Multiframe 11.6 Windows — 03 March 2010 Release Note

This release note describes the Windows version 11.6 of Multiframe, Steel Designer and Section Maker. This release will run on Windows XP/2003/Vista/7.

Contents

Multiframe

Steel Designer

The following features have been modified or added to Steel Designer in this release.

Eurocode 3

This chapter describes the implementation of the EN 1-1-1993 “Specification for Structural Steel Buildings” within Steel Designer. It provides a step-by-step description of how to modify the design properties used by the code.

Notation – Eurocode 3

The notation used in Steel Designer generally follows that used in the EC3 design code. Use has been made of subscripts to clarify the axis of the member to which a quantity refers. For example, the nominal flexural strengths about the Y and Z axes are denoted $M_{y,Rd}$ and $M_{z,Rd}$ respectively.

The geometric axes of a member are denoted as the Y and Z axes where Y represented the horizontal axis of the member and Z the vertical axis of the member. For design to Eurocode 3, it is assumed that the Y axis is the major axis and Z is the minor axis.

Design Checks - Eurocode 3

The types of checks are grouped into the categories: Tension, Compression, Bending Torsion and Buckling. The user may specify which of these checks are performed when a member is designed or checked using Steel Designer.

Bending - Eurocode 3

The design of a member for bending is divided into eight design checks. These check the flexural, shear and combined flexural-shear capacity of the member about the major and minor axes and the combined biaxial bending and axial force and the combined biaxial bending, shear and axial force. Each of these checks may consider one or more limit states depending upon the section and the actions within the member.

When performing a bending check it is necessary to specify how lateral buckling of the member is resisted. Restraint could be provided by other members, purlins, girts or by other structural elements that are not modelled in Multiframe such as concrete slabs. Steel Designer provides three methods of specifying how a member is restrained against lateral buckling. The user may specify that the member is fully restrained against lateral buckling in which case no lateral buckling checks will be performed.
The location and type of lateral restraints applied to the member in which case Steel Designer will appropriately divide the member into a number of spans and consider the capacity of each of these spans in determining the capacity of the member.

Alternatively the laterally unbraced length (L_b) can be specified.

You may need to specify a number of properties relating to the location and type of lateral restraints and the stiffener spacing along the member

Lateral Restraints - Eurocode 3

If the spacing of lateral restraints along the member is specified, Steel Designer uses this information to break the member up into a number of spans in order to determine lateral torsion buckling capacity of each span. In Steel Designer, these spans are known as segments.

Each lateral restraint specified by the user is assumed to provide bracing against lateral displacement of the *critical flange* and/or prevent twist of the cross section. At any cross section, the *critical flange* is the flange that, in the absence of any restraint at that cross section, would deflect the furthest during buckling of the member. In most members the *critical flange* will be the compression flange. However for a cantilevered member, the *critical flange* is the tension flange.

For each restraint located along a member, the user must specify the type of restraint. As this depends upon which flange is the critical flange, which is not know *a priori*, the user must specify the type of lateral restraint that would be present at a section if

- **The top flange was the critical flange, and**
- **The bottom flange was the critical flange.**

In Eurocode 3 no distinction is made between different types of lateral restraints. However, to be compatible with other design codes, Steel Designer allows for lateral restraints at a cross section to be classified as follows

- **Full Restraint –supports the cross section against lateral displacement of the critical flange and prevents twist of the cross section.**
- **Partial Restraint – provides support against lateral displacement of the section at a point other than the critical flange and prevents twist of the cross section.**
- **Lateral Restraint – resists lateral displacement of the critical flange only.**

For the purpose of design in Eurocode 3, each of these restraint types is consider adequate to provide lateral support to the cross section at which they are applied.

Lateral restraints must always be specified at the ends of the beam and so the minimum number of lateral restraints is two. If no restraint exists at the end of a member then it should be specified as unrestrained in which case the member would be regarded as a cantilever. The initial lateral restraints applied to the member are full restraints at each end for either of the flanges being the critical flange.

The location and type of lateral restraints can be displayed in the Frame and Plot windows. The display of lateral restraints can be turned on or off via the Symbols Dialog which contains options for displaying and labelling lateral restraints. The restraints are drawn as a short line in the plane of the major axis of the member. These lines extend each side of the member for a distance that is roughly the scale of a purlin or girt. Lateral restraints are also displayed in the rendered view of the frame in which they are draw to extend from each flange by approximately the size of a purlin. The restraints may be labelled using a one or two letters to indicate the type of restraint (e.g. F - fixed, P – partial, L - lateral).

