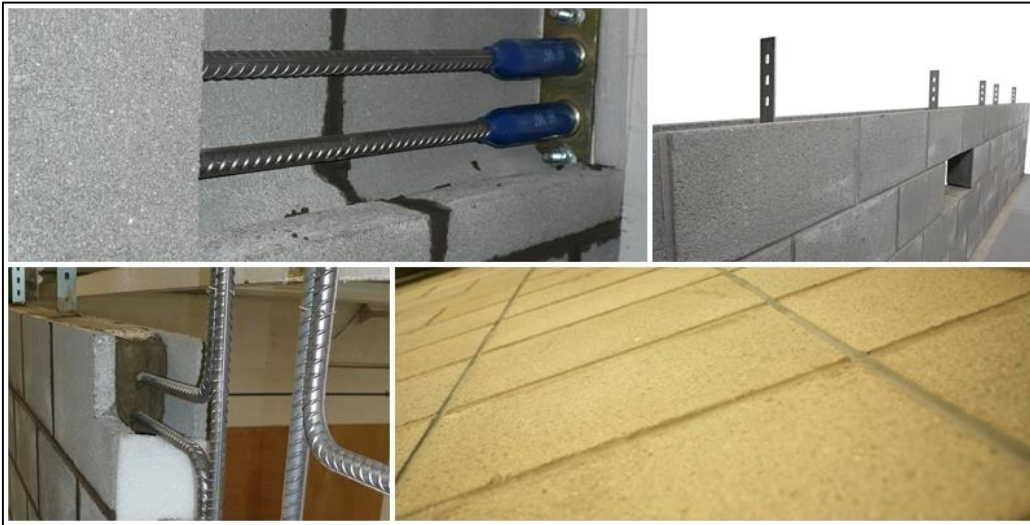




Wi SYSTEM



Wi COLUMN & Wi BEAM DESIGN PROGRAM MANUAL

12th March 2015

Rev v1.2

Wembley Innovation Ltd
38A Fourth Way
Wembley
Middlesex
HA9 0LH

T: 020 8903 4527 | E: office@wembleyinnovation.co.uk | W: www.wembleyinnovation.co.uk

WI SYSTEM DESIGN PROGRAM

The Program is a dedicated software analysis tool to accelerate the design of Wi Columns and Beams subject to lateral loading. As such, it relieves designers of tedious repetitive calculations that would otherwise need to be carried out by hand and other non-dedicated software analysis methods.

The basis of the design method is described within this Manual and the Lucideon (CERAM) report: *Design Guide for Masonry Reinforced by Bond Beams and Columns to Resist Lateral Loading*, September 2014, which can be downloaded from the Wembley Innovation website (click [here](#)).

Designers should satisfy themselves that the approaches given in the Lucideon Design Guide and this Manual are appropriate for their particular project, or case. The Program should be used by competent civil or structural engineers, experienced in masonry and structural design. Any queries should be referred to Wembley Innovation.

The Program was compiled by Damian Janicki of www.YourSpreadsheets.co.uk, in conjunction with Wembley Innovation. Accordingly, the Program is subject to copyright protection and no reverse-engineering, decompiling or disassembling is allowed. Please refer to additional notes and limitations within the "From Author" tab of the Program.

Prior to use of the Program, it is advised that the user checks that the most current version is being used. Please refer to www.YourSpreadsheets.co.uk, or www.wembleyinnovation.co.uk in this respect.

Users are encouraged to contact Wembley Innovation with any issues relating to the Program or any specific design queries regarding the Wi System.

User comments, confirmation of bugs and suggestions for improvement of the Program are welcomed.

Please refer enquiries to:

Eur Ing **Tony Sagoo** BSc (Hons) MBA CEng MICE
Head of Engineering

Wembley Innovation Ltd
38A Fourth Way
Wembley
Middlesex
HA9 0LH

T: 020 8903 4527 | E: office@wembleyinnovation.co.uk | W: www.wembleyinnovation.co.uk

