STEEL BUILDINGS IN EUROPE

Multi-storey Steel Buildings
Part 9: Design software – Simple Connections

SUMMARY

This document describes the connection resistance calculator, created in Excel, for typical, nominally pinned joints used in braced steel frames. It explains the scope of the workbook and lists the National Annexes and languages that are supported in the workbook. A description is given of each of the worksheets and the input information on each sheet. A screenshot of typical output is presented.

1 INTRODUCTION

This document provides an introduction to the Excel workbook that covers the design of nominally pinned joints in accordance with EN 1993-1-8, as part of the design guide *Multi-storey steel buildings*. The workbook offers the alternative of different languages, and selection of National Annex values.

The operation of the workbook is described in Section 2. Screenshots of the various sheets in the workbook are contained in Section 3.

1.1 Visual Basic

The spreadsheet depends on extensive visual basic code. Some users may have security settings set to disable such code.

The security level can be changed by selecting: “Tools”, “Options”. Select the “Security” tab and select “Macro security”. The setting must be at least “Medium”. Usually, Excel must be closed and re-started for the changes in security levels to become effective.

1.2 Scope

1.2.1 Joint types

The workbook covers nominally pinned joints that are commonly used in multi-storey steel structures. The types of connections covered in separate worksheets within the workbook are:

- Partial depth flexible end plates (also known as header plates)
- Fin plates
- Double angle cleats
- Column splices (bearing type)
- Column bases.

For the beam connections, the resistance to both vertical shear and a horizontal tying force is calculated. The splice connections are all “bearing type”, meaning that there is no calculation of their resistance to axial compression. For splices, only the tensile resistance is calculated, for tying calculations. Only the resistance to axial compression is calculated for baseplates.

Each joint type is covered on a different worksheet. The default connection detail will be the recommended standardised detail.

Connection details are also drawn on each worksheet.

Connection resistances and drawn connection details are immediately updated as input data is modified by the user. The standardised details can be restored at any stage.

If warnings are displayed on the diagrams because of some geometrical check not being satisfied, the drawing will not update. An updated drawing will only appear once the geometric warning has been resolved. Resolving one warning may then reveal a second problem, which must again be resolved before the drawing will update.

A more detailed table of the resistance of each connection component can be viewed and printed.

Connection classification

Beam and baseplate connections are assumed to be nominally pinned connections. Although the connections possess some rotational stiffness and some rotational strength, these are assumed to be sufficiently small that their influence can be ignored, and the assumption of pinned behaviour is valid.

EN 1993-1-8 requires connections to be classified. Connection classification may be made on the basis of calculations, or based on previous satisfactory experience. For each connection covered by the spreadsheet, standardised connections are proposed, which have sufficient use in practice to justify classification as nominally pinned on the basis of previous satisfactory experience.

Within each connection type, the user may modify a large range of variables, and thus produce a non-standardised connection. ***Designers should note that if connections other than the standardised solutions are adopted, the connection should be classified in accordance with EN 1993-1-8.***

1.2.2 National Annex

The workbook includes National Annex values for γ_{M0}, γ_{M1}, γ_{M2} and γ_c for the following countries:

The National Annexes covered are:

- Belgium
- France
- Germany
- Italy
- Netherlands
- Poland
- Spain
- United Kingdom

For tying resistance, the spreadsheet adopts a value of $\gamma_{Mu} = 1.1$.

The user has the option to overwrite the in-built National Annex values, allowing flexibility should the values be modified by the national standards body.

1.2.3 Languages

The language for input and output may be set by the user. The following languages are supported:

- French
- German
- Italian
- Polish
- Spanish
- English

1.3 Design rules

The design resistance of each connection is evaluated in accordance with the Eurocodes and the guidance given in *Multi-storey steel buildings. Part 5 Joint design*.

2 OPERATION OF THE WORKBOOK

2.1 Introduction worksheet

The “introduction” sheet merely records the scope of the spreadsheet. On the initial loading of the workbook, this is the only worksheet tab visible. Choosing to “continue” reveals the remaining worksheet tabs.

2.2 Localisation worksheet

The “localisation” sheet allows the user to select the language for the workbook and the National Annex (which determines the Nationally Determined Parameters (NDPs) that are to be used in calculations)..

