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User Guide

Archie-M

Masonry Arch Bridge and Viaduct Assessment Software

Version 2.3.1

By OBVIS Ltd, United Kingdom

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Archie-M is provided with tools for checking all calculations and we recommend that users carry out such checks. OBVIS Ltd undertake to replace the software if it is found to contain errors but will not countenance claims for consequential loss.

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CHAPTER 1

Introduction

Welcome to Archie-M.

What is Archie-M

Archie-M is a Windows program designed to help with the analysis of masonry bridges and viaducts. It is based on the principle of the thrust line, and provides rapid, interactive equilibrium analysis of arching structures. It is designed to help with the analysis of arch bridges and viaducts as part of an assessment or design process. It is quick to use and demonstrably conservative except where code specified parameters may intervene. In particular, the effective width model specified by various authorities has been called into question in 2006.

Archie-M is a result of nearly twenty years of research and consultancy. The program uses the zone of thrust to define the minimum structure necessary to support a given set of loads. Graphical and numerical results are updated continuously as loads are moved across the structure by hand or automatically. The engineer is able to explore the potential for different load paths to transmit loads to the foundations.

Who should use Archie-M?

Archie-M is an engineering tool. It does not pretend to deliver an immediate solution to the problem of assessment. Assessment will always be a matter of judgment at some point. Our aim is to help guide the user to the areas where judgment is best exercised and where its effects will be most valuable. Using Archie-M, it should be possible to gain confidence in a structure until you feel secure in confirming its strength.

About this manual

This user guide is an introduction to the Archie-M program features. It explains how you can operate the program but does not deal with the theory of and calculations for arch bridge assessment. These details are described in the published literature and on our web site. To explore the web pages, begin by opening the site map and entering the engineering pages.

System Requirements

Archie-M is a modest program. It is unlikely that any computer running MS-Windows will have difficulty running Archie-M

Installation

Most users now work within a network environment. Setting up Archie-M on a network may require technical help both from local IT staff and from OBVIS Ltd. If in difficulty call Bill on 0787 942 5884

You should first read and accept the license agreement found in the beginning of the User's Guide. Then install Archie-M:

1. Insert the CD into your CD-ROM drive. The first time you do this, the CD will automatically start the installation program. If the installation program does not start automatically, you can start it by choosing Run from the Start menu and typing

D:\SETUP (where "D:" is your CD-ROM drive). Click "OK."

2. Click the Mathcad icon on main installation page.

3. When prompted, enter your product serial number, which is located on the back of the CD envelope.

4. Follow the remaining on-screen instructions. To install other items such as Axum LE, SmartSketch LE, or on-line documentation, follow step 1 above. Then click the icon for the item you want to install.

#########

Run setup.exe from the root directory of the CD. This will install the program and the necessary Load files to your chosen directory.

The help files are not yet linked into the program. They are web pages stored in the "Engineering Issues" pages of our web site (http://www.obvis.com) . These pages are periodically revised and further notes and a discussion forum can be found at http://billharvey.typepad.com/archie_m/ note there is no www in this web address. Please feel free also to explore the root blog by missing off the archie_m.

We are still discussing the nature of our load files with the Highways Agency and with users. New files will be issued from time to time. Once the program is installed, adding or changing the load files is a simple mater of copying into the load subdirectory, which sits in the program directory.

NETWORK INSTALL ISSUES

A separate note is supplied for setting up Archie on a network.

Comments Are Welcome

We welcome your comments about this manual or Archie-M.

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Contacting OBVIS

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Web address	http://www.obvis.com	

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CHAPTER 2

Getting Started

A quick start to Archie-M

This chapter gives you an introduction to the essential parts and functionality of Archie-M. The subsequent chapters will discuss particular aspects of operation in more detail. If you are an existing user of Archie-M, you may skip this chapter.

Starting The Program

On a successful installation, a program icon is created on your desktop. This icon is a shortcut to the executable Archie-M file. The simplest way to start the program is double-click this icon.

NOTE Please, do not change the properties of this shortcut.

An alternative way to starting the program is to use the Start menu. Under Start—Programs you find Archie-M for Windows that contains the Archie-M program item. Start the program by clicking the left mouse button on the item.

It is possible to add program shortcuts to the Launch Bar at the bottom of the desktop screen. If you drag the Archie-M icon on the desktop to the Launch Bar with the right mouse button down you can create a new shortcut.

Starting the program in a network environment

If you work with a multi-user version of Archie-M, the procedure for starting the program is slightly different. In the multi-user network set up the executable program is most likely to have been installed on a server computer. Other (client) computers do not have a copy of the program installed.

We recommend the following procedure for client machines.

1. Start up Windows Explorer and locate the server machine in Network Neighbourhood
2. Find the directory that includes the Archie-M executable program
3. Map this directory as a Network Drive ()

Create a new shortcut on the desktop

Should you have difficulties these steps or lack the necessary access rights, please, contact your local system administrator.

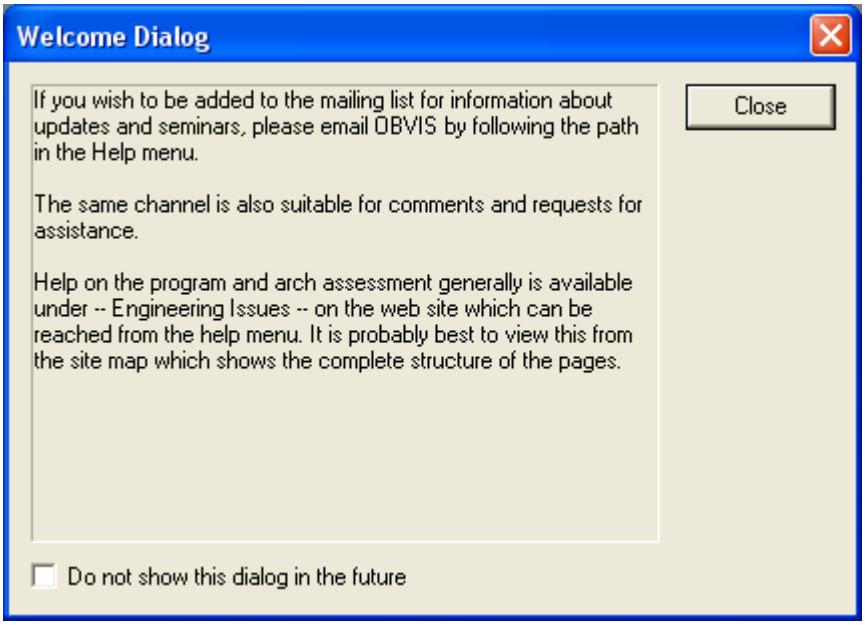
Number of concurrent users

If you run a multi-user Archie-M, the number of users allowed to use the program concurrently is controlled by the NetHASP device. The number of users is equal to the number of licenses you purchased with Archie-M. If the number of active users reaches the maximum number for your program, other users are not allowed to start the program until an active user has finished his or her session. Please, remember to close the program when it is not in use. Leaving it running closes other users out.

If you encounter a situation where the number of users is below the limit and still program start up is locked, or have any other NetHASP-related problem, please contact us at support@obvis.com.

If you would like to purchase extra licenses, please, send an email to sales@obvis.com.

Opening A Sample File



Once the program is running, you are presented with the main Archie-M window. This window is only used for opening existing bridge files or creating new ones.

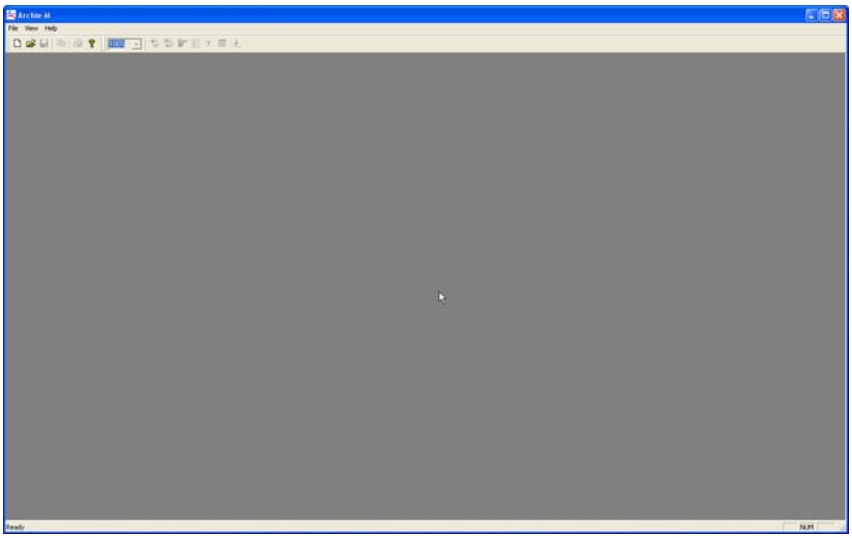


Figure 2-1. The main window of Archie-M after startup.

For simplicity we will start using Archie-M by opening some of the sample files provided with the program. Please, work with these first to develop an understanding of the power of Archie-M.

Click on the File menu and select Open. This command will open the File Open dialog window shown in Figure 2-2. In the 'Look in:' field, select the Test Bridges directory located in the Archie-M directory. Once located, the dialog will list the files shown in the figure. Select, say, the bridge file 'Shinafoot.brg' then click on the Open button. This will open the file and display the bridge in the main workspace as a new window.

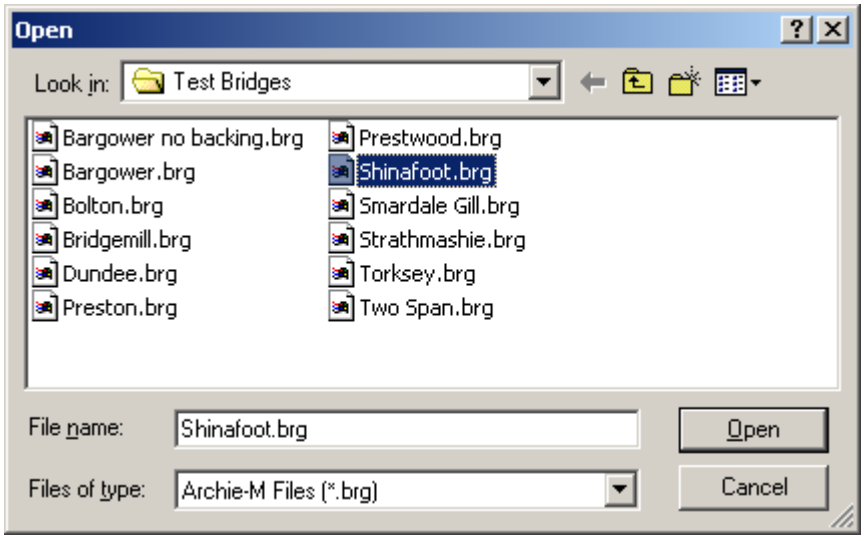


Figure 2-2. The File Open dialog where you can select the bridge to open

This is shown in Figure 2-3. Now we look at the components that make up the workspace.

The Workspace

Opening a bridge file always results in a new window displaying the bridge as shown is Figure 2-3. Archie-M is a multi-document program, which means that – unlike Archie/Multi – you can have many bridge files open at the same time (Figure 2-4). This can make your work more productive and also, you can compare different bridges or same bridges with different material or load parameters.

You may also notice that opening the bridge file has changed the menu system. There are several new menu headings, such as Edit, Structure, Load, etc. These menu headings hold the menu commands that implement the functionality of the program and that you use to interact with it. Before looking at the different menu items, however, let us quickly overview the main components of the workspace.

The windows

The main Archie-M window is a standard Windows window with the three standard buttons in the top right corner to minimize, maximize or exit the program. The main window consists of the menu system, the toolbar, the bridge window(s) and the status bar.

A bridge window is a graphical representation of a bridge in a standard window frame. This is the main working window of the program, where the user interacts with the system to examine the response of the structure. The appearance of this window screen is very similar to that of ARCHIE but a little less detail is present, as much of this has been placed in a separate window.

The window has the same Minimize, Maximise, Close buttons as the main window. In contrast to the main window, the Close button will only close the bridge window, not the application program.

By default, the bridge window does not occupy the full main window area. This is in order to see other documents should they be open. If you work with only one bridge at a time, you may want to use the Maximize button to use the maximum available viewing size.

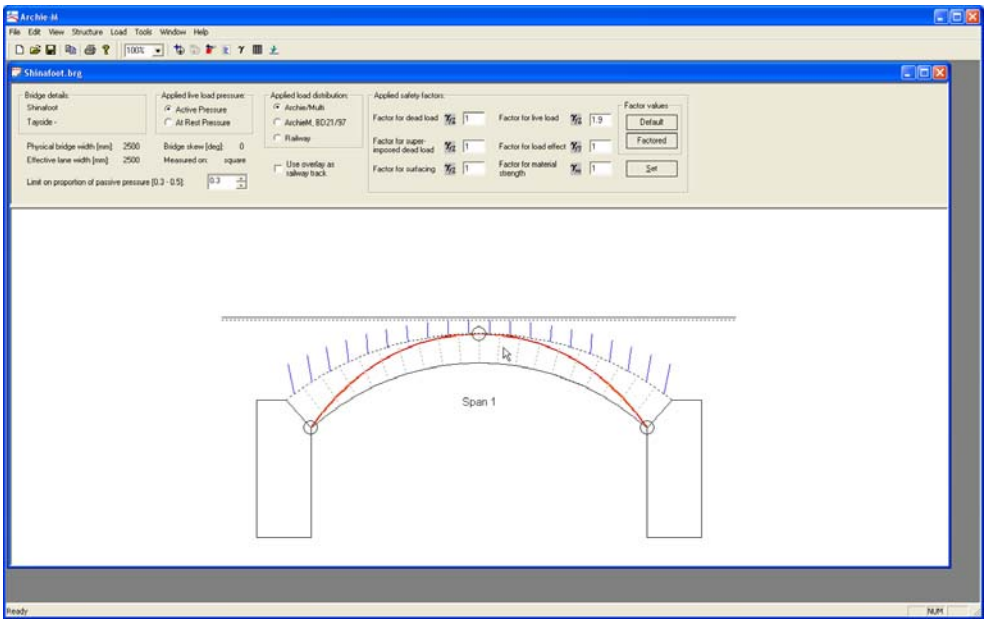


Figure 2-3 Screenshot of Archie-M with one single span bridge open in the default-size window.

Graphical representation of the bridge

Arch

The arch is represented by a solid line for the intrados and a broken line for the extrados. This is because the extrados is not usually well defined or well known, whereas the intrados can be measured.

The arch is divided into segments for the calculation and these segments are shown by dashed lines. Each segment has a vector shown by a solid blue line to represent the loads applied to it.

Fill

The fill has no particular representation, but exists as an object and can be selected by the user.

Abutments

Abutments are shown simply with a solid polygon.

Piers

The piers are shown with a solid boundary and a broken line at the third points.

Road

The surface of the bridge is represented as a solid black line. The bottom of the surfacing is a broken line, as is the top of any overlay added.

Backing

If backing is present, it is represented by a hatched area.

Thrust

The thrust is shown by an orange zone outlined in red.

The menu system

The menu system conforms to the usual Windows menu. It uses the standard menu groups such as File, Edit, View, Tools, Window and Help, and introduces two new ones – Structure and Load – for the bridge assessment related tasks. Special tasks are also listed under the Tools menu. The commands within each groups are given below.

File ! This menu has three subgroups. The first one contains commands for creating, opening and saving bridges. The second one holds printing related items, whereas the third one is a list of the most recently used bridge files. Up to six bridge files are stored in the menu system. !

Edit ! This menu has only one command. The Copy command can be used to copy a bridge into other Windows applications.

View ! Besides the standard commands to toggle the display of the toolbar and status bar, there are additional commands that you can use can control whether or not you want to display the thrust envelope, the hinges or the force vectors during assessment. Disabling the force vectors can become useful if working with many segments in the arch. !!

Structure ! In the structure group you find commands for modifying the geometric and material properties of the existing bridge, changing the number of segments used in the calculations, adding/removing/modifying backings, and adding textual comments to the bridge file.

The default value for the number of segments is 20. The range of possible values is 20-200. Obviously, the more segments you use, the better you approximate the real bridge, but it also increases computation time. We recommend that you experiment with different values and find the optimal value for your particular bridges using your computer.

Load ! The load menu is used to add/remove load case to/from the bridge and to create special, i.e. user -defined, load cases.