TABLE OF CONTENTS

INTRODUCTION	4
Design Program	4
Masonry Infill Panels	4
Masonry Panel Supports	4
Wi System – Wi Columns and Wi Beams	5
Loading	5
DESIGN PROCEDURE	6
Infill Panel Design	6
Wi System Design Program	6
Wi Column & Wi Beam Design Process – Data Entry	7-9
Construction Inputs	10-11
Loading	11
Results	11-12
Iterative Design	12
Designer's Notes	12
Additional Checks	13
Scope of Program	13-14
Wi COLUMN & BEAM PATENTS	15
APPENDIX	16
DESIGN EXAMPLES	
EXAMPLE 1 – Single 140mm Wi Column & Standard Approach	17-18
EXAMPLE 2 – Single 140mm Wi Column & Conservative Approach	19-20
EXAMPLE 3 – Single 140mm Wi Column & Standard Approach with Free Edge	21-22
EXAMPLE 4 – Single 140mm Wi Column & Standard Approach with Free Edge Load	23-24
EXAMPLE 5 – Single 190mm Wi Column & Standard Approach + Barrier loads	25-26
EXAMPLE 6 – Double 190mm Wi Column & Standard Approach + Barrier loads	27-29
EXAMPLE 7 – 140mm Wi Beam & Standard Approach	30-31
EXAMPLE 8 – 140mm Wi Beam & Standard Approach, with Free Edge (eg Ring Beam)	32-33
EXAMPLE 9 – 140mm Wi Beam & Standard Approach, with Barrier & Free Edge Loads (eg Barrier Beam + Cladding load)	34-35

INTRODUCTION

Design Program

This Manual relates to the Wi System Design Program, issued by Wembley Innovation. The Program aids the design and justification of Wi Columns and Wi Beams subject to lateral wind/pressure loading, handrail line loading and UDL barrier loading.

The maximum design bending moments are taken from the Lucideon publication: *Design Guide for Masonry Reinforced by Bond Beams and Columns to Resist Lateral Loading, September 2014*, which refers to BS EN 1996-1-1 (EC6), including the 2013 amendments.

The Lucideon Design Guide was based on an extensive series of full-scale lateral load tests on blockwork wall panels carried out between 2006 and 2013. Copies of the test reports can be obtained by contacting Wembley Innovation.

Masonry Infill Panels

This design method relates to *infill* blockwork panels, which by definition are “non-structural” – the panels will be internal non-loadbearing partitions, or external cladding panels, where the panel and panel support loads are transferred to and supported by the primary structural frame. As the infill panels are invariably built off floor slabs, they will need structural support provision to their ends, intermediate locations and/or their heads. This means that the panels will require support offered by one of the following cases:

- the base, the head and both sides (4 sided support)
- the base and both ends (3 sided support)
- the base and head (2 sided support)
- the base and one end (2 sided support)

Masonry Panel Supports

Structural support to the sides of the panel can be provided by return walls, so long as they are sufficiently tied to the panel in question and are long enough to act as an adequate buttress. The return wall itself must of course be stable and able to resist the design lateral loads.

Alternatively, the end, or intermediate support is commonly achieved by the installation of “windposts”, which are usually steelwork, but can be of reinforced concrete. Steel windposts may be proprietary items or traditional structural steel sections such as universal beams, universal columns, channels and rolled hollow sections. Concrete windposts are less common due to the impracticalities and costs of pre-casting, or insitu casting. However, they may be utilised where the frame is of reinforced concrete and secondary windposts can be cast insitu as part of the main structural works.

Wi System – Wi Columns and Wi Beams

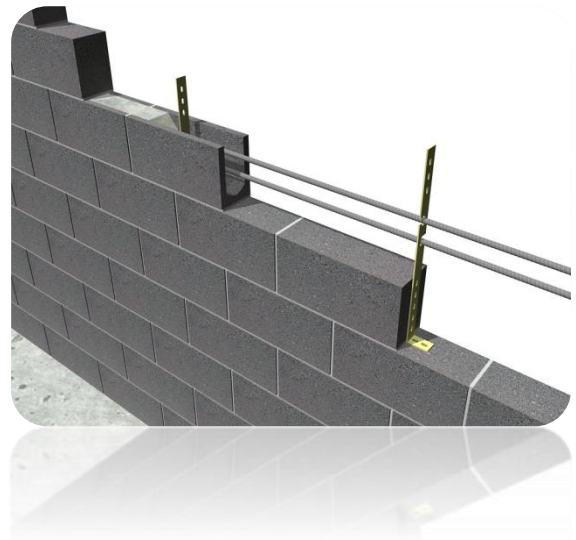
The design information outlined below relates to the use of Wi Columns, or Wi Beams as structural elements which provide support of laterally loaded masonry panels in-lieu of traditional windposts.