Checking the “overwrite” option allows the user to enter values of their choice. Deselecting this option leaves the National Annex selection as a blank – the user must select National Annex from the drop down menu.

Default settings of Language and National Annex may be saved. The values are written to a simple text file, stored in the same folder as the workbook file. Subsequent saving will merely overwrite this file.

Loading defaults will import whatever settings of language and National Annex that had previously been saved.

2.2.1 Material strength

The steel design strength is taken from Table 3.1 of EN 1993-1-1, or the product Standard, according to the choice in the National Annex.

Table 3.1 of EN 1993-1-1 covers material up to 80 mm thick. For thicknesses above 80 mm, the design strength is taken from the product Standard.

2.3 Input worksheet

2.3.1 Input information

Basic selection of section type, section, grade of main member, plates and bolts is made on the "Input" sheet. The options are described in the following Sections.

Section type

Section data is included for the following section types (profiles):

- IPE
- HE
- HL
- HD

Section

All the standard sections within each section type are available for selection from a drop-down menu.

Beam grade

The steel grade for the beams may be selected from the following:

- S235
- S275
- S355
- S460

Plate grade

The steel grade for end plates, fin plates, angle cleats and baseplates may be selected from the following:

- S235
- S275
- S355
- S460

Bolt class

The bolt class may be selected from the following:

- 4.6
- 5.6
- 8.8
- 10.9

Notes:

1. 8.8 bolts and S275 plates are considered standard. Connections may need to be classified in accordance with EN 1993-1-8 if other grades are selected.
2. The National Annex may restrict the choice of bolt class. Therefore the user has to choose a bolt class in accordance with national standards body.

User Information

The user may enter the following details:

- User name
- Project name
- Job number

Any data entered will appear on the printed output.

2.3.2 Operation

Selecting a different section, changing grade of beam or plate, or changing the bolt class triggers a re-calculation of the connection resistances.

In every case, a standardised connection is presented as the default.

If a very small section is selected, where the section is simply too shallow for a standardised end plate, fin plate, double angle cleat and splice connection, a warning appears, and only the baseplate tab remains visible.

The remaining tabs will appear once a sufficiently large member is selected.

2.4 Functionalities on the connections worksheets

Each of the worksheets for splice, fin plate, end plate, cleats and baseplate have two buttons – “Review Summary” and “Use Std detail”.

2.4.1 Review summary

This button opens a further sheet, containing fuller details of the resistances calculated for each component of the connection. From this new sheet, the summary may be printed, or the user may return to the main spreadsheet.

2.4.2 Use Std Detail

This button restores the standardised connection.

2.5 Splice worksheet

A standardised connection is presented, displaying values of tying resistance (axial tension). The critical design criterion is noted. The splices are “bearing type” transferring compression by direct bearing.

If the serial sizes are identical, a second splice option is displayed, with internal splice plates, and a second resistance is displayed.

Sections may be chosen for both top and bottom columns – they must however be the same section type.

The top section cannot be deeper (h) than the lower section. If an attempt is made to choose this configuration, the spreadsheet warns the user, and then adopts the latest section chosen for both top and bottom columns.

The top section cannot be significantly smaller than the bottom section. When the user attempts to choose a top section that is significantly smaller than the bottom section, a warning is displayed. The difference in section depths (h) must be less than 100 mm. The section may be drawn, but no resistance is displayed if the difference in section depth exceeds 100 mm. If the section depths are significantly different, several warnings may be displayed.

The following details of the standardised connection may be changed:

- Section type
- Section (top and bottom)
- Grade
- Plate grade
- Cover plate thickness
- Cover plate width
- Bolt diameter

- Number of bolt rows
- Gauge (horizontal bolt spacing)
- Pitch (vertical bolt spacing)
- End distance (end distance on plate, from top and bottom pair of bolts)

In some cases, the member flange is so thick that the standard offset distance is insufficient, and a standardised connection is not possible. A warning will appear with this information.

End, edge and geometrical distances are checked, and warnings appear as required.

2.6 Fin Plate worksheet

A standardised connection is presented, displaying values of vertical shear resistance and tying resistance. The critical design criterion is noted for both shear and tying.

