piles	cm <sup>4</sup> /m	in <sup>4</sup> /ft
I	Moment of Inertia - frames/beams/soldiers/lagging	cm <sup>4</sup>	in <sup>4</sup>
$K_a$	Active pressure coefficient (cohesionless soils)		
$K_{ac}$	Active pressure coefficient (cohesive soils)		
$K_p$	Passive pressure coefficient (cohesionless soils)		
$K_{pc}$	Passive pressure coefficient (cohesive soils)		
L	Linear load on frame	kN/m	lb/ft
n	Zero passive pressure factor (soldier pile)		
$p_a$	Active pressure	kN/m <sup>2</sup>	psf
$p_p$	Passive pressure	kN/m <sup>2</sup>	psf
$p_w$	Water pressure	kN/m <sup>2</sup>	psf
$p_{eff}$	Effective passive pressure (soldier pile)	kN/m <sup>2</sup>	psf
r	Load reduction factor (lagging)		
R	Rowe's moment reduction factor		
s	Soldier pile separation	m	ft
t	Soldier pile (or frame) thickness	m	ft
Q	Standard surcharge	kN/m <sup>2</sup>	psf
$Q_p$	Magnitude of point/area load	kN	lb
$Q_L$	Magnitude of line load	kN/m	lb/ft
$Q_s$	Magnitude of strip load	kN/m <sup>2</sup>	psf
w	Soldier pile hole diameter	m	ft
$w_{eff}$	Soldier pile effective width	m	ft
Z	Section modulus - sheet piles	cm <sup>3</sup> /m	in <sup>3</sup> /ft
Z	Section modulus - frames/beams/soldiers/lagging	cm <sup>3</sup>	in <sup>3</sup>

# Appendix B

## Rules of Thumb

The toe predicted by **SupportIT** is mathematically correct. However, some rules of thumb based on experience may be applied to enhance the safety of a design. Assuming the depth of excavation is **d**, the rules applied are:

1. No toe should be less than **d/10**.
2. In firm clay (**50 ≤ C < 75**), the minimum toe should be **600mm** or **d/5**, whichever is greater.
3. In stiff clay (**75 ≤ C < 100**), the minimum toe should be **300mm** or **d/10**, whichever is greater.
4. In very stiff clay (**C ≥ 100**), the calculated toe will be very small. It may be better to use a "no toe" design with a frame near the bottom of the excavation.
5. When water is present in granular soils, "no toe" designs should not be used.
6. When water is present in granular soils, the minimum toe should be **0.75 x** depth of water above excavation depth.
7. A minimum of **2** frames are required for "no toe" designs.
8. In cantilever designs, the toe should not be less than **d**.

**Rules of thumb** may be switched on/off in the **Wall** page of the define box.

Rules **1, 2, 3, 6** and **8** may make a design safer by applying a larger toe than predicted by theory. They will **never result in a smaller toe** than theory predicts being used.

If switched on, the rules of thumb will be applied every time a recalculation is made following a change in design specification (eg. changing a soil parameter). A warning is displayed indicating which rule has been applied, if any. To avoid repeatedly seeing this warning, switch **Rules of thumb** off until the design is completed, then switch it on.

Other rules will be added as they are identified.

# Appendix C

## Default Values

The current values/settings of some items are stored when a design is closed. These are then applied to any new design to avoid repeatedly entering preferred settings. Items which are currently saved as defaults include pressure model, embedment settings (analysis method, penetration type, etc), water density, minimum fluid density, installation settings (dig & push, etc).

Note that these default values are only applied to new designs. They do not affect the settings of files which you save - these will be recalled with the settings they had when saved.

All default values may be restored to their original settings by clicking the **Restore Defaults** button on the **Setup** page.

**SupportIT** default values, in order of the pages on which they may be changed are:

<b>Job page</b>	<b>Setting</b>
Show page numbers	On
<b>Excavation page</b>	
Surcharge	10.00 kN/m <sup>2</sup> (200 psf)
Water Density	9.81 kN/m <sup>3</sup>
Minimum Fluid Density	5.00 kN/m <sup>3</sup>
<b>Loads/Slope page</b>	
Yielding wall	On
Ground Profile	Level
Method (sloping ground)	Modify K values
Angle of slope	0 degrees
<b>Wall page</b>	
Support Method	Sheet pile wall (single)
Analysis Method	Net Pressure
Penetration	Free Earth
FOS (for "Defined FOS")	2
R (moment reduction factor)	1.0
Rules of thumb	Off
K <sub>a</sub> factor	1.0
K <sub>p</sub> factor	1.0
C <sub>act</sub> factor	1.0
C <sub>pas</sub> factor	1.0
Embedment only	On
'A' (soldier pile)	1.0
'n' (soldier pile)	0.0
Apply 'A' to both sides (soldier pile)	On
Draw to scale (soldier pile)	Off
Show key (soldier pile)	On
<b>Supports page</b>	
Load Model	Area Distribution
Elastic Shear	Off
P x (earth pressure mobilisation factor)	1.3
Concrete lowest frame	Off
Hanging chains	Off
Scale frames	Off
Show frame description	Off
Share load	Off
<b>Install page</b>	
Stages	Support Positions
Number of stages	5
Clearance	0.3m
Excavate by	Dig And Push
Toe (for "Constant Toe")	0.5m

Use temporary supports	Off
Remove frame above concrete	Off
Show method statement	On
Show full sheet height	Off
Report at each stage	Off
<b>Plan page</b>	
Show leg description	Off
<b>Pressure page</b>	
Pressure Model	Rankine
Toe (Active)	Terzaghi
Moment	Terzaghi
Apply (passive softening)	Off
t (passive softening thickness)	1.0m
Cohesive Soils (Min. Pressure)	Minimum Fluid Head
Cohesive Soils (Hydrostatic)	Ignore Hydrostatic
Show (tension cracks)	Off
t (tension crack depth)	1.0m
$P_{as}$ , $P_{ps}$ , $P_{aw}$ , $P_{pw}$ , $P_{mf}$ , $P_{sur}$ , $P_{cus}$	On
Manual pressure calculation	Off
Passive Cohesive Soils (Apply Hydrostatic)	Off
<b>Setup page</b>	
Works	Temporary
Soil Layers (Shading/Colour)	On
Frame Symbols (Shading /Colour)	On
Table Headings (Shading /Colour)	On
Print Colour Graphs (Shading /Colour)	On
Vertical Scale	Off
Horizontal Scale	Off
Show Both Sides	Off

## Appendix D

### Computer Settings

Your computer should be set to **Small Fonts** when using **SupportIT**, or some tabular output will extend beyond the right edge of the window or overlap. To reset your computer to small fonts:

Open **Control Panel > Display**

Select **Small Fonts** (or '**Normal**' in some **Windows** versions).

You may also prefer to set the following in the **Display** window, although the settings shown are not critical:

**Color Palette** should be set at **High Color (16 bit)**. This produces shading on the side elevation diagram. Other settings give a hatched pattern.

Set the **Show settings icon on task bar** check box. This provides quick access to the **Color Palette/Desktop Area** settings.

The computer may need to be rebooted after changing the **Font Size**, but the **Color Palette/Desktop Area** may be changed at any time, even while the software is running.

The instructions above may vary in different versions of **Windows**.

# Appendix E

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