Wi Columns are direct replacements for windposts – they are vertically reinforced concrete columns that are formed within hollow concrete blocks which exactly match the aesthetic appearance of the adjoining blockwork panel construction when used in conjunction with the Wi Slot Block. The Wi Columns provide structural support to the end and/or intermediate locations of the masonry panels, which can be further enhanced through support to the head of the panel using restraint ties. Using this technique, the masonry panel is usually designed as “two-way spanning”.



Wi Beams are adopted when it is more effective, or practical to span the support element horizontally and to have the masonry panel(s) spanning vertically. Wi Beams utilise trough blocks to form horizontally reinforced concrete beams integrally within the panels, which also match the surrounding standard blockwork construction.



Loading

The most common lateral loads acting on internal masonry panels will generally be internal wind pressure, resulting from the effects of the wind loads filtering through “dominant” openings. However, in some instances, internal partitions may have to be checked against the full wind loads, for “temporary” condition cases. This could apply for loads acting during the construction phase where partitions may not be protected from exposure to the building wind loads, say if the perimeter cladding is not in place whilst the partitions are being built.

Clearly, external-facing cladding panels will be subject to the wind loads and will also need to be checked to withstand higher localised “zone” pressures.

Exceptional, or project-specific lateral loads may also need to be assessed, such as blast loads, impact loads, crowd loads, plenum pressure loads and the like.

DESIGN PROCEDURE


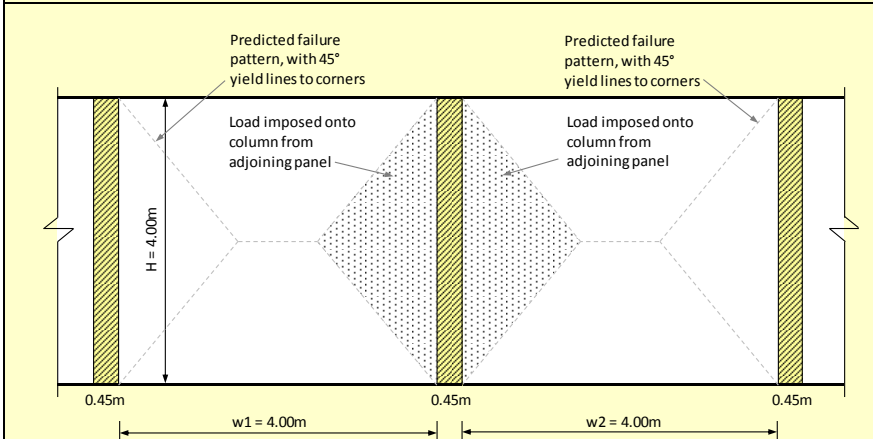
Infill Panel Design

The design of infill panels is outside the scope of this Manual. It is anticipated that a software program such as CADS Wall Panel Designer, Masterkey Masonry Design and TEDDS etc will be used to design the infill panels, to obtain the design span lengths of the panels acting on the Wi Column, or Beam.

Experienced designers will appreciate that the most efficient overall design for the panels and supports will involve an iterative process to derive the most appropriate infill panel length, which equates to the support centres.

Wi System Design Program

The Program is an Excel spreadsheet and an extract is shown below. The locations highlighted in blue text are inputs or toggle selections made by the user. Each entry is described below.