The following details of the standardised connection may be changed:

- Plate thickness
- Bolt diameter
- Bolt rows
- Lines of bolts (a single or double line)
- Gauge (horizontal bolt spacing – only relevant if two columns of bolts are chosen)
- Pitch (vertical bolt spacing)
- End distance (end distance on plate, from top and bottom pair of bolts)
- Edge distance (on the fin plate)
- Beam end distance
- Plate offset (distance from top of beam to top of plate)

In some cases, the member flange is so thick that the standard offset distance is insufficient, and a standardised connection is not possible. A warning will appear with this information.

End, edge and geometrical distances are checked, and warnings appear as required.

The weld is sized to be full strength – no adjustment by the user is possible.

2.7 End Plate worksheet

A standardised connection is presented, displaying design values of vertical shear resistance and tying resistance. The critical design criterion is noted for both shear and tying.

The following details of the standardised connection may be changed:

- Plate thickness

- Bolt diameter
- Bolt rows
- Gauge (horizontal bolt spacing)
- Pitch (vertical bolt spacing)
- Plate width
- End distance (end distance on plate, from top and bottom pair of bolts)
- Offset (distance from top of beam to top of plate)

In some cases, the member flange is so thick that the standard offset distance is insufficient, and a standardised connection is not possible. A warning will appear with this information.

End, edge and geometrical distances are checked, and warnings appear as required.

The weld is sized to be full strength – no adjustment by the user is possible.

2.8 Cleats worksheet

A standardised connection is presented, displaying values of vertical shear resistance and tying resistance. The critical design criterion is noted for both shear and tying.

The following details of the standardised connection may be changed:

- Angle thickness
- Bolt diameter
- Bolt rows
- Leg length
- Back mark (bolt distance from heel of the angle)
- Lines of bolts (a single or double line)
- Gauge (horizontal bolt spacing – only if two columns of bolts are chosen)
- Pitch (vertical bolt spacing)
- End distance (end distance on plate, from top and bottom pair of bolts)
- Beam end distance
- Plate offset (distance from top of beam to top of plate)

In some cases, the member flange is so thick that the standard offset distance is insufficient, and a standardised connection is not possible. A warning will appear with this information.

End, edge and geometrical distances are checked, and warnings appear as required.

2.9 Baseplate worksheet

A standardised connection is presented, displaying the value of the axial resistance.

The calculation of the design bearing strength, f_{jd} assumes that α = 1,5. The foundation joint material coefficient, β_j is taken as 2/3.

The following details of the standardised connection may be changed:

- Grade of concrete
- Plate thickness
- Plate length
- Plate width
- Bolt diameter
- Gauge (horizontal bolt spacing)
- Pitch (vertical bolt spacing)