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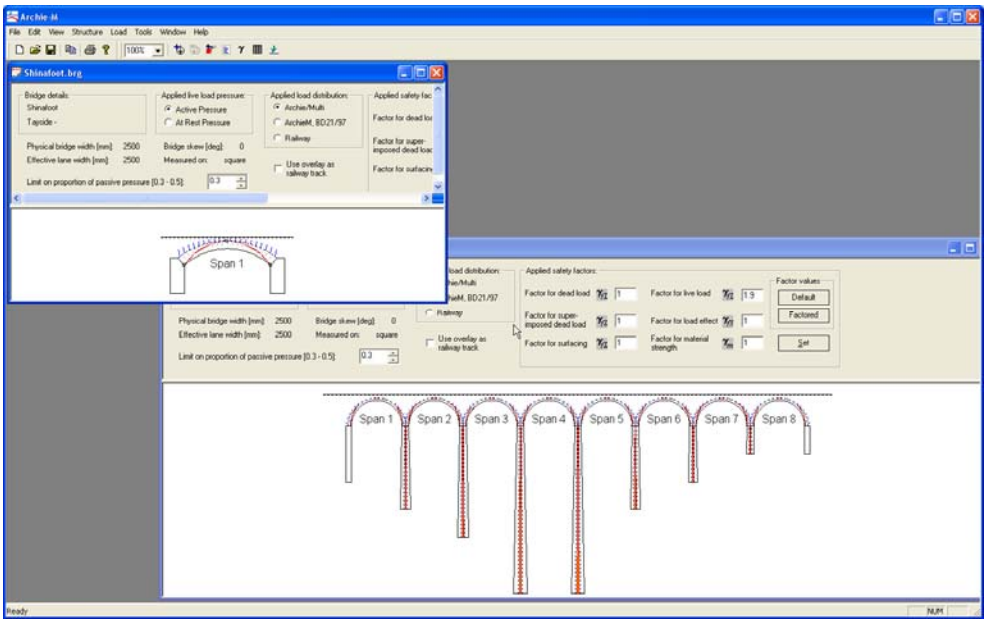


Figure 2-4 The program after opening a second bridge file and resizing windows.

Tools ! This group contains commands related to the assessment process and the customisation of the program. The first two command items are used to adjust safety factors. You can also select the Autoload feature that will drive selected vehicles over the bridge and locate worst-case positions. The 'Show intermediate results…' command opens a tabular result window where you can view numerical values of the calculation. You can also clear the envelope with a command if required.

Window ! This menu group can be used to control how multiple windows, if any, are displayed in the main Archie-M window, as well as to switch among many open bridges. With the New Window command you can open another copy of your current window. This can become very handy when working with large bridges. !

Help ! The help menu contains only one item, the infamous 'About' command that displays a basic information dialog. The single most important use of this window is to display the version number that is very important in case you have a problem with the program.

As you can see, there are no help files linked into the program. They are web pages and can be found at our web site www.obvis.com.

For easier access you may want to copy the help files into an appropriate directory on your local hard disk, or in the network case into a server location accessible to all users.

The exact purpose and use of the menu commands will be explained later in the manual.

The toolbar

The most frequently used commands have an icon equivalent in the toolbar. The first part of the toolbar holds the standard Windows toolbar items, *New*, *Open*, *Save*, *Copy*, *Print* and *About*. The second part of the toolbar holds the Archie-M specific icons, such as *Zoom level*, *Add load*, *Remove all loads*, *Create special load*, *Edit backing*, *Add comment*, *Adjust safety factors*, *Open tabular window*, and finally the *Autoload* command.

Figure 2-5. The Archie-M toolbar.

Zooming, Resizing and Scrolling

When you open a bridge file or create a new bridge, a system default size window is created and the bridge is scaled to fit fully in that window. This is the default zoom mode of Archie-M and is referred to as 100% zoom level or magnification ratio.

There are two basic ways you can change the display of the bridge in a window, by zooming and window resizing.

Zooming

The easiest way to understand zooming in Archie-M is to think of it as specifying how much of a bridge you want to view. If you want to see only half of a bridge in the window, select 200% in the zoom combo box of the toolbar.

Note You can also type in specify custom zoom levels by changing the value in the zoom level combo box, in which case you need to press the TAB key while in the zoom box to make it have an effect.

The zoom level is defined in terms of the largest extent of the bridge. If you work on a long but shallow bridge, 200% means half the bridge length in the window. If, on the other hand you have a short but tall bridge, eg due to tall piers, then the same zoom level will mean half bridge height in the window.

At any zoom level – except 100% -- the window will show scrollbars when necessary. Use the scrollbars to locate the part of the bridge you are interested in.

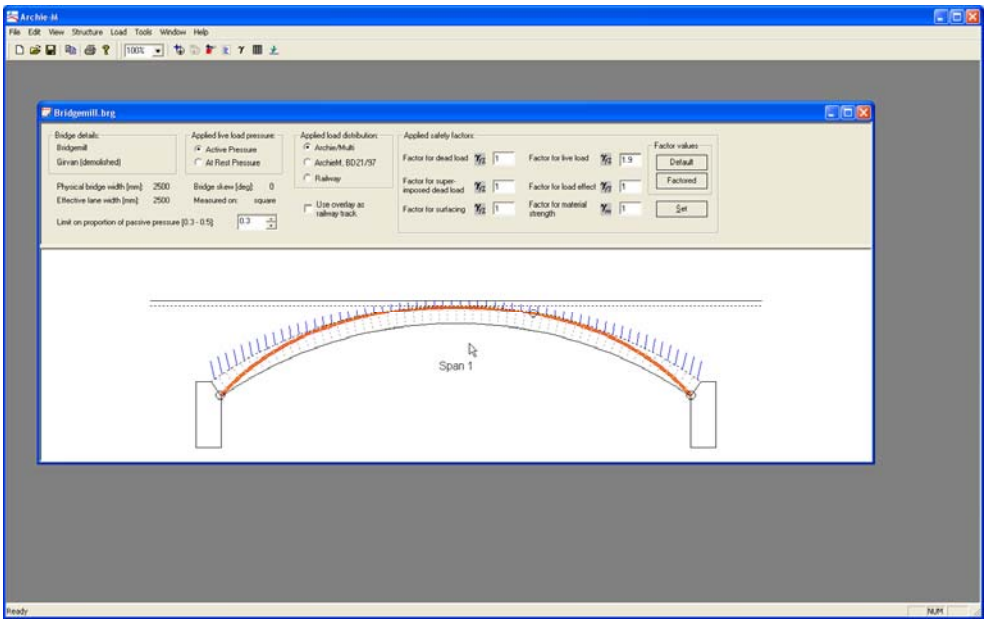
Resizing

While Archie-M makes a good effort to best fit your bridge at the selected zoom level in the window, it does not resize the windows to fit the bridge optimally.

Should you have large unused areas around the bridge, you might want to resize the window manually to save window space and perhaps make room for other bridge windows.

When you resize the window, the zoom level will not change. That is, the same proportion of the bridge is visible. At 100% zoom level you will not see the scrollbars, you always have the full structure displayed in the window, since your bridge will be re-scaled to fit the new window size optimally. At other zoom levels, the re-scaling will affect the scale of the scrollbars.

As an example, open the sample bridge file Bridgemill.brg. The bridge will be displayed in the default view, as shown in Figure 2-6. Now, try to resize the window to remove the unnecessary space above the bridge. Figure 2-7 shows the window after resizing.



!

Figure 2-6. The Bridgemill.brg sample bridge before resizing.

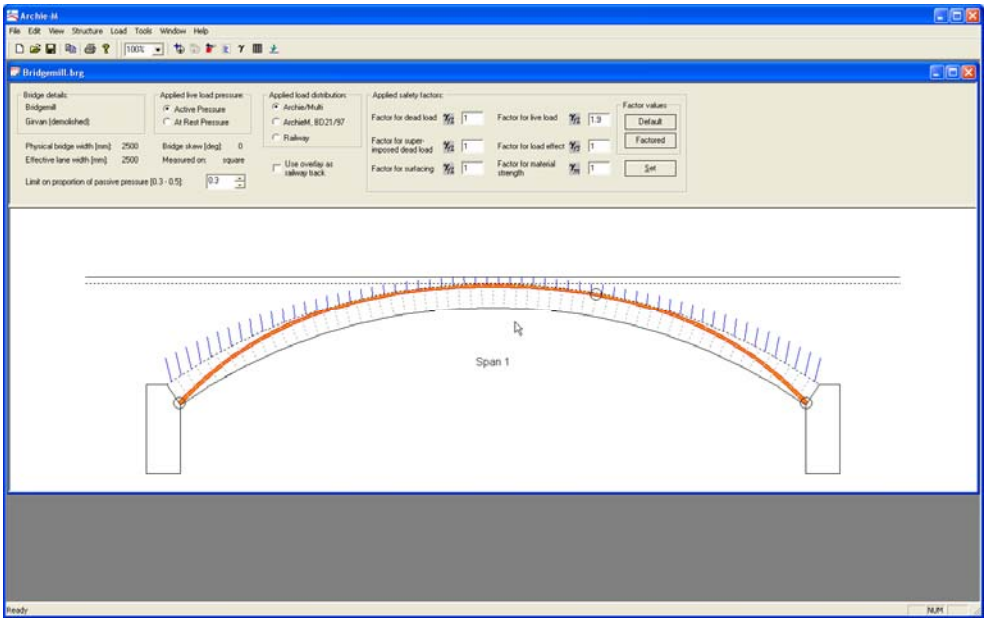


Figure 2-6. The Bridgemill.brg sample bridge after resizing.

Mouse actions

Archie-M is an interactive program. The main control device is the mouse. Most menu commands can be executed by mouse clicks (not using the menu system) and some commands (eg manual adjusting of the thrust) are only available through mouse actions.

The most important mouse events that you will use in the program are

- Click with left mouse button — executes a selected command.
- Click with right mouse button — opens up a pop-up menu with commands when performed within the graphical window.
- Double click with left mouse button — opens the bridge modification wizard when performed over some part of the bridge.
- Dragging the mouse with left mouse button pressed — moves the load when dragging begins on load case.

!

Working With Loads

Since Archie-M is a tool for assessment, its most important part is the load manipulation. There are four main functions you can perform with loads. These are

- Add a load case to the bridge
- Move a load case
- Remove a load case
- Create a new load case

Adding a load

There are three ways to add a load case to the bridge. Firstly, you can add it using the Add/Remove command in the Load menu. Secondly, you can use the toolbar shortcut icon Add load (as shown in Figure 2-7). Finally, if you right click with mouse on any non-bridge area in the bridge window, ie above or below the bridge, a pop-up menu appears from which you can select the ‘Add load case…’ command.

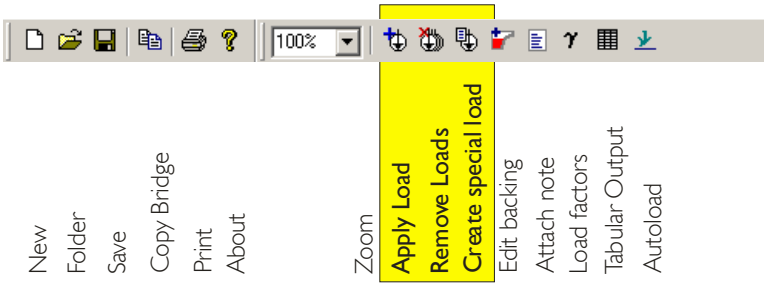


Figure 2-7. The load control icons in the toolbar.

Whichever way you use, you will be presented with the Live load dialog, shown in Figure 2-8. This dialog allows to specify how many and what load cases you want to apply to your bridge.

The available load cases you can select from are displayed as a tree in the left window of the dialog. The '+' box in front of the load family name indicates that there are branches of that particular item. Click on the '+' sign to expand the tree. Figure 2-9. illustrates the case where we expanded the C&U vehicles Double axle bogies group.

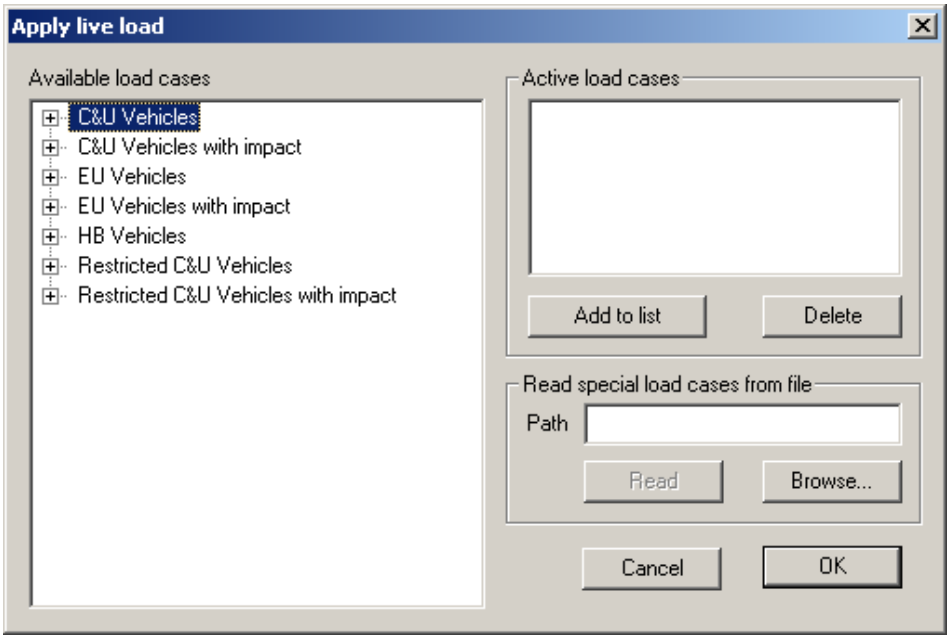


Figure 2-8. The live load dialog showing the available load cases on the left, the active load cases – currently none – on the right.

If required, additional load files can be read in and loaded into the load tree by specifying a new directory name either directly or by pressing the Browse button.

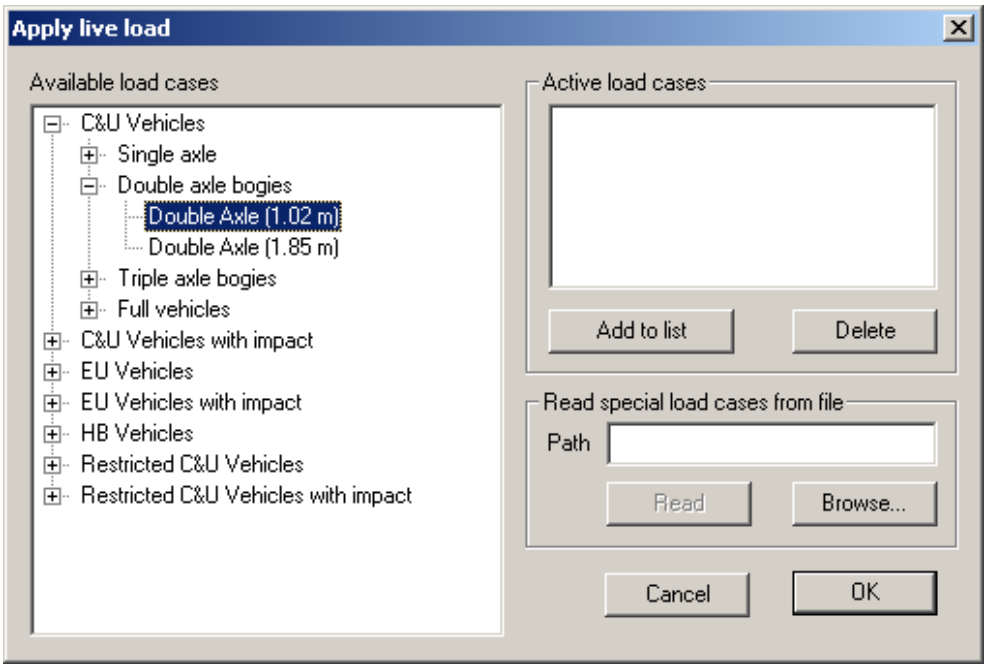


Figure 2-9. The live load dialog with expanded subtree.

Now, double click on the load case you want to add – Double Axle (1.02 m) in our example – or press the 'Add to list' button to add the selected load to the active load cases list.

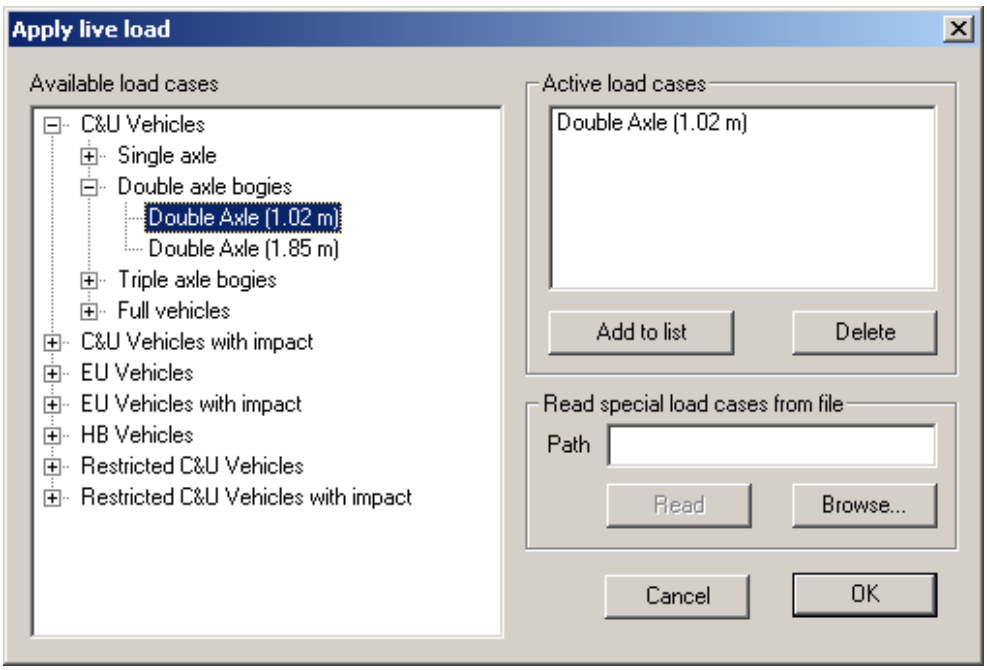


Figure 2-10. The live load dialog with one load added to the active load list.