 Wembley Innovation Ltd 38A Fourth Way, Wembley, Middlesex, HA9 0LH office@wembleyinnovation.co.uk Tel: 0208 903 4527		Job No: Revision: Prepared By: TS Page: Checked By: Date:	
Wall Ref.:			
GENERAL DATA Element type: Wi Column Design approach: Standard		SUMMARY OF RESULTS Wi Column utilisation ratio = 0.26 ...ADOPT: 140mm thk Wembley Innovation Wi Column	
ELEMENT ARRANGEMENT Wi Column width: Single Left side construction type: Standard Right side construction type: Standard Wall thickness 't' [mm] = 140 Panel height 'H' [m] = 4.00 Distance to left column's face 'w ₁ ' [m] = 4.00 Distance to right column's face 'w ₂ ' [m] = 4.00		DESIGNER'S NOTES Wi System to be constructed in accordance with manufacturer's specification. Colour coding not required colour coding	
UNFACTORED LOADING Lateral wind load 'W _k ' [kN/m ²] = 0.50 Barrier distributed load 'W _{b,UDL} ' [kN/m ²] = 0.00 Barrier line load 'W _{b,line} ' [kN/m] = 0.00 Barrier height 'h _b ' [m] = 0.00 Partial load factor for wind load 'γ _f ' = 1.50 Partial load factor for barrier load 'γ _f ' = 1.50 Partial material factor 'γ _M ' = 2.00		CALCULATIONS Unfactored moment: wind load [kNm] = 3.12 Unfactored moment: barrier distributed [kNm] = 0.00 Unfactored moment: barrier line load [kNm] = 0.00 Total applied unfactored moment 'M _{Ed} ' [kNm] = 3.12 Total applied factored moment 'M _{Ed} ' [kNm] = 4.68 Moment of resistance 'M _{Rd} ' [kNm] = 18.00 ...ADOPT: 140mm thk Wembley Innovation Wi Column	
DIAGRAM			
			

Wi Column & Wi Beam Design Process – Data Entry

GENERAL DATA	
Element type:	Wi Column
Design approach:	Standard

Element type – Wi Column or Wi Beam

The first selection is to toggle for design of either a Wi Column, or a Wi Beam, adjacent to “Element type”.

Design approach – Standard or Conservative

The Program utilises *Yield-line Theory* to calculate the resultant reaction loading from the adjacent panel(s). Such an approach is well accepted in masonry design and indeed forms the basis of design codes and standards and therefore software design programs. Essentially, yield-lines are predicted failure mechanisms and in the simplest form, the lines extend outwards at 45° from corners until they meet another yield line, or panel edge. The combination of the yield lines for a case creates the predicted failure mechanism – in a four-sided panel, such a pattern of yield-lines is often referred to as a *back-of-envelope* failure (Refer to Figure 1).

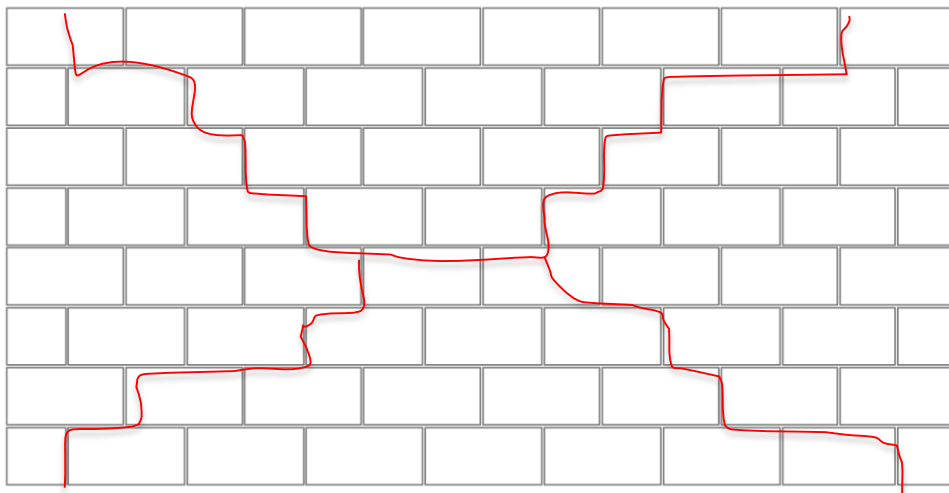


Figure 1 – “Back-of-envelope” infill panel failure pattern

There are two approaches available within the Program to assess the nature of loading acting on a Wi Column, or Wi Beam: “Standard”, or “Conservative”.

The recommended Standard method utilises the full benefits of the yield-line theory, where loads applied to the Wi Column, or Beam are either triangular or trapezoidal in area, depending on the height/span ratio.

Figure 2 shows triangular loading acting on the Wi Column, as the height of the column is equal to, or less than half the horizontal support span/spacing.