3 SCREENSHOTS

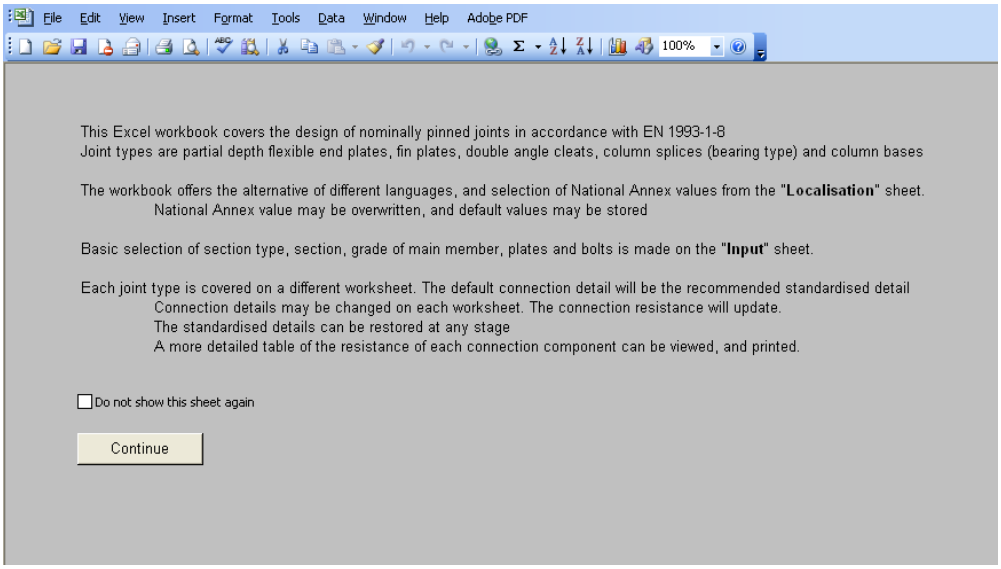

Figure 3.1 Introduction worksheet

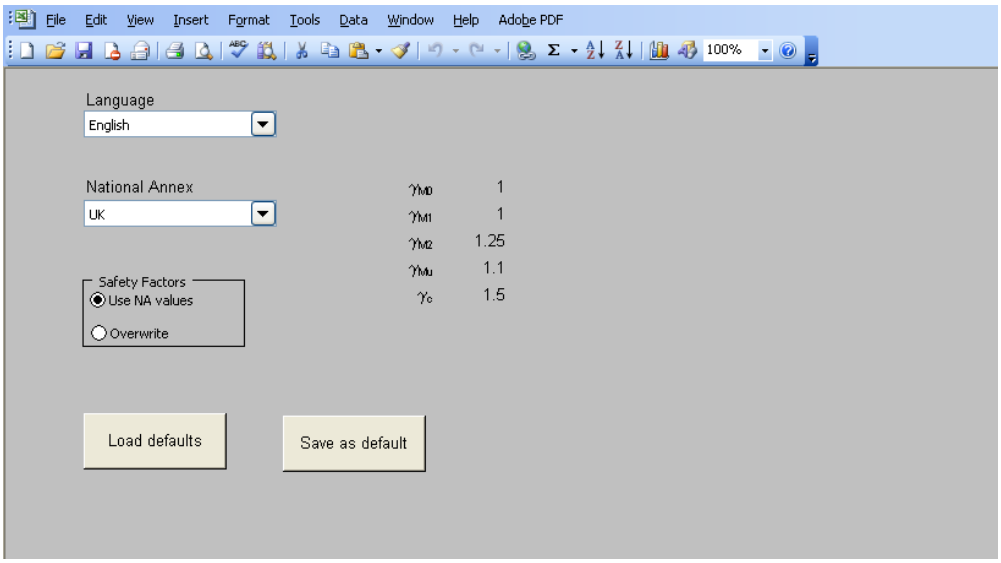

Figure 3.2 Localisation worksheet