You can add multiple load cases to the active list, or if you change you mind, remove one or more from the list by selecting a load and clicking the 'Delete' button.

Once you are happy with you load cases, click OK to confirm that you have finished choosing loads. The load cases specified in the active load list will be added to the bridge at the default – above the first left springing – position. This is illustrated in Figure 2-11.

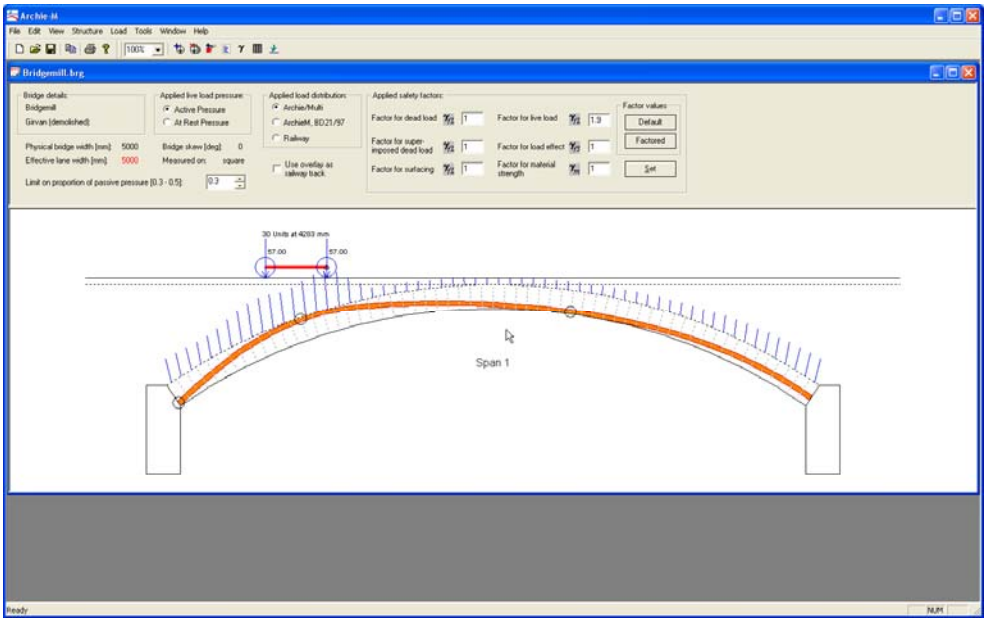


Figure 2-11. Specified load case added to the structure.

Moving the load

A load is represented in Archie-M by one or more wheels each having an arrow in it representing the generated force and its point of application. A thick line connects the wheels of a load case to help distinguish the wheels of different load cases. The first wheel of any load case is marked with a small circle in the centre of the wheel. This is useful in identifying the direction of a load. The load case display also includes factored axle weights in tonnes, the name of the load case and its current position. This is all shown in Figure 2-12.

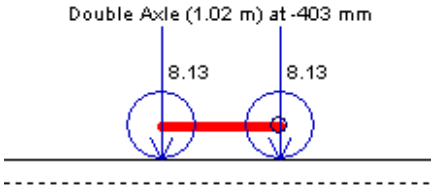


Figure 2-12. A load case in Archie-M moving from left to right.

The thick connecting line is red if the load is selected (load active – responds to drag) or grey if the load is not selected (load inactive – does not respond to drag). Clicking into a wheel of the load will select the given load as active, and consequently, dragging a load will always move the load in whose wheel you click to start dragging.

Now, try to drag the load by placing the cursor in the wheel and pressing the left mouse button. Next, try to add more loads and move them around independently.

An alternative way to move the loads is to use the ← → cursor keys. One key press moves the active (red connecting line) load 100 mm to left or right. If you have a large bridge, you can speed up the movement by pressing down the SHIFT key before pressing the cursor key. In this case the load moves 1000 mm for each key press.

Removing the load

If you want to remove all loads from the structure, use the Remove All command from the load menu or its shortcut icon form the toolbar (Figure 2-7).

Should you want to remove particular loads, either use the Add/Remove command from the load menu and remove the load in question from the active load list, or right click on any of the wheels of the load to be removed and select 'Remove load' from the pop-up menu (Figure 2-13).

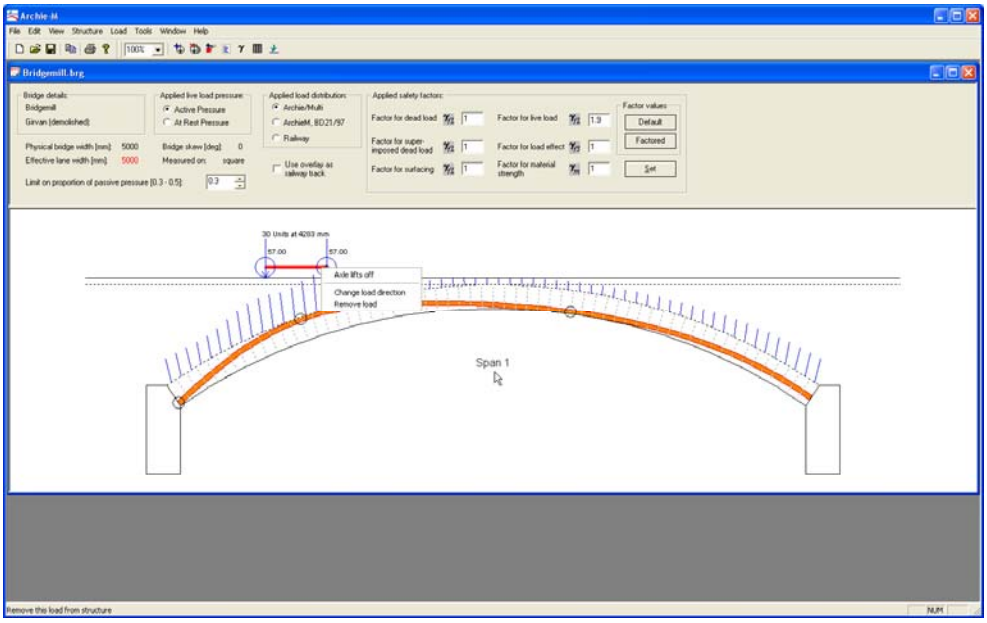


Figure 2-13. Removing one particular load using the pop-up menu (right mouse button click).

Other load operations

There are two more functions you can perform on load cases from the pop-up menu.

You can change the direction of the load by right clicking on a wheel and selecting ‘Change load direction’. The load will be turned around about the first wheel position.

Right clicking on a wheel also allows that load from that axle to be lifted off by 50% and transferred to the other axle appropriately. The lift-off axle is displayed using a dashed line, as shown in Figure 2-14. Note that middle axles (eg in a triple axle bogie) are never allowed to lift off or take on transferred load.

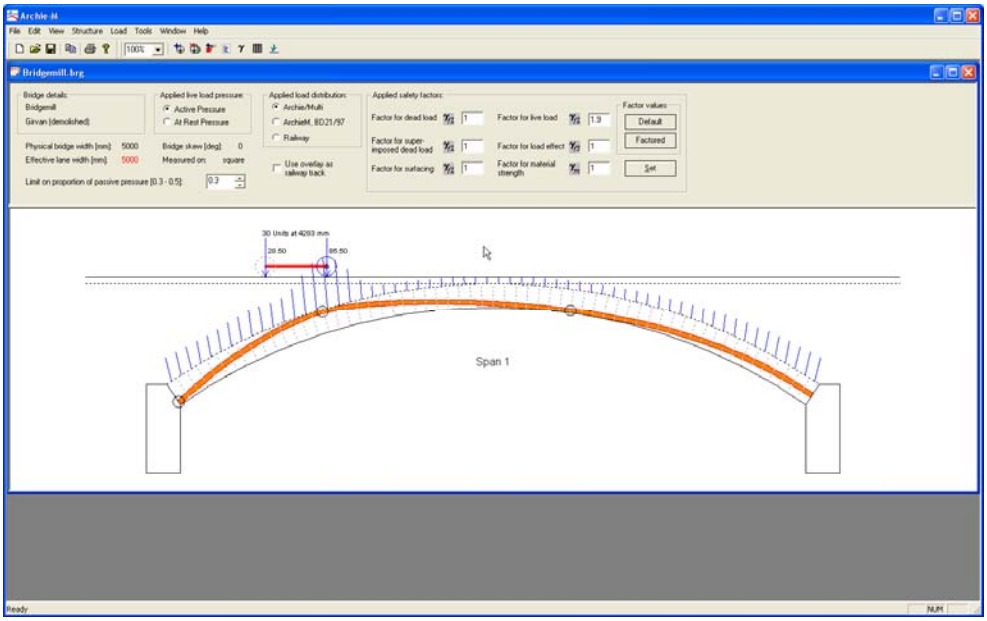


Figure 2-14. Load case with the front wheel set to lift-off.

CHAPTER 3

The Bridge Model of Archie-M

Archie-M has been designed to help in the assessment of single and multi-span bridges. Since Archie-M is an object-oriented program, a bridge in Archie-M is a complex composite object modelling a real bridge structure. In this chapter we describe the different parts of the Archie-M bridge model along with their geometric properties.

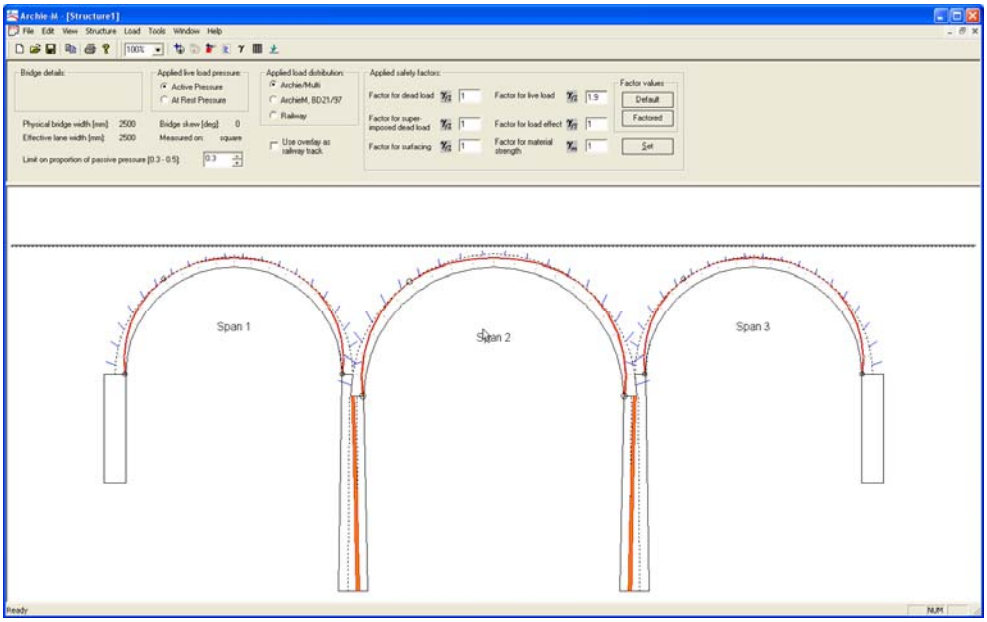


Figure 3-1. A complex multi span bridge with backing showing the various parts of the Archie-M bridge model.

Arches

The program supports several different predefined arch geometries as well as the ability to create true arch shapes based on real site measurement data. Note that in the program, the arches of a multispan bridge do not have to be of the same shape. In Archie-M the maximum number of arches (ie spans) is limited to 100.

Archie-M supports the following arch shapes:

- Circular
- Elliptical
- Three-centred
- Pointed
- Flat
- True-shape

Predefined arch specification

When building a bridge using the predefined arch shapes, the following properties have to be specified: span, rise, ring thickness at crown and springing and the left hand springing position. For three centred and pointed arches the quarter point rise is also needed. These are illustrated in Figure 3-2.

Note, that in the circular arch shape case, you do not need to specify the quarter rise parameter. This value is not used for circular arches.

In a single span bridge you can use the default 0,0 LHS coordinates, but in a multi span bridge it is necessary to specify at least the x dimension of LHS of all but the first span. This effectively fixes the pier width at the arch springing.

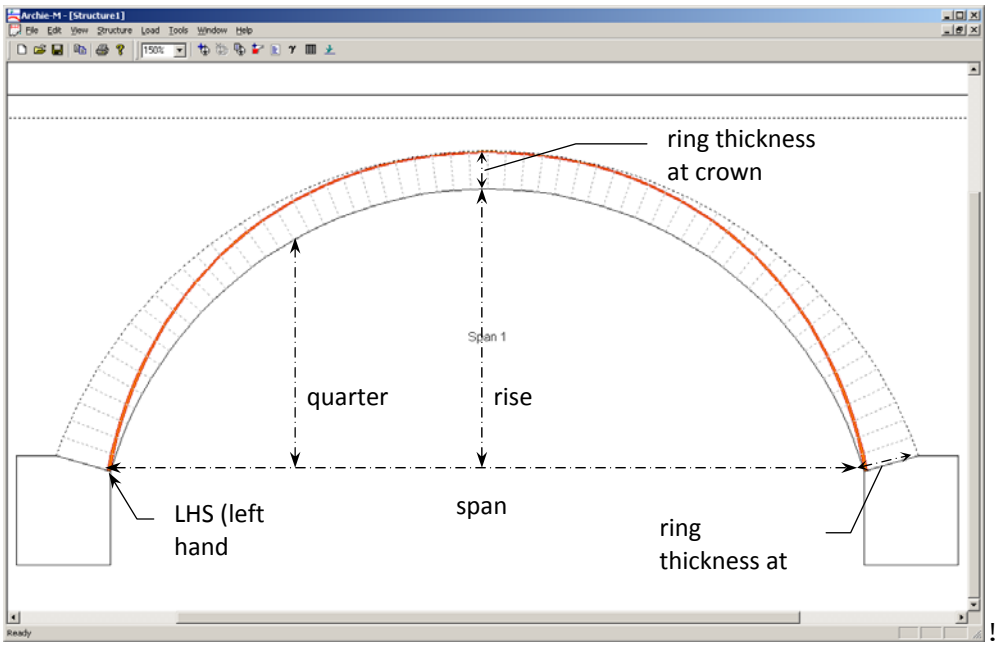


Figure 3-2. Geometric properties of the predefined arches in Archie-M.

True shape arch specification

Should you need to create a more elaborate arch shape, you can use measurement data to construct a true shape. The arch shape is generated by spline-interpolation using your measurement points as base points.

The base points can be specified by one of two methods – using X-Y coordinate points or the two-tape measurement methods. The meaning of these is illustrated in Figure 3-3. Note that in both cases, the values are relative to the springings of the given arch.

Note that a true shape is only of value if the arch is distorted and that can usually be assessed by eye. If a true shape is to be generated, a nearly segmental curve can be modelled from 9 points carefully placed but a more complex curve will need more points. As a guide, the points should be spaced to give equal changes in the tangent angle.

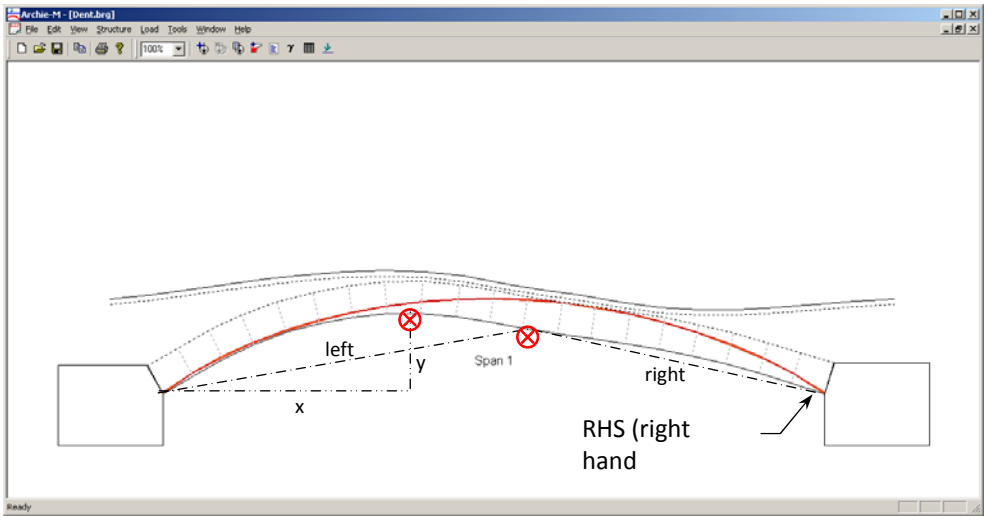


Figure 3-3. Specification of a true shape arch using XY coordinate values and the two-tape method.

Piers

Piers in Archie-M are specified by three parameters, the thickness of the pier at the top, the base level and the batter. The top of the pier is always defined as the lower level of the two springings. The model is shown in Figure 3-4.

In the program, the top thickness is computed automatically from the left and right arch geometries. The number of piers in a bridge is always *number of spans* – 1.