Note that lateral restraints at the end of a member are draw slightly offset from the node so that restraints at the ends of connected members may be more readily distinguished.

Unbraced Length (L_b) - Eurocode 3

Instead of specifying the position of lateral restraints it may be preferable to directly set the laterally unbraced length of the member (L_b).

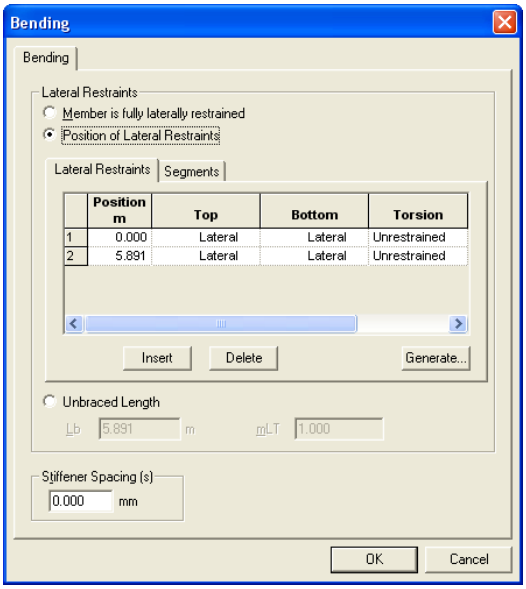
Web Stiffener Spacing - Eurocode 3

When checking or designing a member for bending, you may need to specify the spacing of any stiffeners along the web of the member. This affects the member's susceptibility to buckling due to bending. If there are no transverse stiffeners, you should leave the stiffener spacing set to zero.

Bending Dialog Eurocode 3

To set the properties for bending

- **Select the required members in the Frame window**
- **Choose Bending from the Design menu**



- **Select the "Member is fully laterally restrained" option, or**
- **Select the "Position of Lateral Restraints" option, and then**

To add new restraint to the member

- **Position the cursor with the table and click the Insert button to add a lateral restraint to the member.**
- **Select the position of each restraint**
- **Select the type of each lateral restraint from the combo provided in each cell.**

or

- **Click the Generate button to automatically generate a number of restraints.**

To delete a restraint from the member

- **Position the cursor within the table on the lateral restraint to be deleted and click the Delete button.**

To define the unbraced length

- **Select the "Unbraced Length" option, and then**
- **Enter the unbraced length (L_b)**

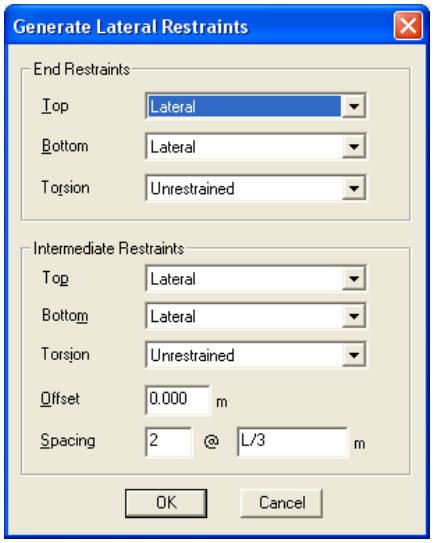
To define the stiffener spacing

- **If there are transverse stiffeners on the web, type in values for the stiffener spacing (a)**
- **Click OK**

Generate Lateral Restraints Dialog - Eurocode 3

When the user selects to generate the lateral restraints from the Bending dialog, the Generate Lateral Restraints dialog is displayed. This dialog enables the user to generate lateral restraints are a specified spacing along the member.

- **From the Bending dialog, click the Generate… button**



- **Select the type of restraints to be used at the ends of the member**
- **Select the type of restraints to be used at intermediate points within the member**
- **Enter the offset length at which the first intermediate restraint will be positioned. Leave this field as zero if no offset is same as the spacing**
- **Enter the number and size of spacing for the intermediate restraints.**
- **Click OK**

All lateral restraint applied to the member will now be regenerated and will replace all existing restraints.