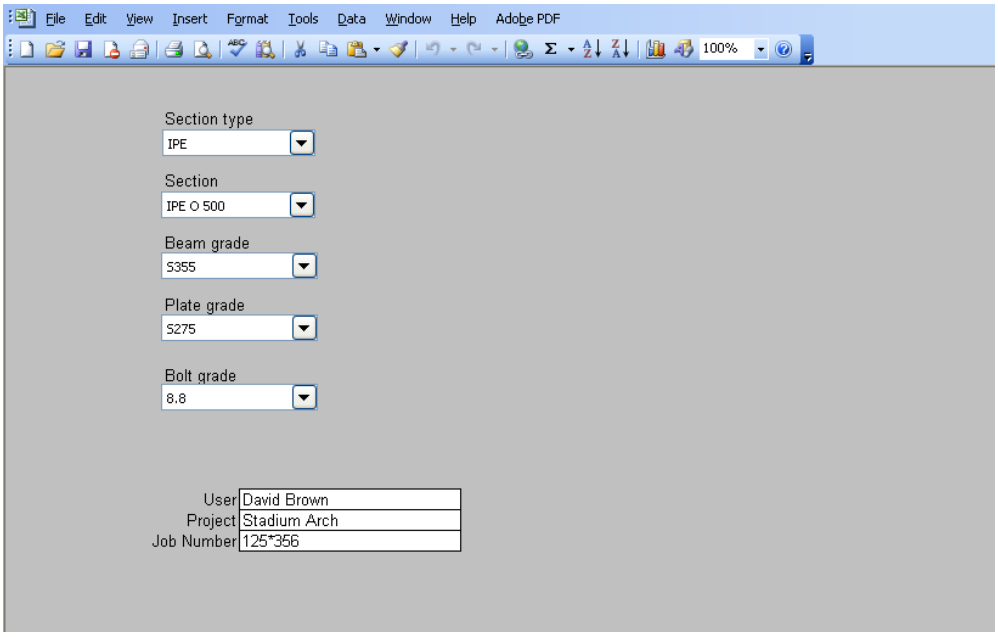

Figure 3.3 Input worksheet

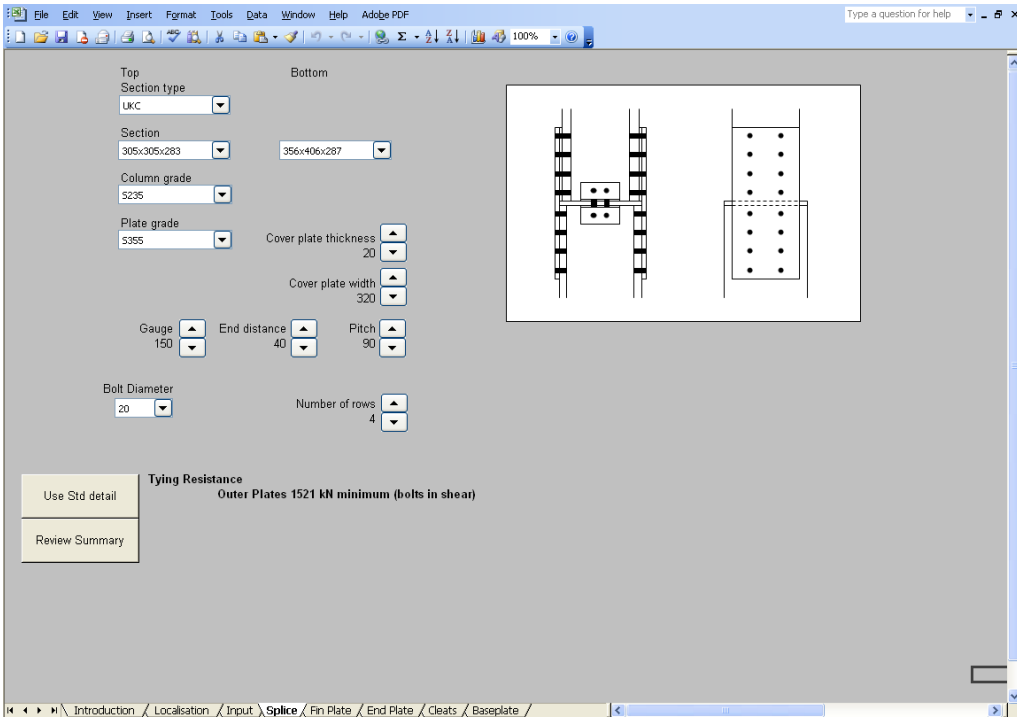

Figure 3.4 Splice worksheet

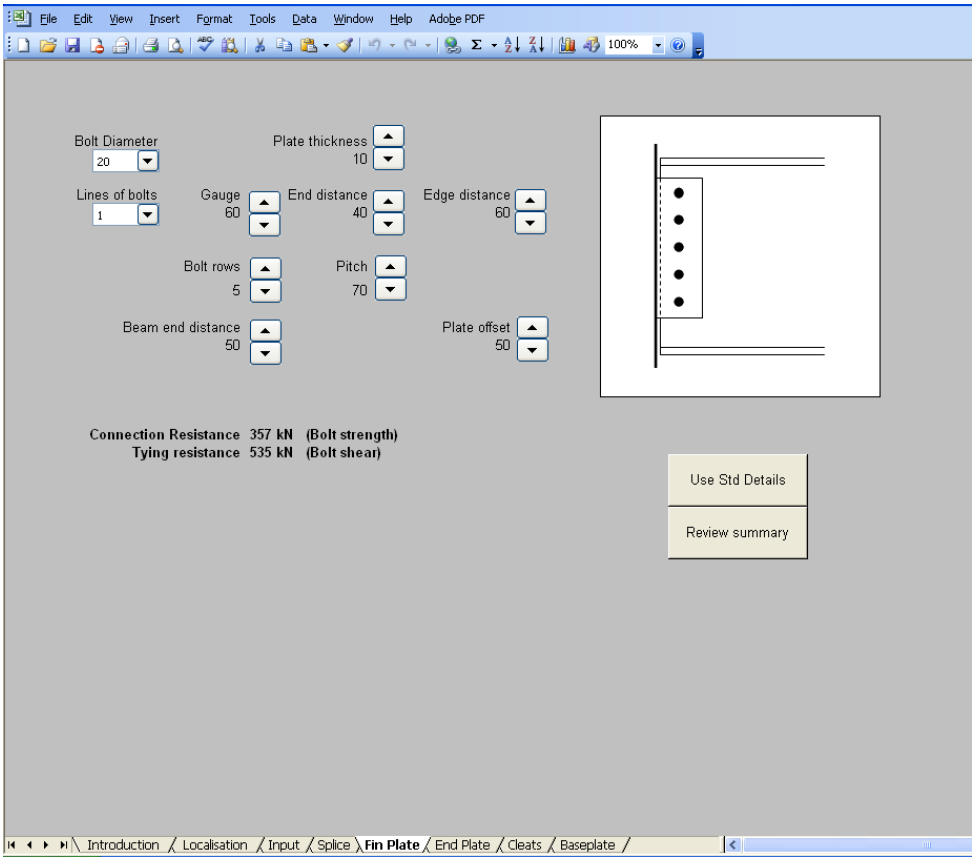