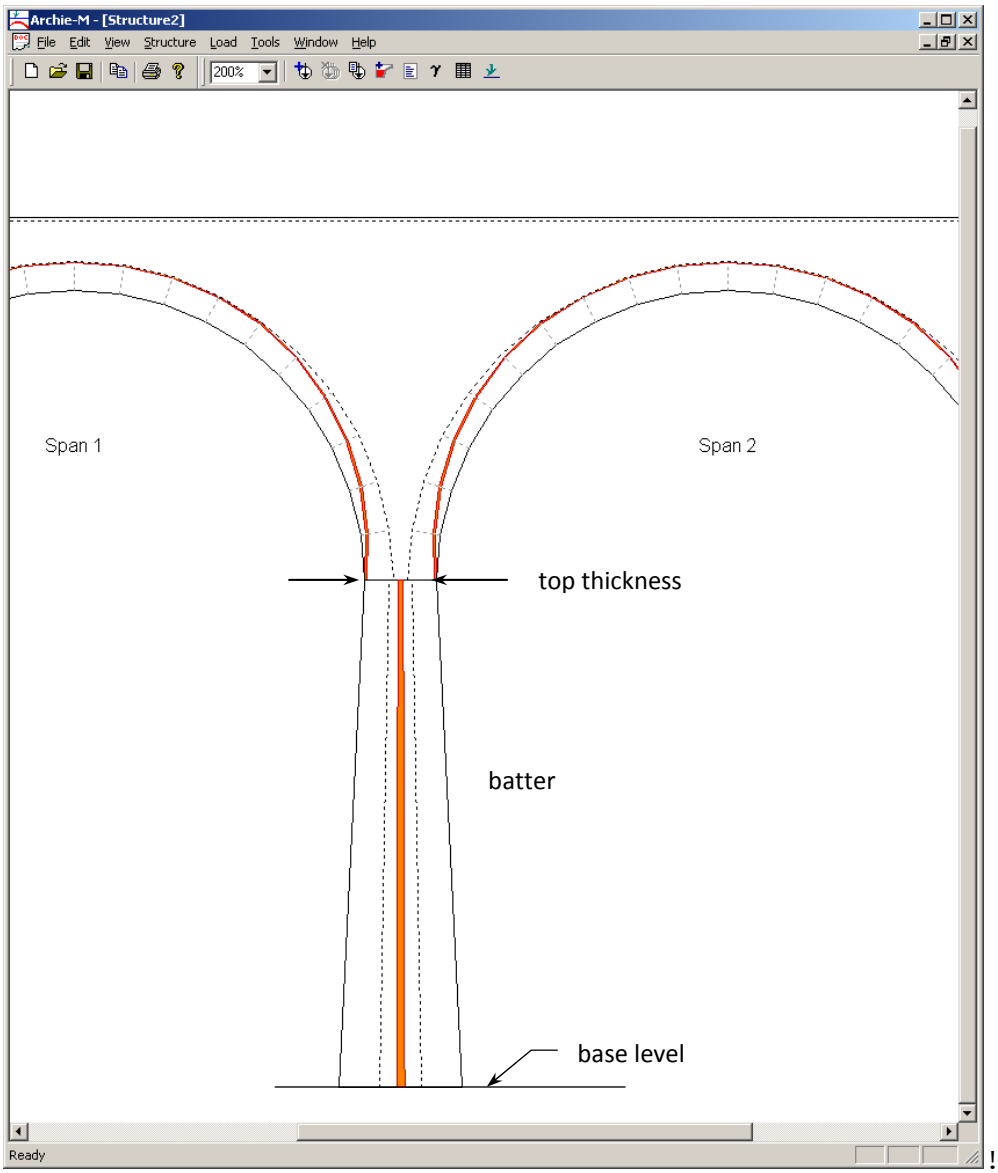


Figure 3-4. The pier model and its properties.

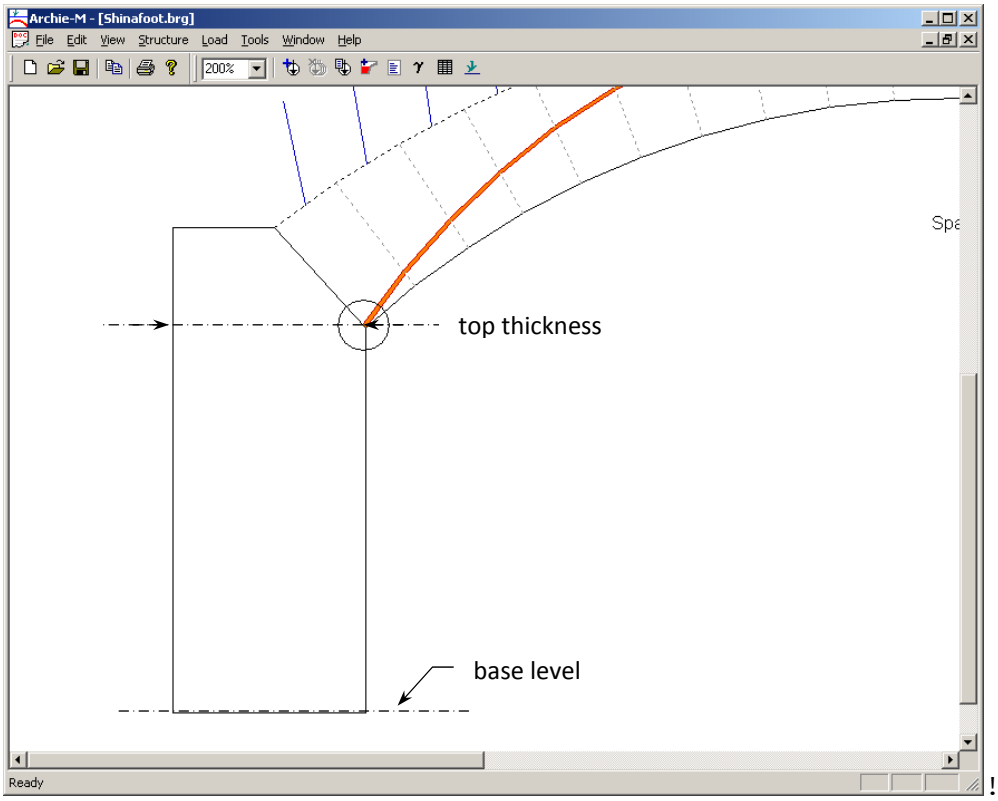
Abutments

Abutments in the program are always assumed to be rectangular blocks. Their two properties are the top thickness (at springing level) and the base level. The slope of the abutment is computed automatically to match the slope of the first/last segment of the arch. The abutment model and its properties are shown in Figure 3-5.

You can create bridges without abutment, but note that the underlying calculation will assume the necessary reactive forces.

!

!



!

Figure 3-5. The abutment in Archie-M.

!

Fill

Archie-M, at the moment, only supports uniform fill. As a consequence, you do not need to specify geometric properties of the fill. The exact shape will be computed automatically once the arch/pier and road geometries are specified.

Road

The road is defined by a number of possible shapes. Please note the importance of providing end points which are beyond the extent of the arch extrados. A curve cannot be fitted through less than seven points. Remember that the levels are absolute, and that you set the origin by giving a y value to the arch springings. The lane width is an important item.

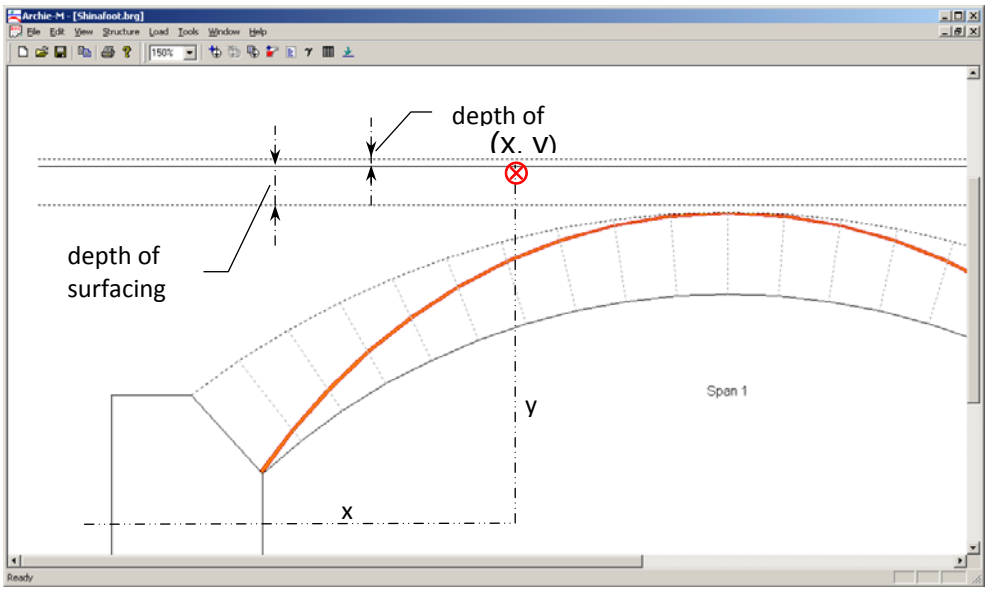


Figure 3-6 The one-point road specification mode and the corresponding road geometry. The resulting road shape is a horizontal line.

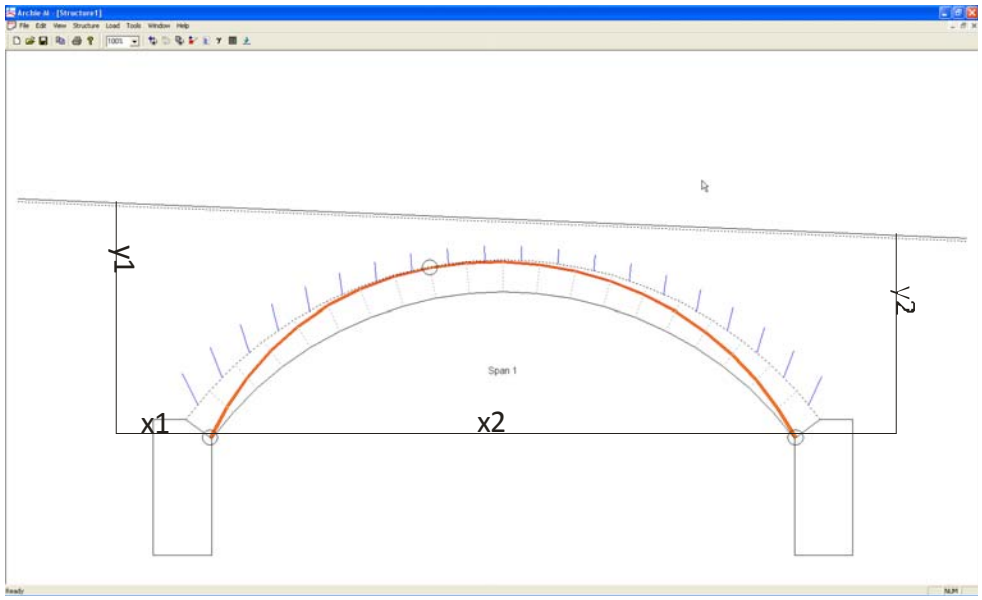


Figure 3-7 The two-point road specification mode and its geometry. The resulting road shape is a sloping line.

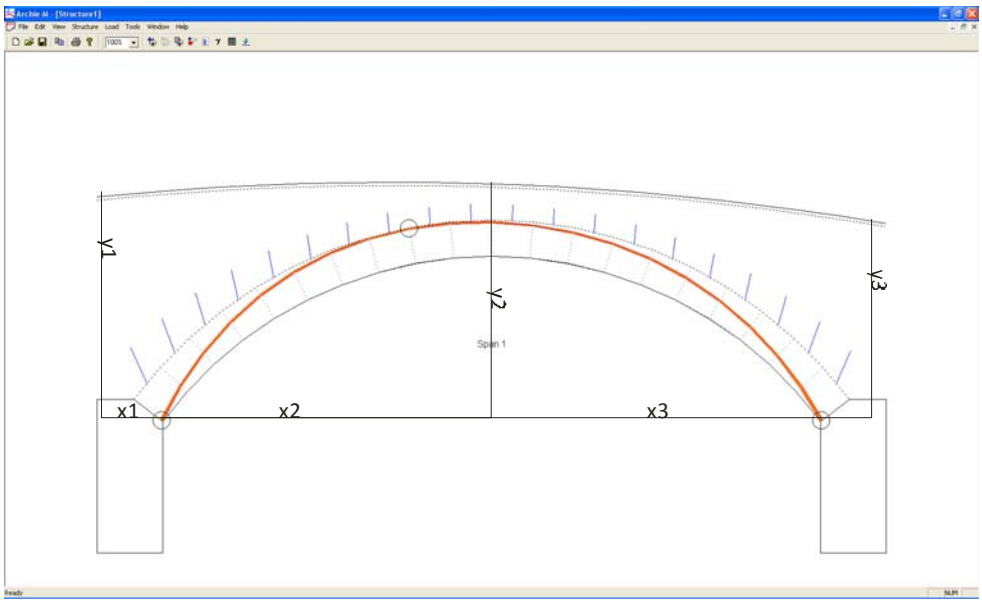


Figure 3-8 The three-point road specification mode and its geometry. The resulting road shape is a circular segment.

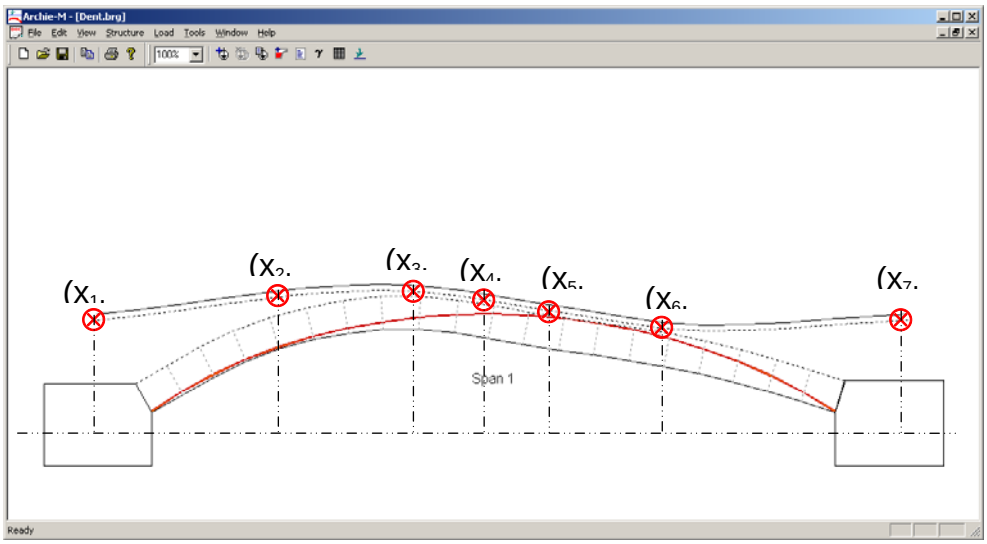


Figure 3-9 The true-shape road specification mode and its geometry.

Backing

Archie-M supports two types of backing, flat-top and tangential ones. The flat-top backing must be specified by its height above the springing and its width measured from the x dimension of the springing, as shown in Figure 3-10.

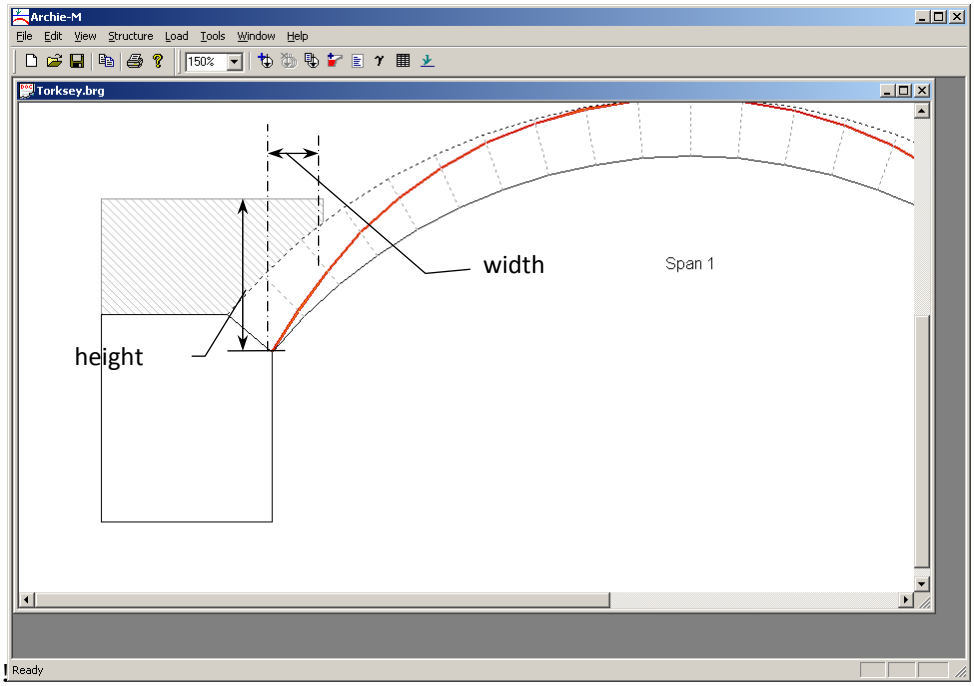


Figure 3-10 Geometry of the flat-top backing.