Tension - Eurocode 3

The capacity of a member to resist tensile forces is implemented as a single design check. A number of modification factors may be entered to change the section properties used for checking tension. This includes the area of holes in the flange or web of the member and a shear lag factor to account for the distribution of forces at the ends of a member.

In addition to checking the tensile capacity of the member, a design constraint will be applied to the member enforcing the slenderness of the member to be less than 300.

Bolt Holes - Eurocode 3

When checking or designing a member for tension, you need to specify any reduction in area due to boltholes or other openings within the section. The net area of the section is the gross area minus the combined area of boltholes in the flange and web.

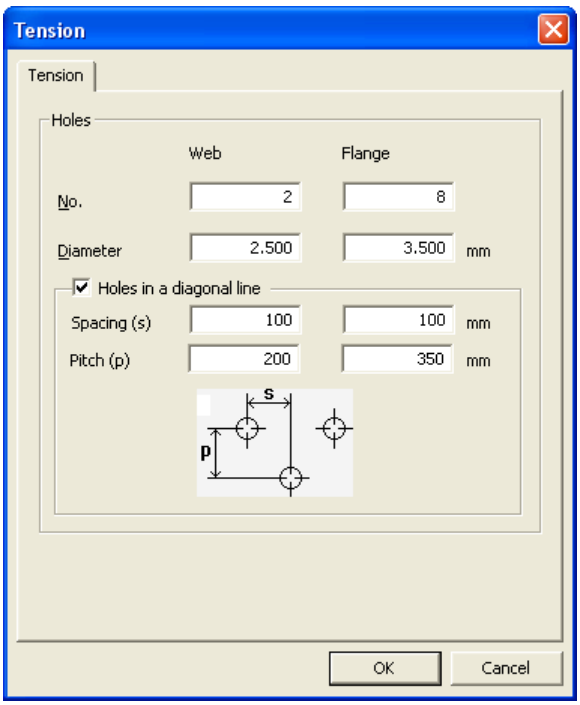
For a chain of holes extending in a diagonal or zigzag line, the net width of the section is obtained by deducting the sum of the diameters of all holes in the chain and adding for each gage space in the chain the quantity $s^2/4p$ where s is the longitudinal centre to centre *spacing* of any two consecutive holes and p is the transverse centre to centre *pitch* between fastener gage lines.

The reduction in area can be specified by setting the number, diameter, pitch and gage of holes in the web or flanges of the member.

Tension Dialog - Eurocode 3

To enter the properties for tension

- **Select the required members in the Frame window**
- **Choose Tension… from the Design menu**



- **Type in the number and diameter of holes in the webs and flanges**
- **If the the holes extend in a diagonal or zigzag line check the Holes in Diagonal Line box and enter the Spacing and Pitch of holes in the webs and flanges**
- **Click OK**

Compression - Eurocode 3

To determine the critical buckling load for a member, it is necessary to enter an effective length to indicate the type of restraint on the ends of the member. The effective length is given by an effective length factor multiplied by the length of the member. The effective length may be different for buckling in the major and minor axis directions. The effective lengths are given by

$L_{ey} = K_y L_{cy}$ and $L_{ez} = K_z L_{cz}$

where

L_{cy} and L_{cz} are the lengths of the member in x and y direction respectively,
K_y and K_z are the two effective length factors for the major and minor axes respectively.
The initial values of K_y and K_z are 1.0.

Unbraced Length - Eurocode 3

To determine the critical buckling condition of a member, it is also necessary to know the spacing of any bracing (if any) along the member. This bracing could be provided by purlins, girts or other structural elements which are not modelled in Multiframe. Some bracing may only restrain lateral deflection in one direction, therefore it is necessary to enter unbraced lengths for both axes of the section, L_{cy} corresponding to the spacing of restraints preventing compression buckling about the y-y axis and L_{cz} corresponding to the spacing of restraints preventing compression buckling about the z-z axis.