Figure 3.5 Fin plate worksheet

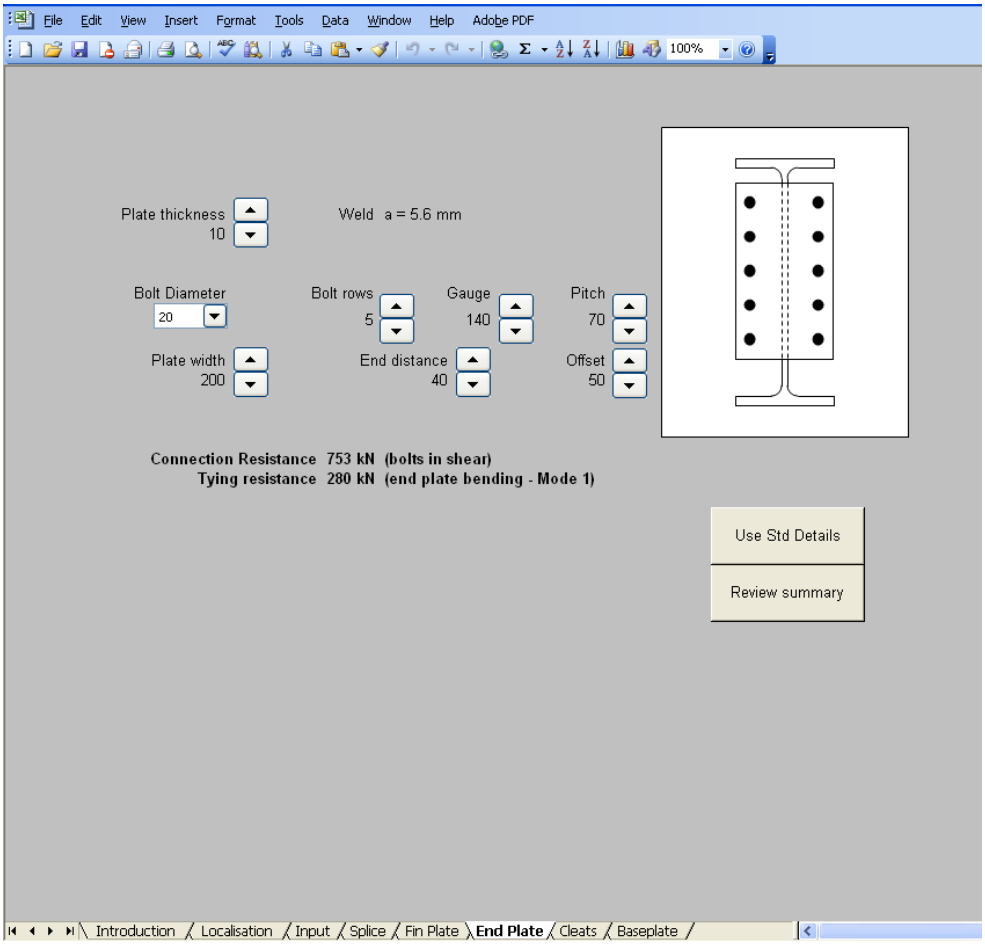

Figure 3.6 End plate worksheet

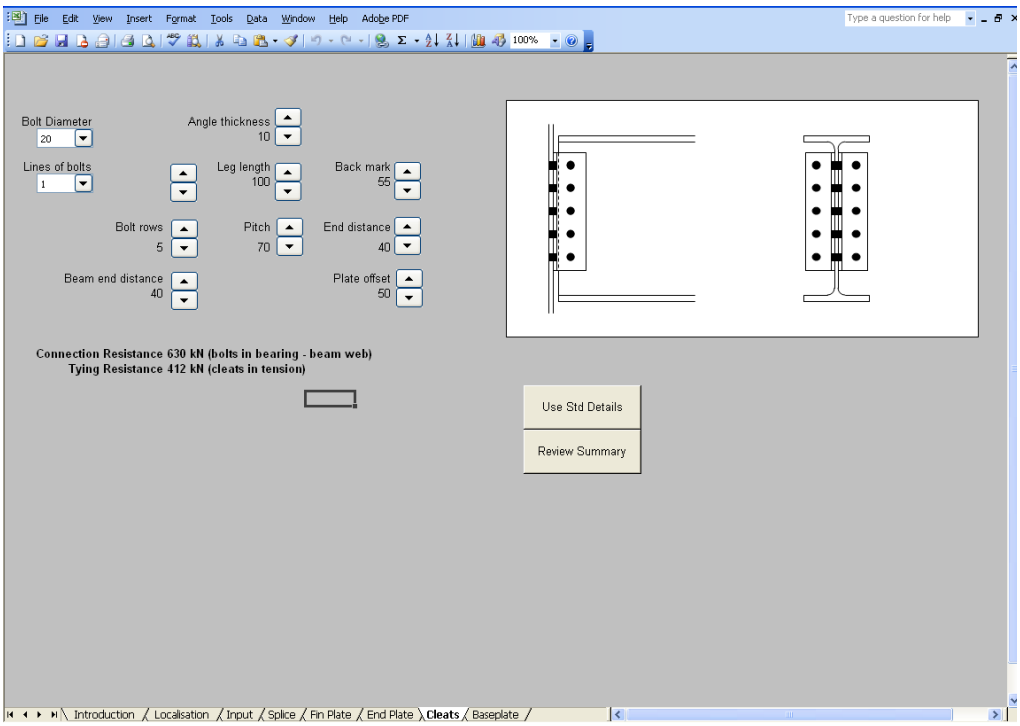

Figure 3.7 Cleats worksheet