The tangential backing only requires the specification of one point above the springing (by its height). This point is then used to draw a tangent line to the arch and compute the corresponding geometry, as shown in Figure 3-11.

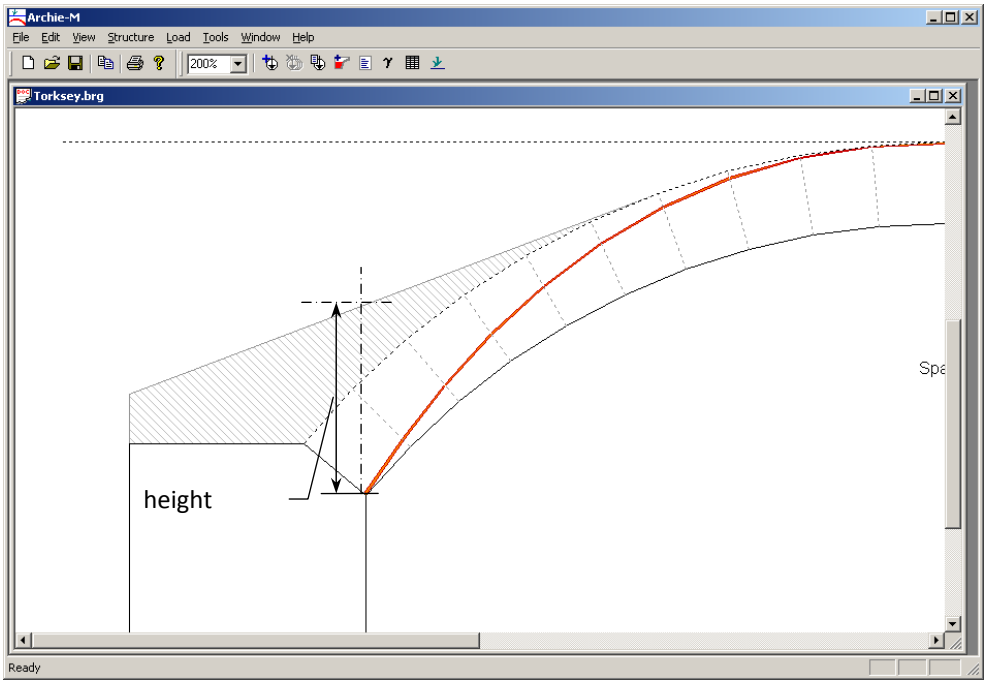


Figure 3-11 Geometry of the tangential backing.

CHAPTER 4

Creating a New Bridge

A new bridge can be built using an easy to use bridge wizard. The wizard can be opened by using the *File-New* command, or by clicking on the New Blank Document (“clean page”) icon on the toolbar.

The data input wizard is essentially self-explanatory. The same dialogues deal with one or many spans.

Using the Wizard

Page 1 – Bridge Details

The first page of the wizard records the basic details of the structure - Number of Spans, Name of the bridge, Bridge Number, Location, Creator, Checker, Revisor, Company, and Date. These will be printed in the text box on graphical output. You may leave a cell blank if you wish. Note the need to specify the number of spans in this dialogue. If you forget and come back to this dialogue, the program assumes you are creating a new bridge and resets all data.

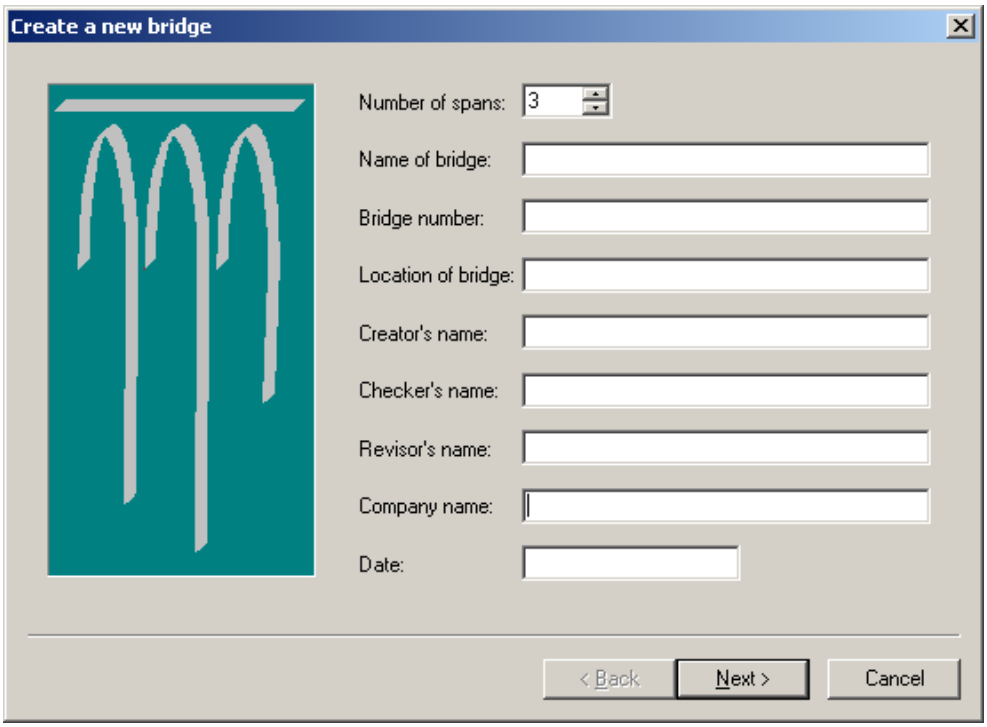


Figure 4-1. The general data section of the wizard.

We recommend that you keep a list of actions in the comments attached to each bridge file (see the section Adding Comments later in this guide).

Page 2 – Arches

The second page of the wizard (Figure 4-2) is used to gather arch-related data. Geometry data is input in a table where each row represents one span of the bridge. Other general properties can be set in separate fields outside the table. All dimensions are in mm.

The number of spans is already set since Page 1, here it is only displayed for information purposes. The program assumes that all arches have the same strength and unit weight; therefore only one value needs to be entered for the spans.

A set of check boxes is included to control and speed up data entry n the table.

- Identical Arches ! If set, this flag ensures that it is sufficient to enter the geometry data of only one arch of a multispan bridge. The data fields affected by this flag are Shape, Span, Rise, Q-rise, d-ctr (ring thickness at centre), d-spr (ring thickness at springing). The remaining arches are set to the same shape and geometry automatically.

  Note that, by default, all arches are identical. It can be very useful to set up a group of identical spans, then uncheck the box and alter the few that are not the same. Simply uncheck the box before altering the values for the different arches.

- Ring Factor = 1 ! If set, this flag ensures that it is sufficient to enter one ring thickness value. All ring thickness fields are set to this value automatically.

- Same Mortar Loss If set, this flag ensures that it is sufficient to enter one mortar loss value for a multispan bridge. !!

!

Input table

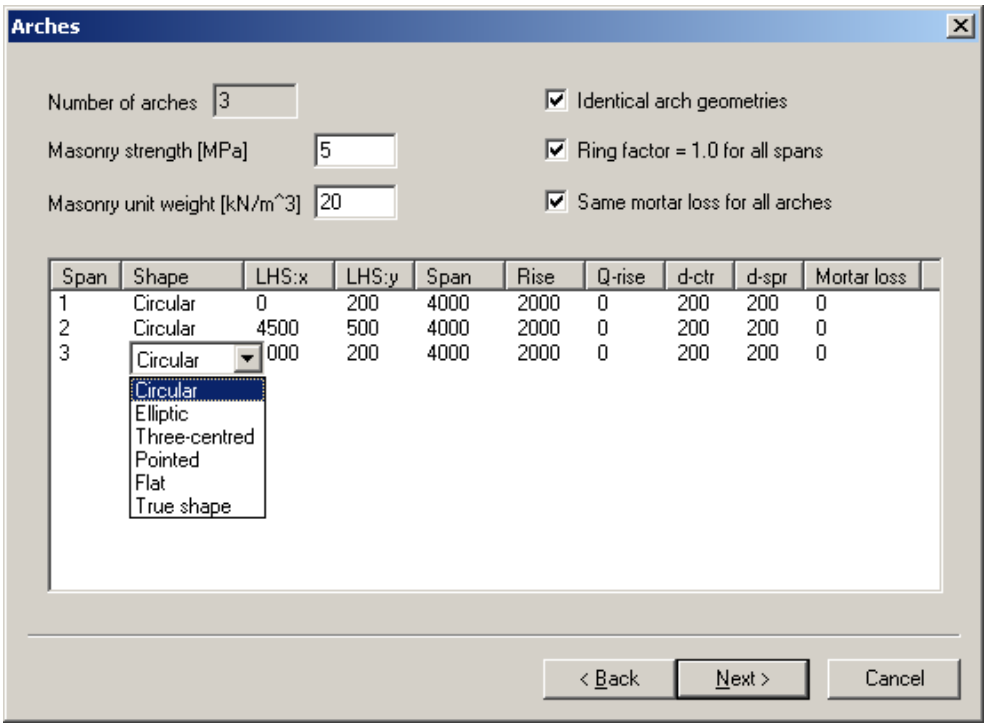
Once the flags are set, you can input the data in the table. You can move around within the table using either the cursor keys or the mouse.

Each row represents one arch in the bridge. The arch index is automatically generated, thus it cannot be modified. The arch shape cell provides a drop-down list to select the required shape. The possible choices are Circular, Elliptic, Three-centred, Pointed, Flat, and True Shape. The default value is 'Circular'. With some of the shape choices, certain cells in the table are ignored. When you select 'True Shape', an additional data entry dialog opens, which will be described later in this section.

The next two columns are to specify the left hand springing of each arch (see Figure 4-2). Use the default LHS values for single span bridges, unless you use a different datum. In a multi span bridge it is necessary to specify at least the LHS:x dimension of all but the first span.

The Span column is to enter the span of the arch. If the 'Identical Arches' flag is checked, moving from this cell will set the span for all arches. The Rise and Q-rise (quarter rise) columns work similarly. Note that the Q-rise value is only required for the three-centred and pointed arches.

!



!

Figure 4-2. The arch data entry page of the wizard.

The next two columns are used to enter the ring thickness of the arch at the crown (d-ctr) and at the springing (d-spr), accordingly. Using these two values is the alternative to the ring depth factor in the old Archie.

The last column is for the mortar loss. Mortar Loss, Mortar loss in mm through the whole arch. We plan to introduce the facility to model more complex patterns of mortar loss. The mortar loss value specifies how much mortar is missing from the arch measured from the intrados.

When finished with the data entry, click Next to proceed. The program verifies the data entered and warns you in case it finds invalid data values.

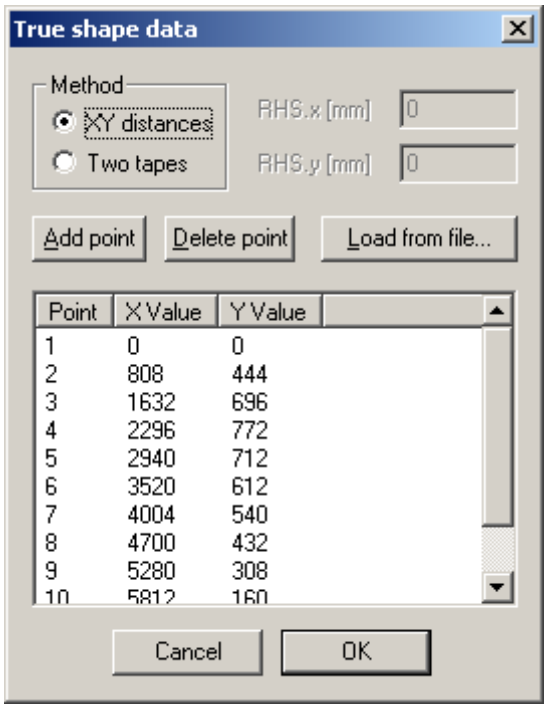
True Shape Arches

True shapes can specified using x-y plotting or the two tape method. Select the necessary method by clicking on the appropriate radio button in the

Method group (see Figure 4-3). If using the two tape method, make sure to specify the right hand springing as well in the RHS fields. Changing the specification method always clears the data table.

The data values are entered in a table. Use the Add button to create additional points in the table if more than 7 points are needed. Should you need to delete a point, right click on the given row and press the Delete button. Note that you cannot reduce the number of points below 7. The practical minimum number of points to define a curve is 9 and these must be spaced to give roughly equal changes in slope (ie more near the ends in a three centred bridge.

Click on the OK button when finished and the resulting arch shape is generated by spline interpolation. Spline interpolation generally has difficulties at specifying the beginning and end of the curve. You should always give the end, and another point on the curve near to the end in order to provide a good anchor. If fitting a true shape to a pointed arch, always give a point near to the crown on each side, as well as the crown point.



!

Figure 4-3. The True Shape data entry dialog.

Page 3 – Piers, Abutments and Fill

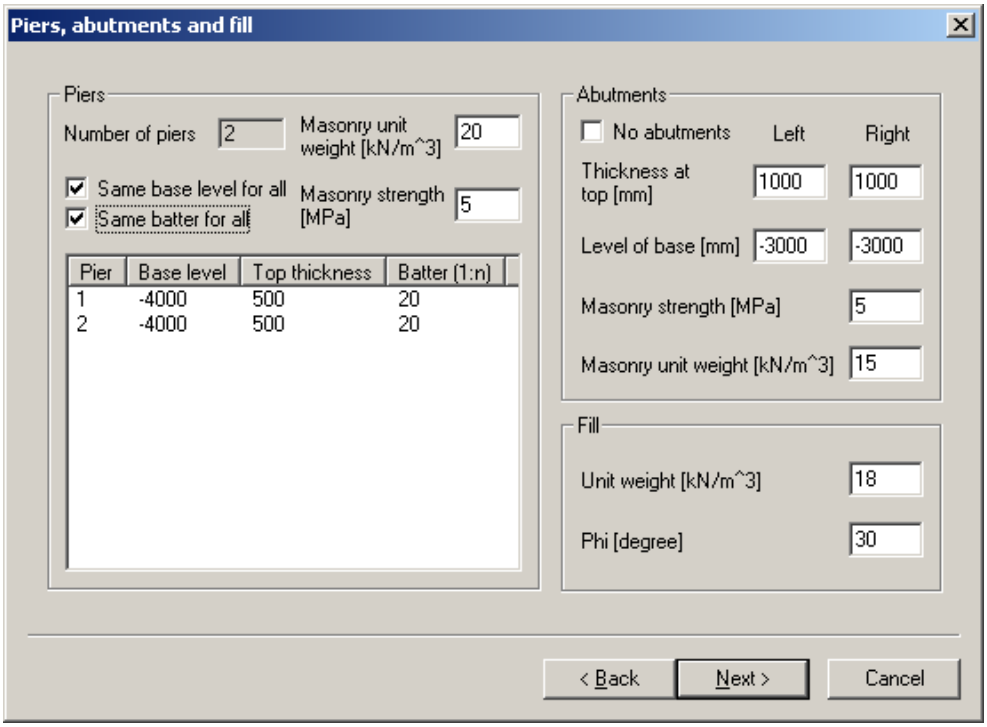
The third page of the wizard is used to specify multiple components of the bridge, such as the piers, abutments and fill.

Piers

The number of piers field is set automatically, similar to the number of spans on the previous wizard page. Set the unit weight and strength for the pier masonry if the default arch masonry values are not sufficient. Changing the unit weight might be necessary e.g. to take account of hollow or perforated piers. The same values are used for all piers of the bridge.

Check boxes help in entering data for identical piers quickly. If the 'Same base level for all' and 'Same batter for all' flags are checked, it is sufficient to enter data for one pier only, the cells for the others are automatically filled in as you move from one cell to the other. In the table enter the base level and batter values only. The top thickness is automatically computed from the arch geometries. Negative base level values are allowed and may be needed if the springing level was set to zero. See Figure 4-4 for details. Enter the n value for batter (from 1:n). For example, 1:50 means 1 unit horizontal, 50 units vertical. NOTE, however,: zero cell value means 0 batter, not infinity!.

!



!

Figure 4-4. Piers, abutments and fill

Abutments

Abutments take no part in the analysis as yet. They are merely illustrative. They can therefore be ignored if you wish. Removing (rather than ignoring) the abutments produces unfortunate results when backing is added. In this case zero height abutments are therefore added automatically.

Fill

In the Fill section of the page you specify the unit weight and Phi values for the fill. Phi is used to set the at-rest and active soil pressures. It is also used to calculate limits to the passive pressure that may be applied. The default value is 30 deg.

The action of the fill may be very important to the performance of a structure. In multi span structures we have not allowed the fill pressure to increase towards passive because we are not sure where the reaction might come from (probably the next span, and modelling that would be difficult).

Page 4 – Road

The last page of the bridge entry wizard is used to specify the road over the bridge. As described earlier (see Figure x-x), the road is defined by a number of possible shapes. The required method (shape) can be selected in the 'Road specification method' section of the page.

If a single point is given a level road is assumed. With two points, a straight grade runs from point to point. A circular curve may be described with three points. This is not a common form, but may be close enough to the truth for realistic results. A complex curve can be created by interpolation based on at least seven base points.