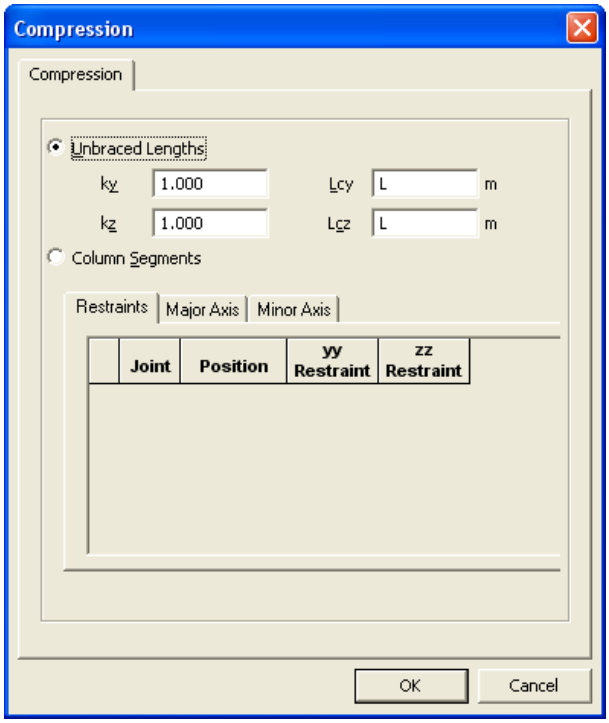
Compression Dialog – Eurocode 3

To set the properties for compression

- **Select the required members in the Frame window**
- **Choose Compression… from the Design menu**

If the unbraced lengths of the member are to be specified directly then

- **Select the Unbrace Length radio button.**



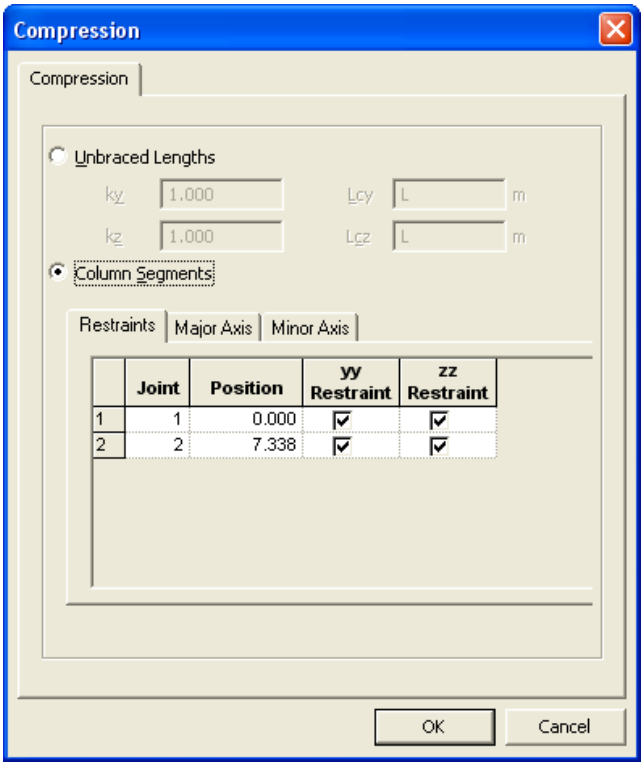
- **Type in values for ky and kz**
- **Type in values for Lcy and Lcz**
- **Click OK**

The initial values of L_{cy} and L_{cz} are the length of the member. The default values of k_y and k_z are 1.0.

Otherwise if the design for compression is to be performed using column segments.

- **Select the Column Segments radio button.**

The tabbed control in the dialog will become active. The first page in this table lists the location of joints along the members and indicates if they provide restraint against column bucking about either axis of the member.

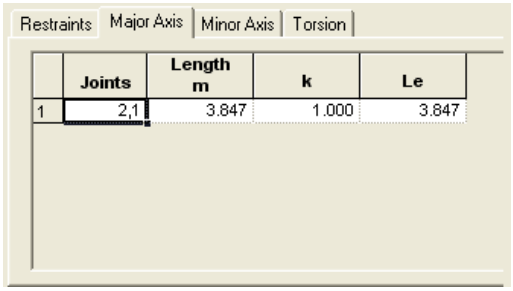


- **Enter the restraints associated with each node.**

The restraint information is used to build a list of column segments that span between the specified restraints.

- **Click on the Major Axis tab.**

This displays a table of column segments that will be used for the design of the member for compression when considering buckling about the major axis.