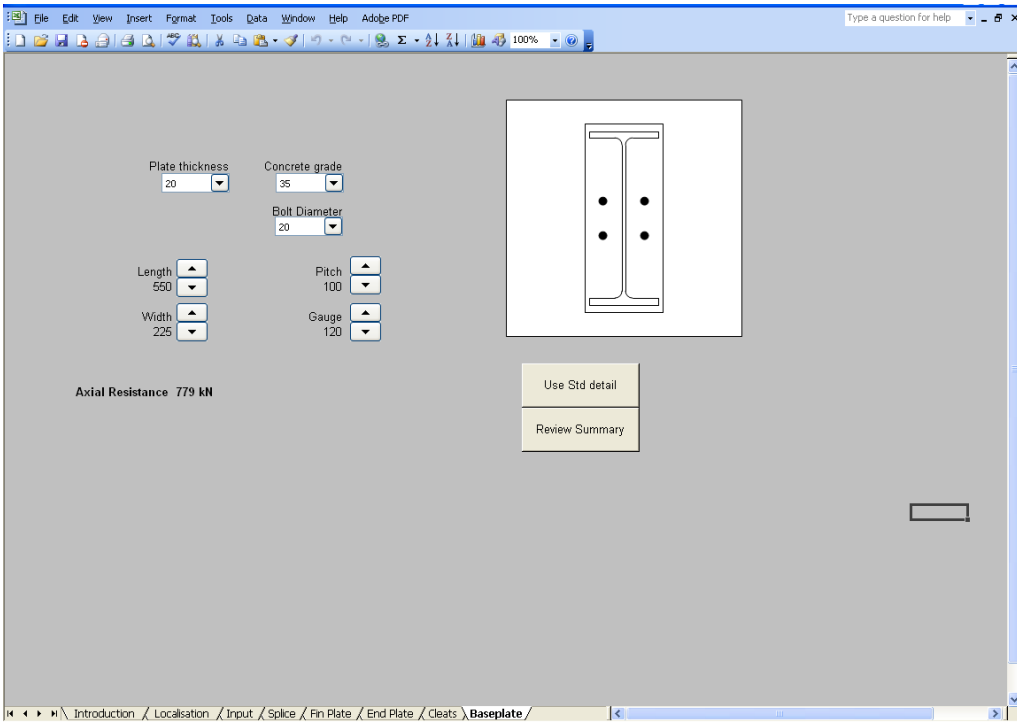

Figure 3.8 Baseplates worksheet

4 OUTPUT

The following worksheet will appear when clicking on “Review summary” on the end plate