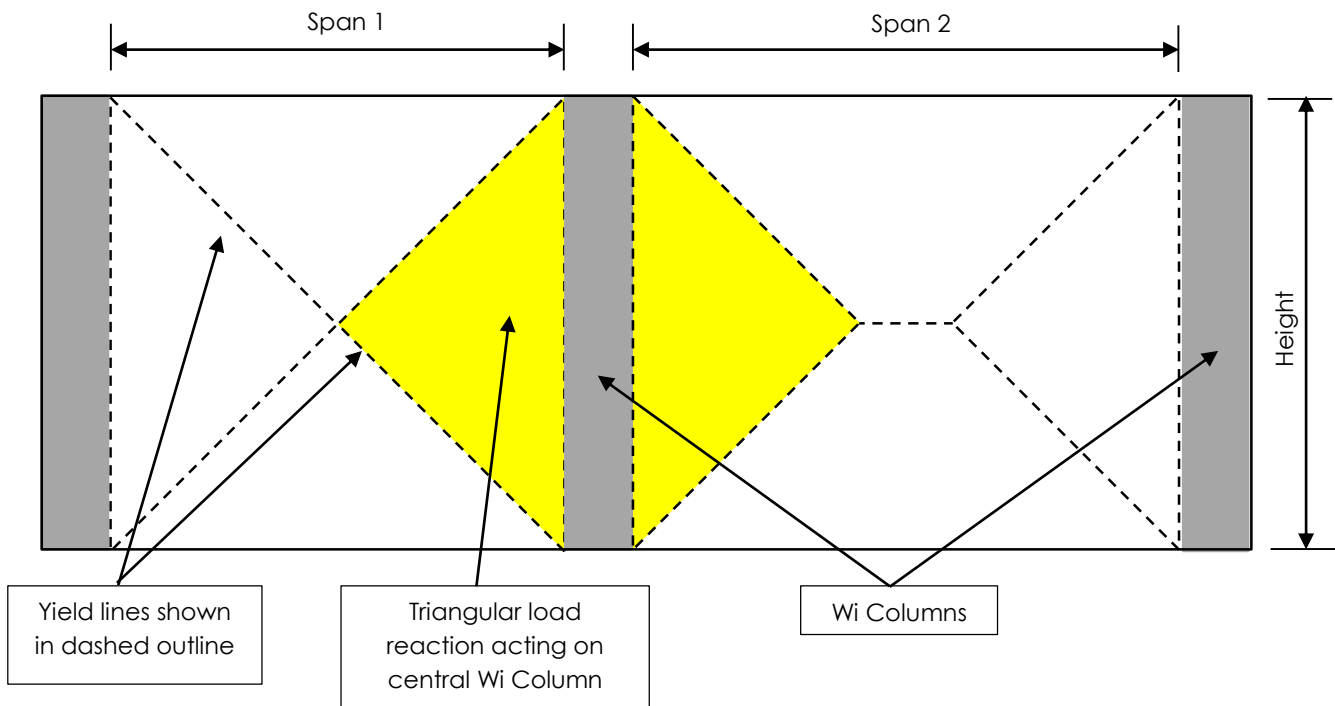


Figure 2 – “Standard” Load acting on a Wi Column for $H \leq \text{Span}/2$

Once the horizontal support spacing exceeds the height, the load acting on the Wi Column, remains the same, as any additional loading is dispersed to towards the top and bottom supports, as the associated trapezoidal area increases, whilst the triangular areas remain unchanged.

Figure 3 shows the case where the height is equal to, or greater than half the span/support spacing. In this case, the loading acting on the Wi Column, is trapezoidal in area.

For the “Conservative” approach, yield-line load dispersion is ignored and effectively, rectangular loading is applied, as in Figure 4. Whilst such an approach is unrealistic and overly conservative, it may serve a purpose for non-standard cases, or as an extra safe-guard if precise loading is unknown or is difficult to assess with confidence.

The description above relates to Wi Columns; however, the principle applies equally to Wi Beams. The only difference is that the “Standard” approach is the only option, as the Wi Beam span is likely to generally exceed the overall height of the panel i.e. the “Conservative” approach is the same as the Standard.

The load acting on the area of the Wi Column (or Wi Beam) is also taken into account by the Program in the calculation of the bending moments.