- **Enter the effective length factor (k) for each segment.**
- **Click on the Minor Axis tab and enter the effective length factors for the minor axis column segments.**
- **Click on the Torsion tab and enter the effective length factors for the calculation of torsional buckling resistance.**
- **Click OK**

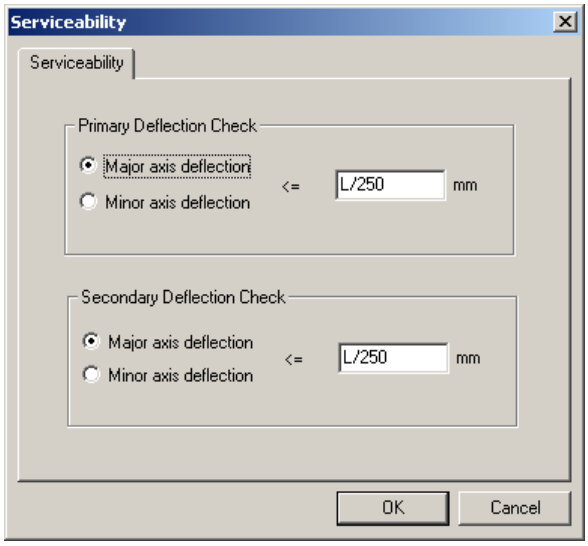
Serviceability - Eurocode 3

Steel Designer provides two design checks for the serviceability of a member. These design checks are used to check that the deflection of a member about either the major or minor axes does not exceed a specified deflection limit.

Serviceability Dialog - Eurocode 3

To set the design properties of a member for serviceability

- **Select the required members in the Frame window**
- **Choose Serviceability … from the Design menu**



- **For each deflection check, select the axis about which the deflection will be checked.**
- **Type in values for the deflection limits.**
- **Click OK**

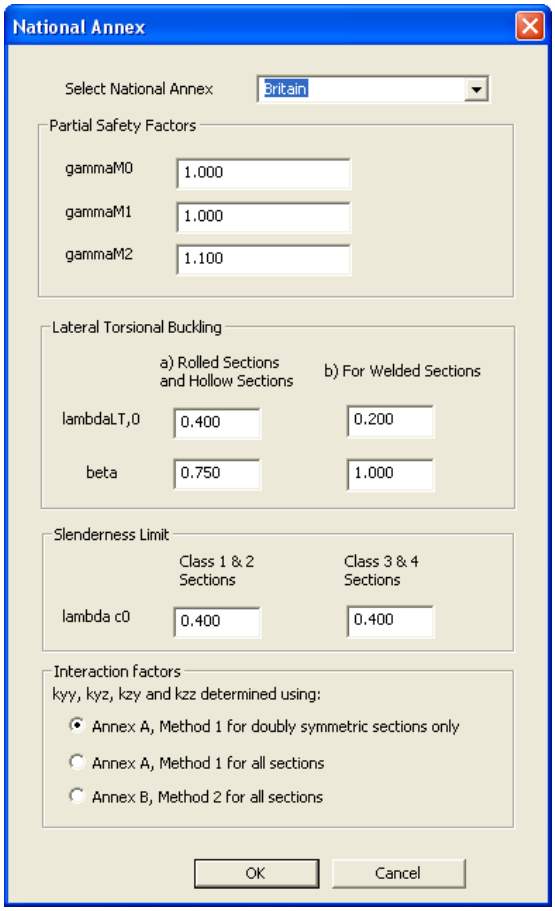
National Annex

Steel Designer allows the choice of National Annex within Eurocode 3. Default values for nations supported can be used or properties can be manually enetered.

National Annex Dialog – Eurocode 3

To set the National Annex properties for a model

- **Choose National Annex … from the Design menu (must have Eurocode 3 selected)**



- **From the Select National Annex drop down box choose the country you are working in. All other fields will be automatically populated. If your country is not available, choose Other**

- **If you have chosen Other or want to change any of the properties type in the desired values**

- **Click OK to save and use these selections**

Default Design Properties - Eurocode 3

There are a number of design variables, which are used when doing checking to the code. A summary of all of the design variables is as follows;

Variable	Description	Default
f_y	Yield strength of the section's steel	250Mpa
f_u	Ultimate Tensile Strength of the section's steel	410Mpa
k_y	Effective length factor for buckling about the section's strong axis	1.0
k_y	Effective length factor for buckling about the section's weak axis	1.0
L_{cy}	Unbraced length for bracing preventing buckling about the section's strong axis	Member's length
L_{cz}	Unbraced length for bracing preventing buckling about the section's weak axis	Member's length