worksheet. From this new sheet, the summary may be printed, or the user may return to the main spreadsheet.

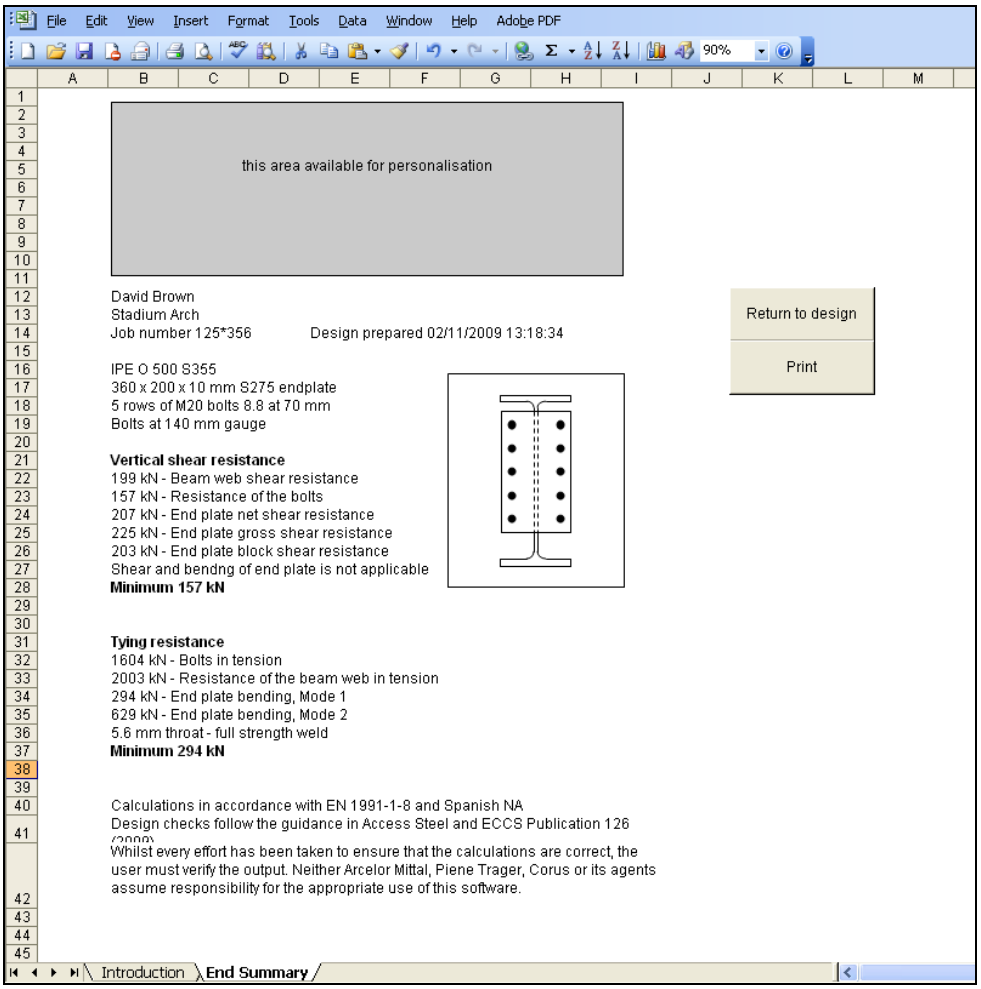

Figure 4.1 End summary worksheet