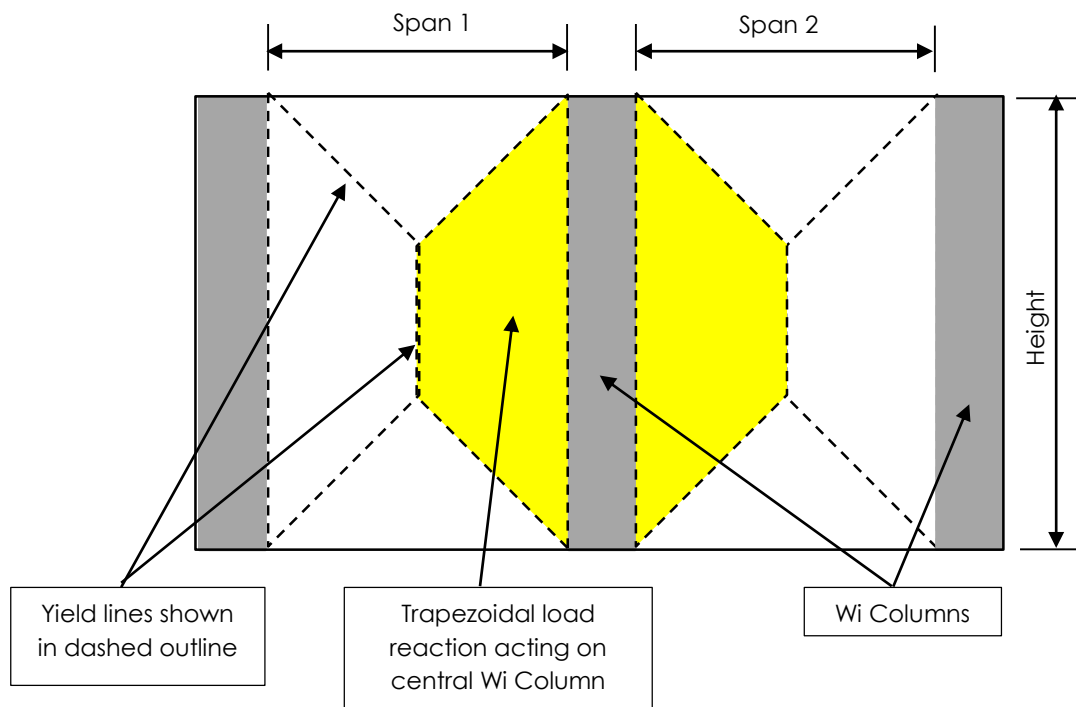


Figure 3 – “Standard” Load acting on a Wi Column for $H \geq \text{Span}/2$

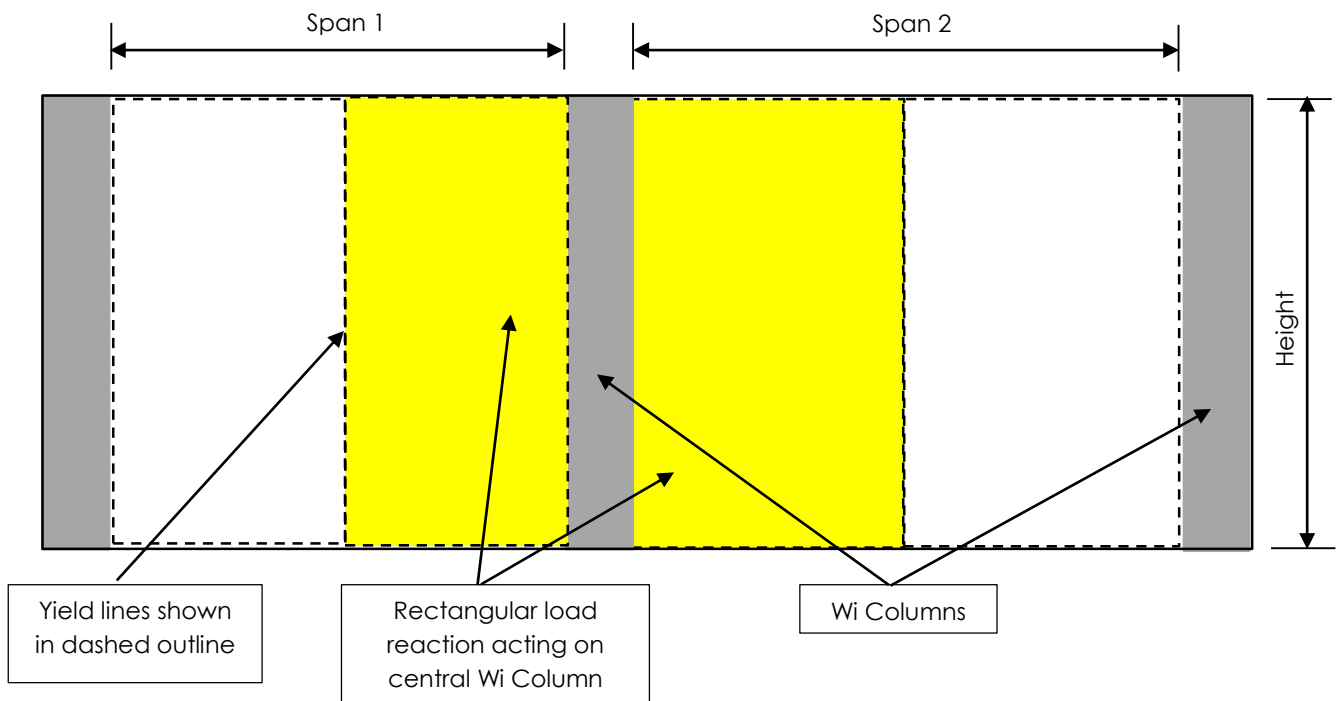


Figure 4 – “Conservative” loading acting on a Wi Column

Construction Inputs

These entries relate to the basic sizing and nature of construction of the panel and Wi Beam or Wi Column.

ELEMENT ARRANGEMENT	
Wi Column width:	Single
Left side construction type:	Standard
Right side construction type:	Standard
Wall thickness 't' [mm] =	140
Panel height 'H' [m] =	5.00
Distance to left column's face 'w ₁ ' [m] =	5.00
Distance to right column's face 'w ₂ ' [m] =	5.00

Wi Column width or Wi Beam height

This function allows the use of single, or doubled, Wi Columns or Beams. Whilst the majority of cases will only require single elements, there may be occasions where exceptional loads may require the adoption of doubled elements.

Construction type

Differing construction can be entered for the panels adjoining the Wi Column or Wi Beam either side. The default will be for "Standard", which represents a normal infill panel. However, a "Free edge" such as the end of a wall can be selected, or a "Loaded free edge" such as a door opening, or cladding/glazing that is fixed the element can be chosen. Different construction type can be entered either side (left or right and top and bottom, for Wi Columns or Wi Beams respectively).

Wall thickness

As it suggests, this entry selects the desired wall thickness from 140, 190 and 215mm (140 and 190 for Wi Beams).

Panel Height/Length