Lateral restraints	The lateral restraints acting on the member.	Each end of the member is fully restrained at both flanges.
L_b	Unrestrained length of member for lateral torsional buckling.	Member's length
a	Spacing of web stiffeners. This is the spacing of any stiffeners along the web of a beam	0.0 (i.e. no stiffeners)
No. of Flange Holes	The number of holes in the flanges of the section.	0
Diameter of Flange Holes	Diameter of holes in the flanges of the section.	0.0
Staggered pitch of Flange Holes (s)	Spacing of fastener holes measured parallel to the member axis	0.0
Spacing of Flange Holes (p)	Transverse spacing of staggered holes in the flanges of the section	0.0
No. of Web Holes	The number of holes in the webs of the section.	0
Diameter of Web Holes	Diameter of holes in the webs of the section.	0.0
Staggered pitch of Web Holes (s)	Longitudinal spacing of staggered holes in the webs of the section	0.0
Spacing of Web Holes (p)	Transverse spacing of staggered holes in the webs of the section	0.0
Fabrication	The method by which the section was manufactured. This describes the residual stresses in the section.	Hot Rolled

It is not necessary to enter all of the above information for all members. Usually you will want to check some members for bending, others for compression and so on. The items under the Design menu help you enter just the required information depending on what type of check you are doing.

Code Clauses Checked – Eurocode 3

When carrying out code checks, Steel Designer uses the following clauses of the applicable codes to check your structure. No other checks are performed unless they are specifically listed below.

EN 1993-1-1:2005 "Eurocode 3: Design of Steel Structures – Part 1-1: General rules and rules for buildings", May 2005

The design checking procedure is as follows:

The net area of the section is computed by subtracting the area of holes in the section.

For each serviceability load case:

The maximum local displacement of the member is compared to the deflection limits specified deflection limits.

For each load case representing a strength limit state,

The design actions, or required strengths, of the member are determined as the maximum moment, shears and axial forces within the member.

For first order analyses, the design bending moments are amplified using the moment amplification factors. Only moment amplification of braced frames is considered which corresponds to the situation in which no moments result from the lateral translation of the frame. Amplification factors for sway frames are not considered and a second order analysis should be used for sway frames requiring moment amplification.

The plate elements of the section will be classified as Class 1, 2, 3 or 4 as per the requirements of Section 5.5.2 and Table 5.2. In Class 4 cross sections effective widths are calculated to make the necessary allowances reductions in resistance to the effects of local buckling.

For Tension checks, the capacity of the member is determined in accordance with Chapter 6.2.3. The smaller of the values for design plastic resistance without considering fastener holes and the ultimate resistance including fastener holes is used.

For Compression checks, the capacity of the member is firstly computed using the area of the cross section for Class 1, 2 or 3 cross-sections. For Class 4 cross-sections the effective area is used.

For Bending checks the provisions of Chapter 6.2.5is adhered to. Major and minor flexure checks are performed separately. For Class 1 and 2 cross-sections are designed to their elastic limit. Class 3 and 3 cross-sections to their plastic limit, with Class 4 cross-sections using a reduced effective Plastic Modulus. At present no allowance is made for fastener holes.

The design for Shear is carried out in accordance with Chapter 6.2.6. Major and minor shear checks are performed separately.

Where shear force is present is allowed for in the combined Bending and Shear check as described in Chapter 6.2.8.

The combined cases of Bending and Axial force and Bending, Shear and Axial force are checked as described in Chapter 6.2.9. The Shear check is only included if present.

Torsion is detailed in Chapter 6.2.7. The torsional strength is a combination of the uniform torsional section resistance and the biomoment section resistance as per “The Behaviour and Design of Steel Structures to EC3” by Trahair et al.

The buckling cases of Compression Buckling, Lateral Torsional Buckling and Bending and Compression buckling are checked in accordance with Chapter 6.3. The Bending and Compression buckling interaction factors are calculated by either Method 1, detailed in EN 1993-1-1 Annex A or Method 2, detailed in EN 1993-1-1 Annex B. The decision as to which method to use depends on which National Annex is used or can be manually selected.

Section Maker

Problem Reports

We greatly appreciate any bug reports or suggestions you may have. Please report any bugs or anomalies you find to:
Fax: +61 8 9335 1526
Email: support@formsys.com