With multi point curves, please ensure that the end points are beyond the limits of the arch EXTRADOS, in other words, the road runs beyond the bridge both on the left and right end.

For those used to the old Multi program, this road specification method is a major change. The road in ArchieM is a continuous curve described as a single unit for the structure.

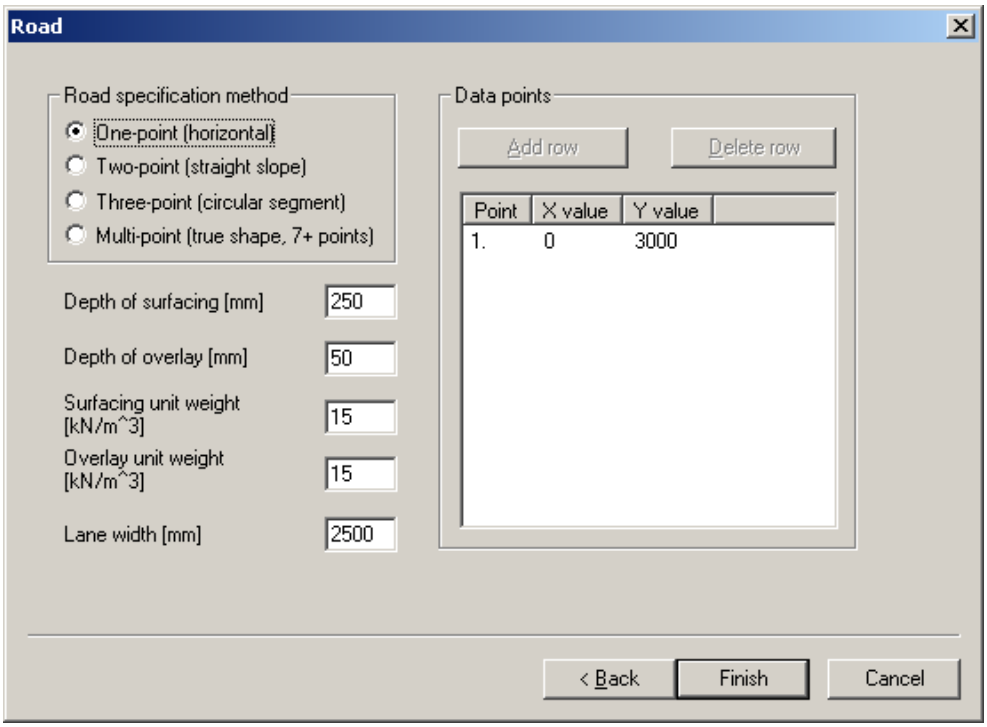


Figure 4-5. "Road" details

In the Data points section, use each row for one point entry. The Y value is the road surface height at the given point, whereas the X value is the distance from the datum.

Remember to use a minimum of 7 x-y points for the true shape road and use two points near each end to set the tangent to the end of the line correctly.

In the remaining separate fields, you can enter the depth of the road surface and the overlay, as well as their unit weight and the lane width.

The main function of overlay is to increase the depth through which the load is distributed. In general terms, the effect will be limited to an improvement in longitudinal distribution (see the section on Lane Width).

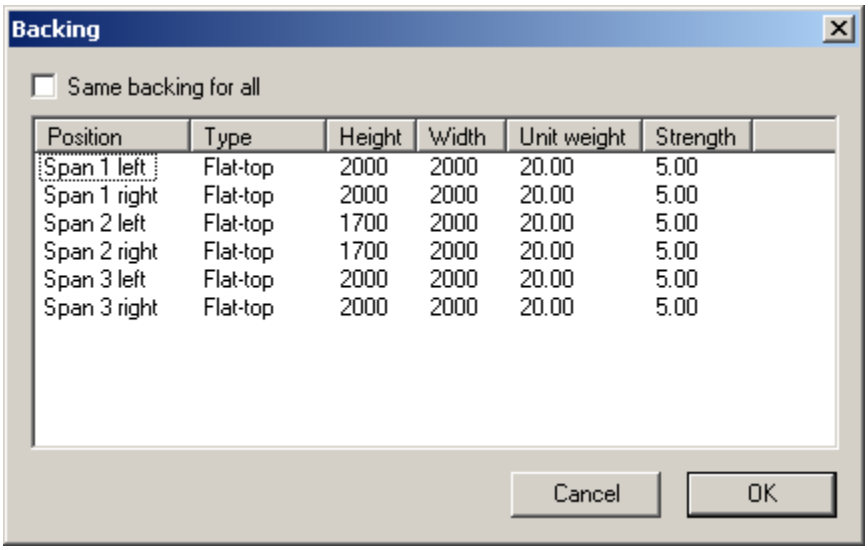
The lane width is an important item. It defines the width over which the axle load is distributed. It is our experience that the width available is always less than the theoretical distribution allowed in BD21.

Modifying the bridge

Double clicking on any element of the bridge will open the bridge wizard at the appropriate page. Remember to save the file under a new name if you generate a new model from an existing one.

Creating and modifying backings

Backing has no structural action within the program, but it is normal to allow thrust to flow through the backing. To add backing to a bridge, click on the backing icon or click Structure/Modify Backing. For flat top backing it is necessary to define a width as shown in figure 3-10. If the top of the backing intersects the extrados, it is sufficient that the width is set to more than necessary, but it should not be greater than half the span.



!

Figure 4-5. Backing details

Changing the Number of Segments

Large numbers of segments give smooth thrustlines but take longer to process. Numbers between 20 and 50 seem to work quite well. Over 50 the reduction in speed becomes progressively greater, especially in multi-span bridges. This is much less of a problem in 2007 than it was in 1999.

CHAPTER 5

Creating a new load

The program comes with a set of load files installed in the Loads subdirectory of the Archie-M program directory. There are cases, however, when these predefined load cases are not adequate for the task. The built-in load editor of Archie-M makes creating and modifying loads simple and fast.

Definition

Building a load family is best accomplished using WordPad or some similar text editor. NotePad has a reduced feature set compared to WordPad which may increase the difficulty. Remember that Notepad has a habit of adding a .txt extension when you save, even if there already was an extension. Files labelled (eg) load.ldf.txt will not be recognised by the program. The most effective approach is to open an existing load file, save it with a new name and then edit the lines to give the load patterns you require.

Note

Addition details have been included in the load file for more recent versions of Archie-M. The program will use the old files and ignore the additional parameters, but users should be careful to ensure that loads are applied appropriately and that the tabulated values are as expected.

!

CHAPTER 6

Assessment Tools

This chapter looks at the assessment tools in Archie-M. The program has several features that help the engineer in performing assessment tasks. These include the ability to view and check intermediate calculations in tabular format, adjust safety factors, apply passive pressure and find worst case situations automatically.

Viewing Tabular Results

Select the Tools-Show intermediate results menu item or click on the 'Show results' icon on the toolbar to open a textual window showing the intermediate results of calculation. The table lists all the geometric and force data required to check calculations.

The window is updated live as the main window receives actions from the user and calculations are carried out. The page can be printed or pasted to other applications. Copying the page to a spreadsheet makes manipulation easy and is particularly useful for checking purposes. The formatting facilities in a spreadsheet can be very useful in presenting the data in an effective way.

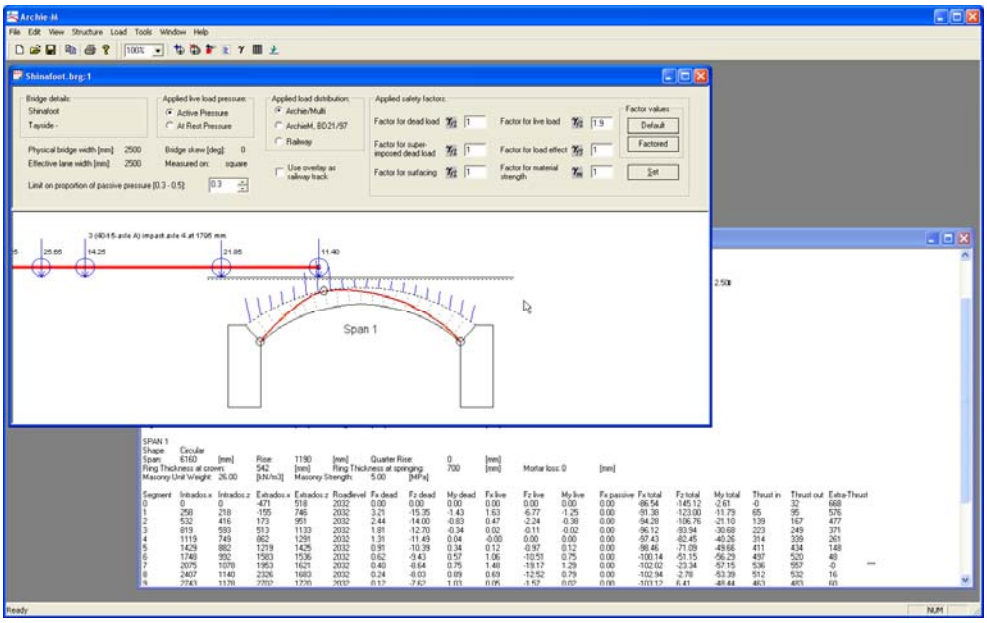


Figure 6-1. Graphic and text windows visible

If required, it can be maximised to fill the whole working area of the main Archie-M window. This is shown in Figure 6-2.

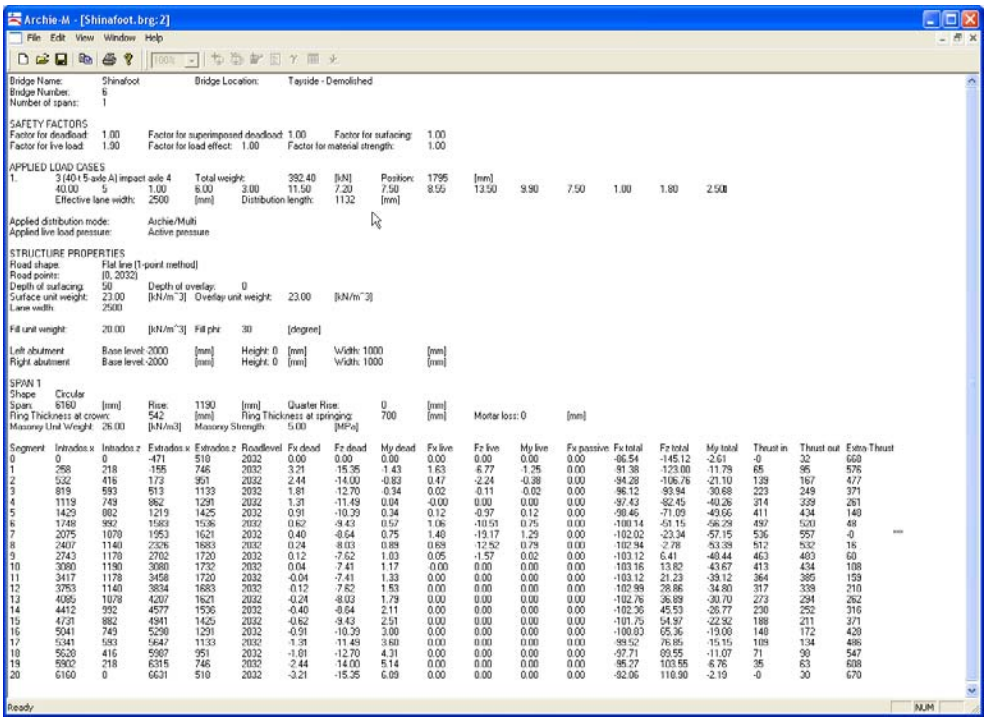


Figure 6-2. The text window

Safety Factors

The safety factors dialogue is in the ribbon at the top of the working screen. We suggest that if you set non-standard values, you reset to default values before you save the file.

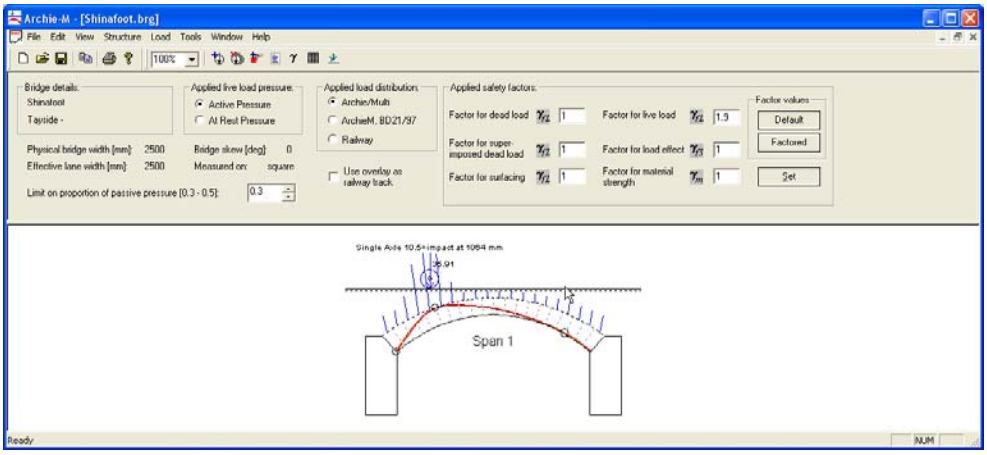


Figure 6-2. Partial safety factors dialogue

The Partial Factors can be reset live. Please remember that new factors are not applied until the set button is pressed. Defaults can be restored at any time using the defaults button. There are a number of difficult issues when dealing with the partial factors from BD21/97.

- Gamma Fl

BD21 gathers together the impact factor and GammaFl into a combined factor of 3.4 on the most heavily loaded axle. We have separated them back out, applying impact within the load files and using GammaFL=1.9. Please take care not to double count factors

- Gamma F3

GammaF3 is a partial factor to cover the fact that the structural model used may not truly represent the behaviour of the structure. It is not to cover errors on the part of the engineer, or the programmer. There are no safety factors which can adequately cover risk which has no statistical significance attached to it. BD21 suggests that GammaF3 may be set to 1 if the program has been calibrated. The old Archie and Multi programs were regarded as calibrated. The new one is more conservative, because there was a distribution error in the old one. We believe that it is therefore appropriate to use 1 here.

- Gamma M

The factor on material strength is designed to cover variability in the values used. It is not strictly appropriate to use it to apply condition factors, which should be applied via the load itself. It is our view that the condition factors are entirely arbitrary.

!!

Adjusting gammaFl

BD21 asks the assessor to specify an ultimate load factor for a particular load. We believe that this demands a level of confidence in the whole assessment process which is not achievable. However, we have provided the facility to adjust GammaFl with a scroll bar until the thrust just fits in the arch. Please remember that there are load paths in the structure which Archie-M does not consider. The true load factor is almost certainly significantly higher than the result obtained here.

!

!

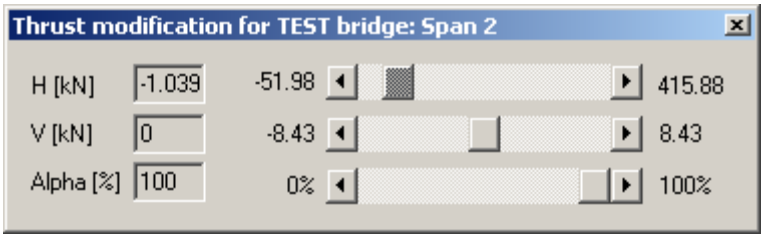
Figure 6-2. Adjust GammaFl dialogue

There is (in 2006) reason to suspect that small bridges with shallow fill have lower resistance to multiple loads than the current model suggests.

This is a result of a poor effective width model rather than errors in the analysis scheme. Look out for more details in the near future.

Manual Thrust Modification

In a multi span bridge, the thrust in passive spans (those which supply passive thrust to stabilise a heavily loaded pier) can be adjusted manually to show the structure in equilibrium. The thrust is adjusted at the centre of the span by changing the horizontal component (which affects the spread), vertical component (which affects the tilt) and position (via the factor alpha relating to the position through the depth of the arch at the crown 0% being at the intrados and 100% at the extrados. Beware that tilting the thrust with alpha set to zero may take the thrust outside the intrados away from the centre. This can be checked by zooming in on the picture, or using the intermediate results window where the offset of the thrust from intrados and extrados is displayed.



!

Figure 6-2. The dialogue for adjusting thrust in unloaded spans

Figure 6-2 shows the adjuster bar which is brought up by right clicking on the appropriate arch. Figure 6-3 shows the tool in use.

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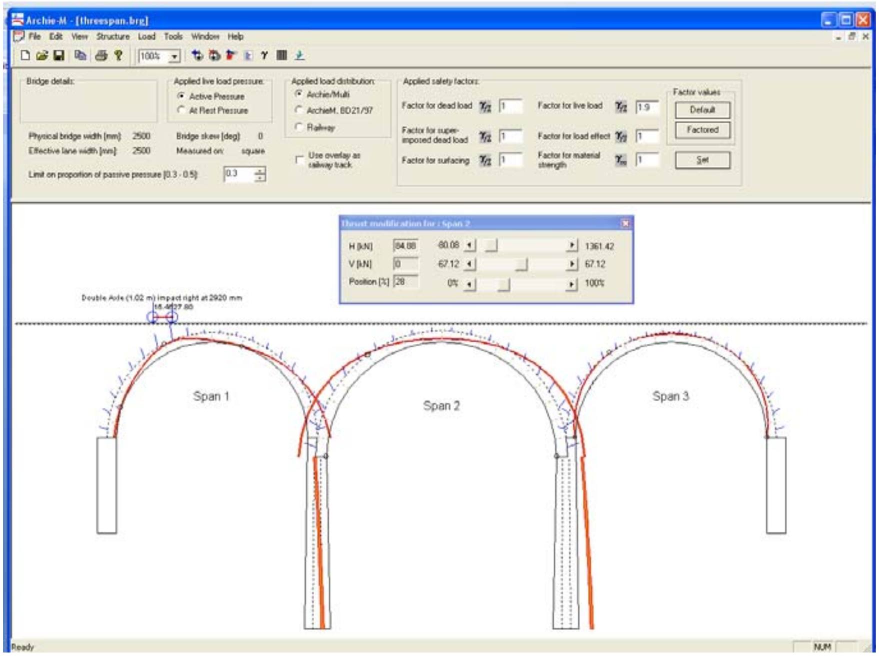

Figure 6-3. Adjusting thrust

OPUF!Uif!gbdu!uibu!uif!bsdi!uisvtu!dsptt!jt!pg!op!tjhojgjdbodf/

Applying Passive Pressure

Passive pressure in the soil can only be applied when working with single arches. This is because we have not been able to identify a reaction path for the additional pressure which does not impact on adjacent spans.

If the thrust goes outside the arch, right click in the fill to apply passive pressure. A new hinge will be created at the springing point and the thrust will be brought into the arch at that point. The factor on passive pressure displayed is the proportion of the range from at rest to passive that is required to bring the thrust into position(Figure 6-4).. If the thrust is outside the arch above this hinge, it is possible to move the hinge up the arch with the mouse. The passive pressure requirement will then increase.

We believe that it is not appropriate to use more than about 0.3 of the passive pressure increment. This is because larger passive pressures can only be developed through substantial movement which would change the geometry of the structure.

There is a maximum limit set to the proportion of passive pressure available. This can be adjusted in the parameters ribbon but cannot be increased above 0.5.

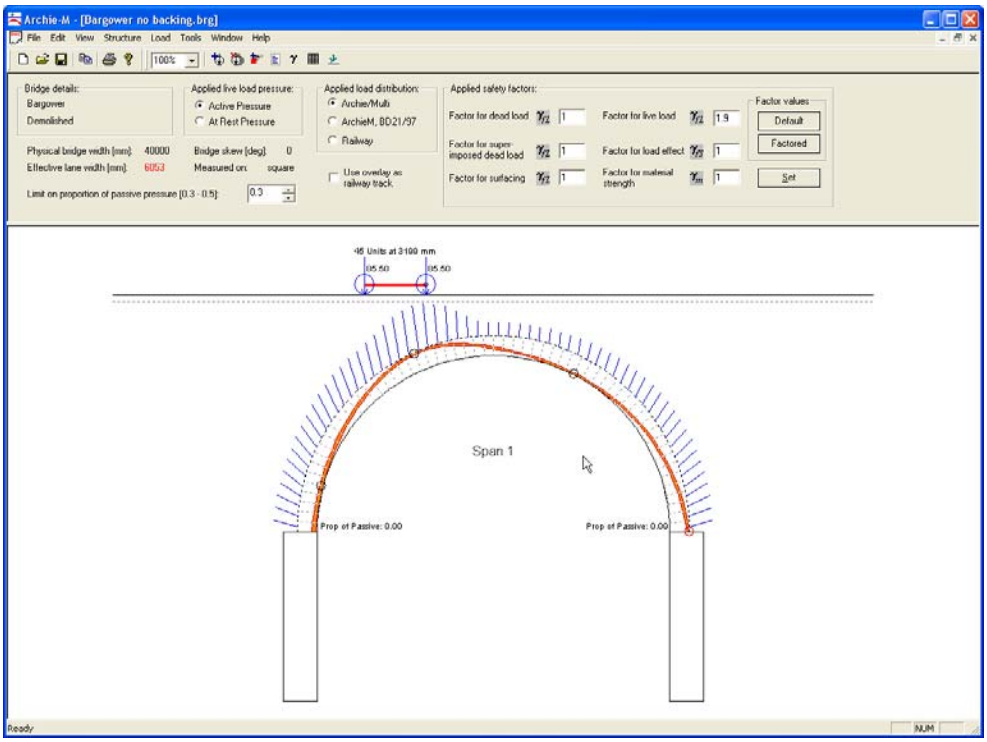

Figure 6-4. Passive Pressure factor displayed

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Performing Autoload

Running a range of loads over the bridge to find the worst case is a useful feature, but may not always reveal the worst possible condition. It works by finding the load position that produces the maximum deviation of the thrust line in the arches or piers. In a multi span bridge, a small deviation in a low pier may be more onerous than a larger one in a tall pier. We recommend that users run the worst load found across the bridge manually, observing the thrust changes and checking by adjusting the thrust where worse conditions may apply.

To use the autoload facility, open the window shown in Figure 6-5 using **Tools/Autoload** open up the families to be considered and check the appropriate boxes *at both the top two levels*. The system will not run without both levels being checked. Checking the third level has no effect, though we expect to make it work correctly in version 2.3.

The table in Figure 6-6 shows the outcome of an autorun. This table can be highlighted by pressing on the left mouse button in the top left corner and sweeping over the whole table. It can then be copied to the clipboard using Ctrl/Ins and pasted into Word or Excel. In excel, the table will occupy a single column, but can be spaced out using Data/Text to Columns.

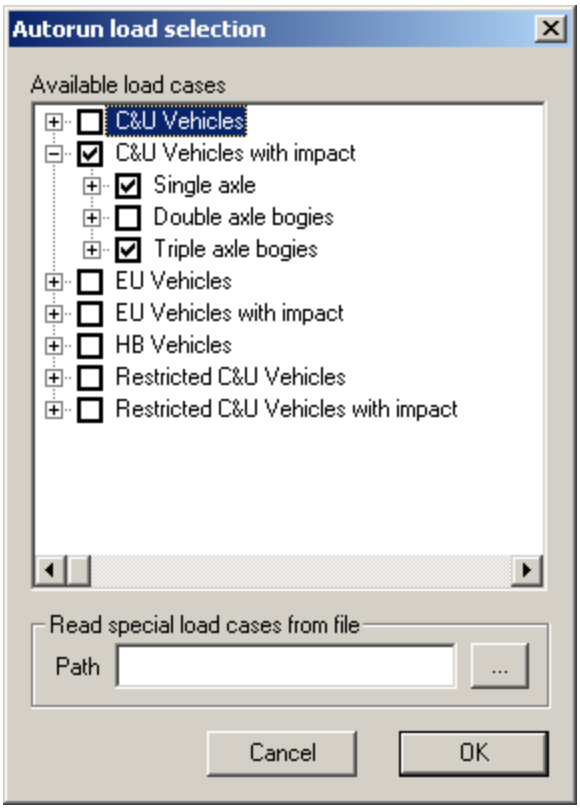


Figure 6-5. Selecting loads to Auto-Run

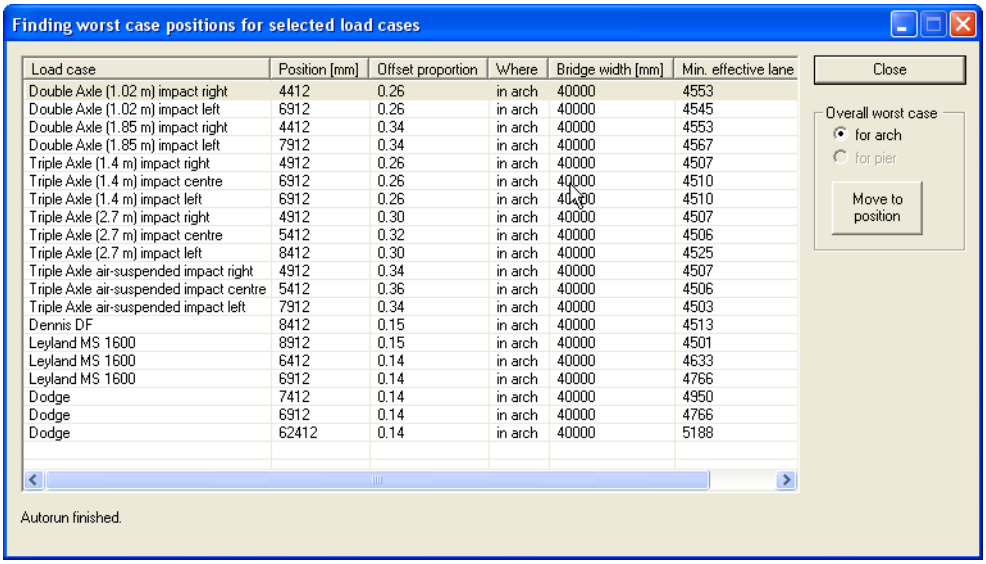


Figure 6-6 Autorun Loads output.

Any desired load can be applied to the bridge by double clicking on that row of the dialogue shown in Figure 6-6.

Live Load Distribution Mode

It has become clear that there was an error in Archie/Multi, which allowed nearly twice the distribution intended. If you wish to explore the effect of this difference, The radio buttons in figure 6-7 allow you to do this. Call up the dialogue using **Tools/Set distribution mode**.

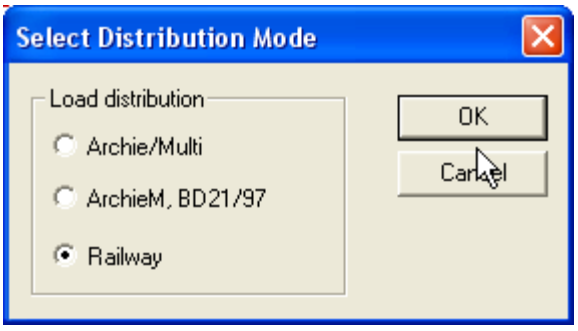


Figure 6-7. Choosing the load distribution method

Live Load Pressure

All the soil pressures, except that from the live load, used by default in Archie-M are calculated using the at rest pressure coefficient. For the live load the pressure is calculated using the active coefficient (this is a change from version 2-0-7. If you wish to check the effect of using at rest pressure for the live load use this facility.

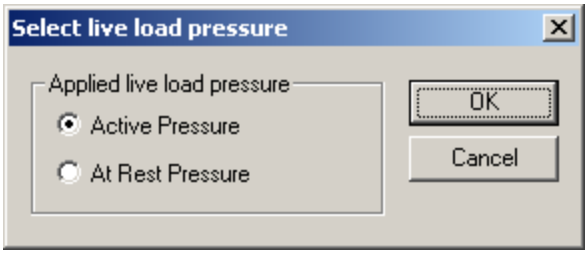


Figure 6-8. Choosing the live load spoil pressure

Working With Large Bridges

Try resizing the window and zooming the picture. Note that scroll bars appear if you zoom in. Try opening a new window (Window-New) and sizing it to observe a section of bridge more closely. This can be very useful when balancing thrusts as is necessary to explore pier behaviour. (Figure 6-9)

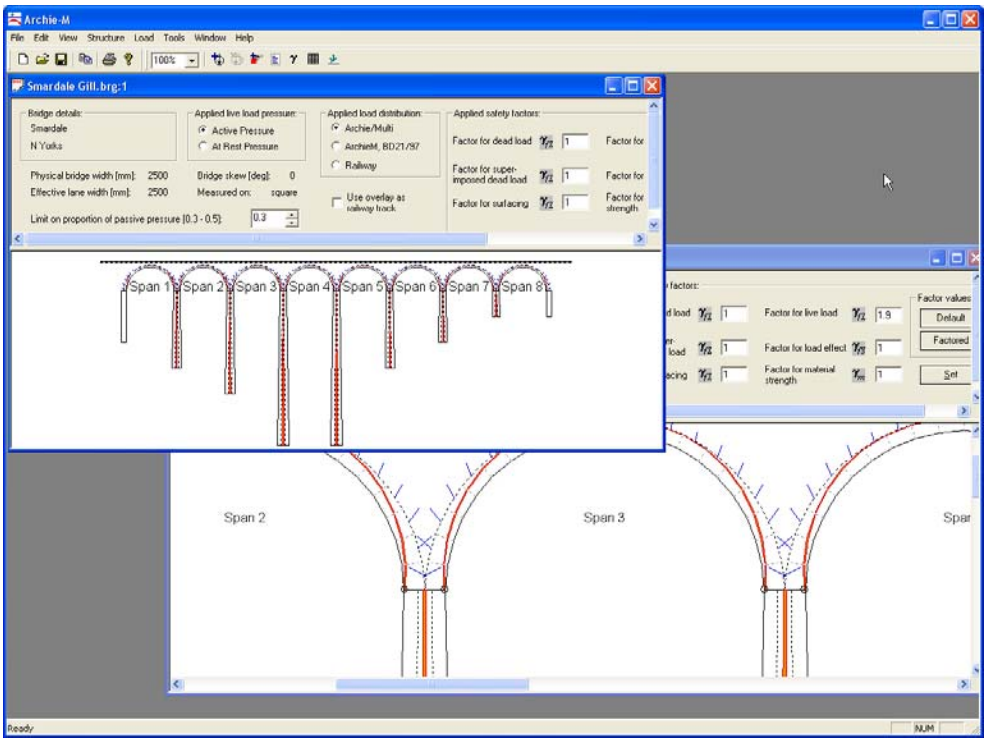


Figure 6-9. Multiple windows on the same bridge

CHAPTER 7

Other features

Printing and Print Preview

The print function works differently depending on what is in the active window. If the graphic screen is active, a picture is generated which has rather more detail than appears on the screen. The actual content can be seen in Figure 7.1.

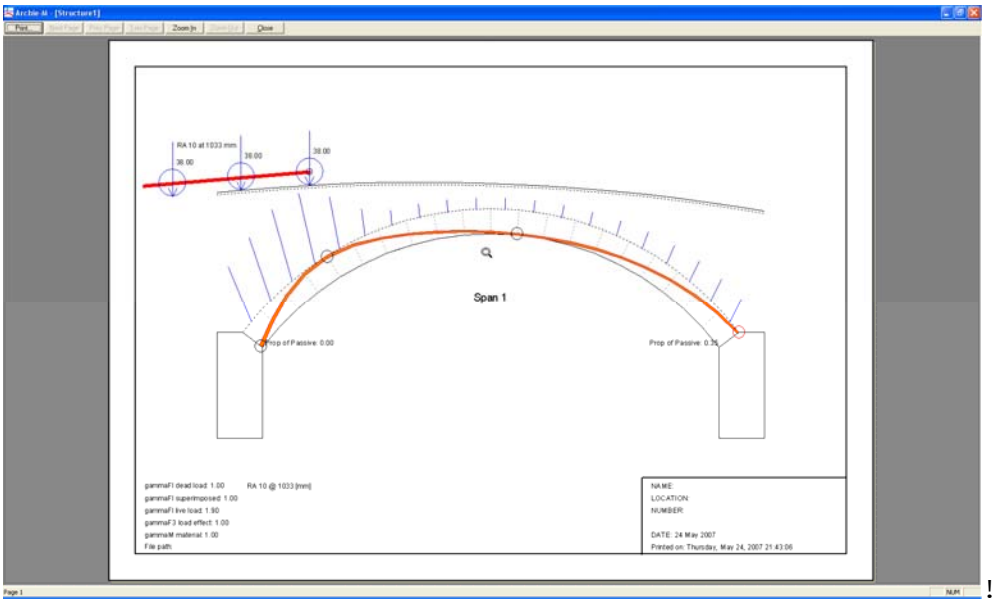
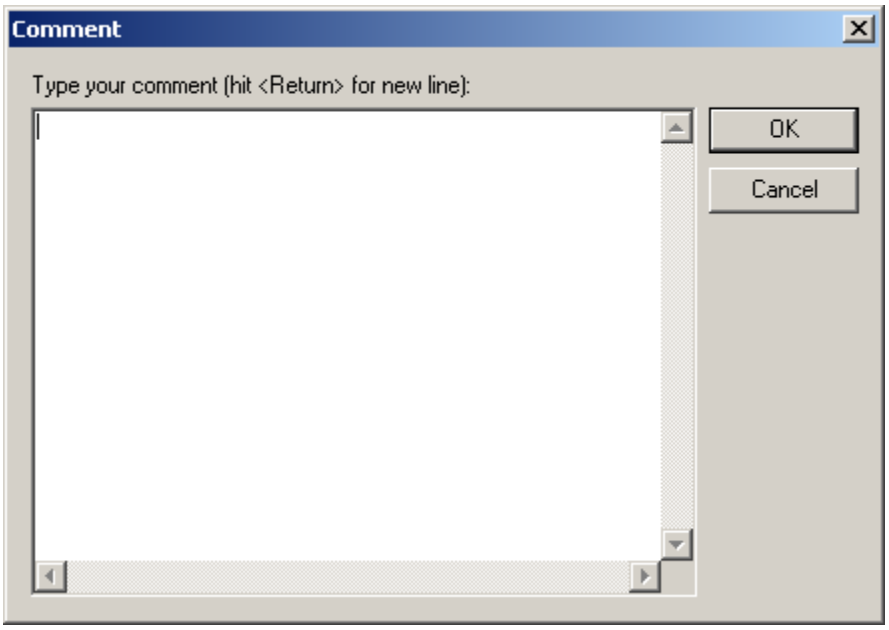


Figure 7-1. Print preview for a graphics screen

It is possible to copy the actual screen content to the clipboard but this function (built by MicroSoft) is unstable and often causes the program to crash. An alternative used by many is to use the Shift/Print Scr function to copy the screen to the clipboard. There are also proprietary screen grabbers available with more functionality.

If the tabular screen is active, it will be printed on as many pages as required, but this gives a difficult distribution. It is often more convenient to copy this table to the clipboard (the edit copy function works OK here) and paste it as Unicode-text into excel from which it can be effectively formatted and printed in an appropriate layout.

Adding Comments



!

Figure 7-2.

Opens a text editor window which allows the user to edit the text file associated with the structure. We have included this facility to allow users to record what analysis and changes they have made. We thought this might be especially useful if one user set up a bridge and another changed it. We would, however, prefer to think that any change to the structure produces a new bridge and should therefore be reflected in the file name.

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Communicating With Other Programs

Graphics

As described above, screen grabbing is more stable than copying the graphics from within the program. If you wish to get an editable picture into a graphics program, it may be possible to print to pdf or to a postcript file and then load the file into a program for editing. Bill regularly uses pdf files and Corel Draw in this way. Many of the images in this manual were produced using Corel Capture which can grab only the active window.

!

Text

The tabular output page can be copied to the clipboard and pasted (best via Paste/ Unicode Text) into Excel (Figure 7-3). This creates a structured table on which check calculations can be effectively carried out and where advanced modifications to the model can also be created (contact bill@obvis.com for details).

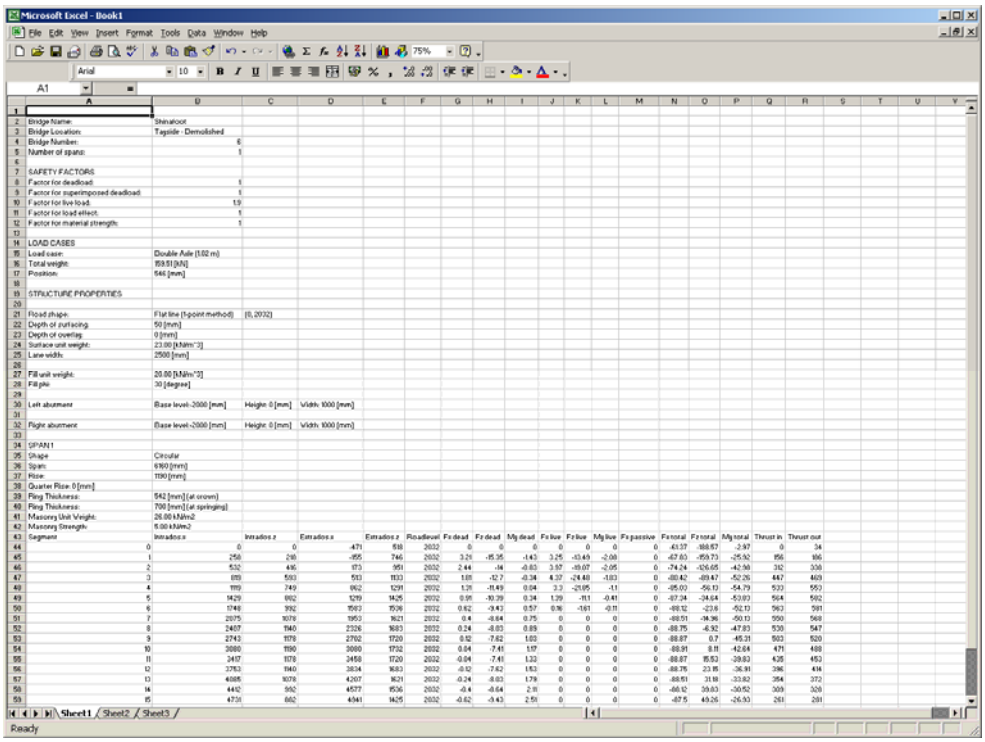

Figure 7-3. The tabular output pasted into Excel

Options

Tools/Options allows the user to set a special (temporary) default directory for loads. This sends the program direct to the appropriate directory when loads are changed instead of going back to the global default every time.

There is also a check box here to allow the overlay to be used to represent railway track. (Figure 7-4) Checking this box moves the loads to the bottom of the overlay which then acts as dead load without contributing to distribution of the live load.

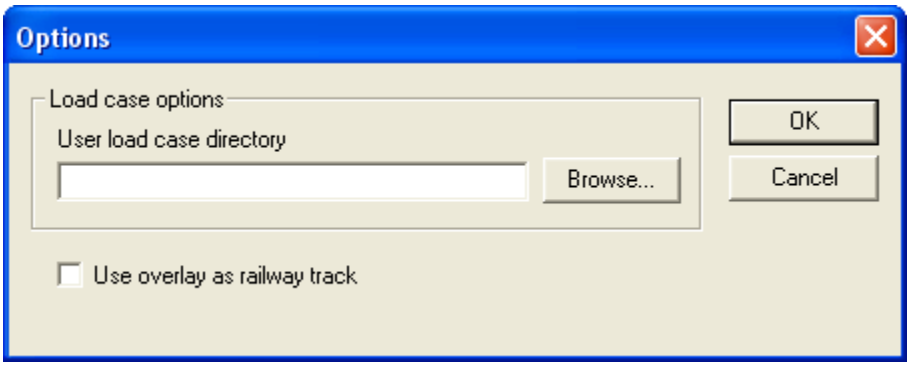

Figure 7-4. Choosing a user generated load directory

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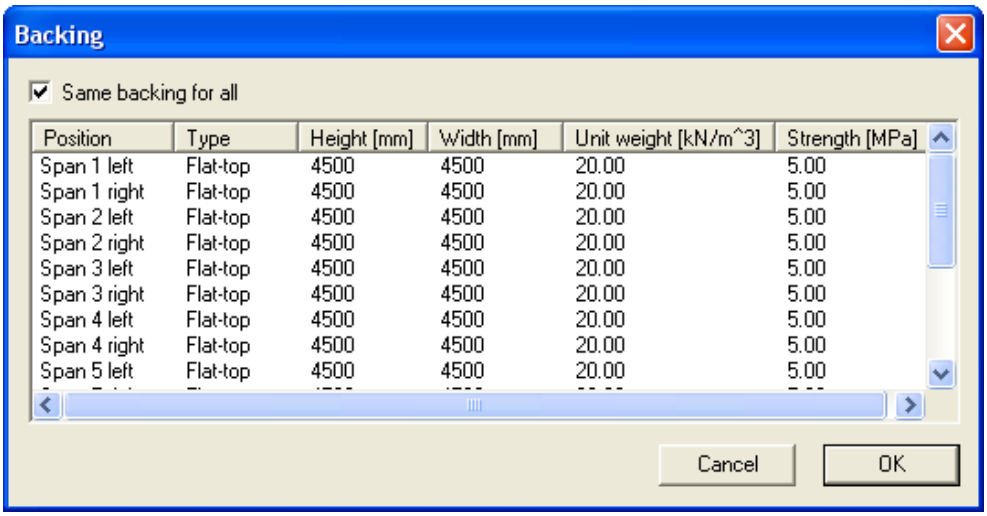
Multi Spans

Multi span bridges require more work from the user.

Open the file Smardale Gill.

Add backing by clicking on the backing icon. Check the Same backing for all box, set the type to flat op and the depth and width to 4500. This brings backing to the level of the crown which is typical (or possibly low) for such a bridge (Figure 7.5).



!

Figure 7-5 Adding backing to Smardale

Now apply a substantial load (eg 35 units of HB or a large railway load [this is actually a railway bridge]) (Figure 7-6)

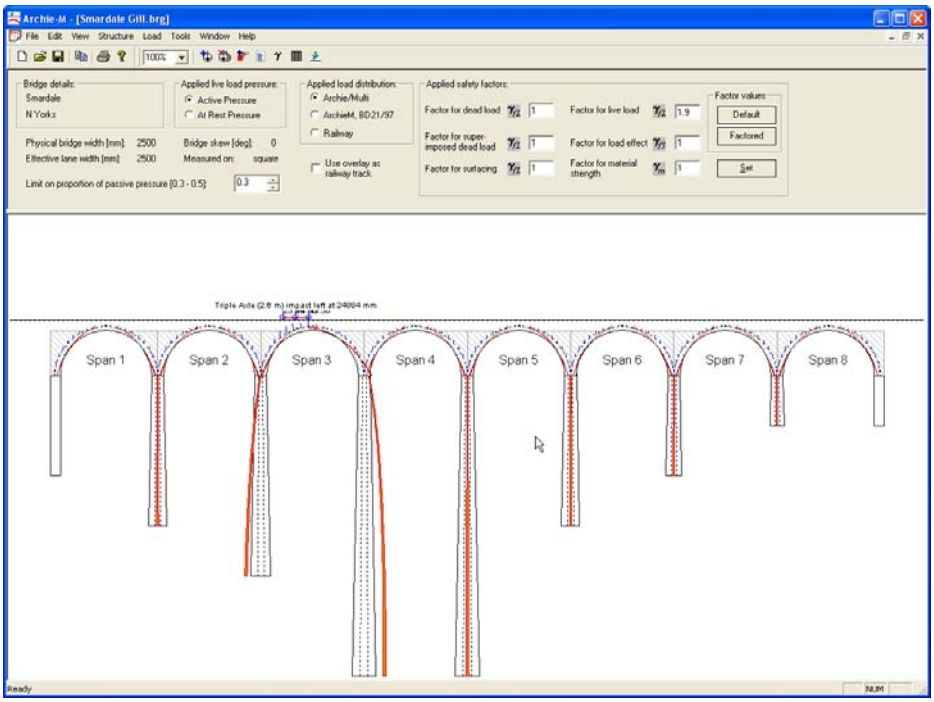


Figure 7-7

Right click on the span to the right of the load and choose Modify Thrust. The slider bars increase the horizontal thrust, skew the thrust and move it up and down. Try them. The dialogue box can be moved to clear the view. The aim is to keep the thrust inside the arch and the pier at every point. It might help to open a second, magnified, window to show a detail.

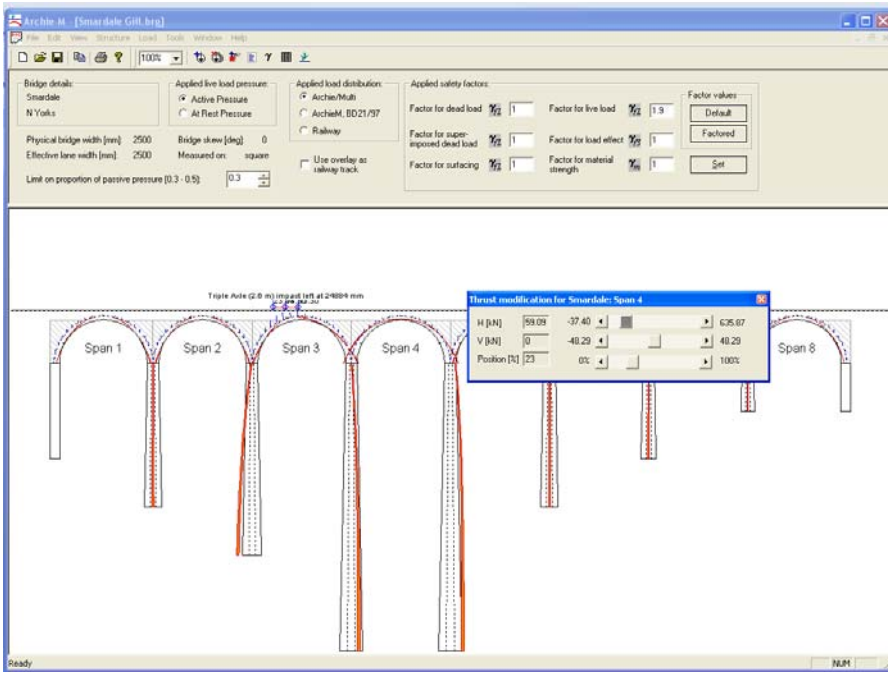


Figure 7-8 Adjusting thrust in a propping span

It is usually easiest to begin by moving the thrust to the intrados at the crown by pulling the lower bar to the left. The thrust can then be increased by pulling the upper bar to the right. Often, there is value in tilting the thrust using the middle bar. The ONLY constraint is that the thrust must stay within the structure at all points. There is a degree of conservatism in this because there are a number of alternative paths for the load.

Note that the thrust cross over the pier between spans 3 and 4 (Figure 7-8) this is not important. Truncating the thrust is difficult, but once the two thrusts meet, they combine and form the thrust in the pier.

!

Saving Modifications

Once you have made modifications to the bridge model you must decide whether they are to be permanently effective, in which case you can simply save the file, or are merely exploratory, in which case you might choose to discard them or to save the file under an appropriate but different name using saveAs. Note that this does not affect the name of the bridge which is fixed on the first page of the bridge wizard.

Tabular Data

Intermediate Results

The intermediate results page is designed to help users to run QA checks as well as to provide confirmation of the graphical output. The page includes input data except where this is implied by the tabulated information below. It is probably best to use this data with a relatively low number of segments or handling the numbers and pages becomes cumbersome.

Content

Axis System

Archie works with forces expressed as Fx, Fz and My. The x axis is horizontal and the z axis vertically upwards. The y axis is then into the page and clockwise moments are positive.

Basic Data

The basic data describing overall properties of the structure appears at the head of the page. All the items are labelled. After some initial difficulties, we believe that these are now all transferred correctly.

Tabular Data

The table for each arch and pier sets out the geometry of the structure, the forces generated on each element, the total forces and the thrust positions.

Geometry

The geometry of the structure is defined by the intrados and extrados points at each segment boundary. Line 0 is the left hand springing.

Local forces

Dead loads and live loads are treated separately. The values refer to the segment to the left of the position. Thus segment zero has no local forces. My in segment 1 is the moment produced by the combination of Fx1 and Fz1 about the intrados point at 1.

Total Forces

Archie-M works by accumulating the total effect of all the forces to the left of a section. The force normal to the section line is then divided into the moment about the intrados to find how far up the segment line the force crosses the boundary. This is exactly the process used in finding the location of the reaction under a retaining wall.

The force to the left of section 0 is the reaction at the left hand springing. By the time you reach section 1, the forces and moments from segment 1 have been added in. There is a modification to My at 0 to allow for the fact that we now need to know the moment of all the forces about the intrados at 1. This process continues through the table until the forces at the last section are those transmitted to the right hand springing. This means that Fx will normally be positive at both ends, increasing steadily towards the middle then declining again. Fz on the other hand is positive at the right hand end and negative at the left. The difference is the total vertical load on the structure.

Application

The intermediate results can be printed direct, or transferred to Excel for manipulation. This is acomplished by useing edit/copy then pasting the result on to an Excel page as Unicode text.

Graphics

The graphical output can be printed from within the program or copied to another windows program, such as word, where it can become part of a report. As a result of faults in Microsoft's programming language, this function remains unstable after many years effort. It is usually better to use the print screen function to trap the results in the clip board.

Factors of Safety

Factors of safety are applied explicitly in Archie-M. Use the tools menu or the Gamma button to open the Partial Factors dialogue which will float over the working window if you wish. Changes are only applied when the Set button is pressed. The default value for all the factors except the live load factor is 1. The live load factor is 1.9 to comply with BD21. An additional dynamic factor of 1.8 is applied to a critical axle in the load files with impact in the name. (For the time being, these are provided separately from the load files installed through setup.

Numerical Output

Both for checking and for records, detailed numerical output is needed. Using Tools-Show intermediate results, you can open a second window containing data which is updated live with the active graphical window. The data can be copied to a spreadsheet via the clipboard.

Graphical Output

The picture in the active window can be printed to a Windows printer. This will also print details of the bridge. We would like feedback from you on what you would like to see on this printout (email if possible).

The picture can also be copied to the clipboard and transferred to another program for report writing. The picture below was created in this way

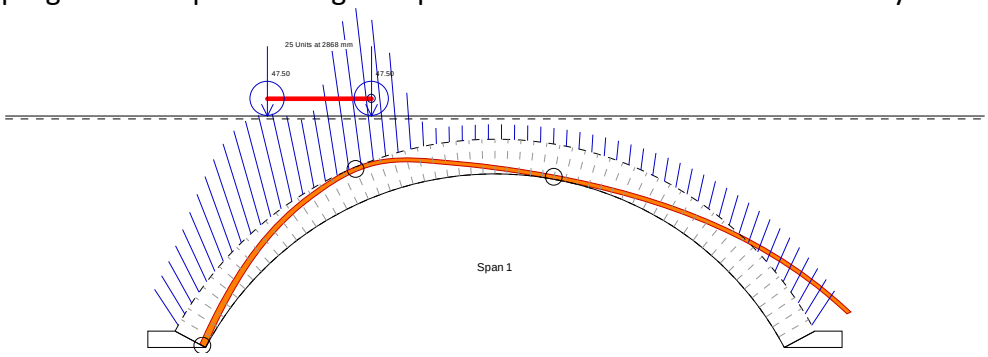


Figure 7-9 Image from Clipboard