Depending on whether a column or beam is selected, the panel "Height", or "Length" is entered here. The maximum Wi Column height should be restricted to 7.0m, to accord with test data and experience. Wi Beams have been designed and built to 12m, but due attention to the panel blockwork is required to account for potential shrinkage and movement effects. The use of bedjoint reinforcement is recommended for panel lengths over 6.0m for traditional concrete blocks, or 7.5m for Wi Slot blocks.

Distance to Column face/support face

This selection requires the entry of the distance between the faces of the Wi Columns, or support (e.g. primary structural column), not the centre-to-centre dimension.

The width of a Wi Column can be taken as a standard format block + a perpend i.e. 450mm.

Similarly, for Wi Beams, this entry will be the distance between the faces of other Wi Beams, or the bottom slab/top edge support. The depth of a Wi Beam is a standard format block + mortar bed (course height) of 225mm

Loading

UNFACTORED LOADING	
Lateral wind load ' W_k ' [kN/m^2] =	0.50
Barrier distributed load ' W_{b_UDL} ' [kN/m^2] =	0.00
Barrier line load ' W_{b_line} ' [kN/m] =	0.00
Barrier height ' h_b ' [m] =	0.00
Partial load factor for wind load ' γ_f ' =	1.50
Partial load factor for barrier load ' γ_f ' =	1.50
Partial material factor ' γ_M ' =	2.00

The first entry is simply for the lateral Wind load, or acting pressure, followed by a UDL Barrier load and then the option for a Handrail line load. The barrier height can then be entered, if relevant. Then the *Partial Load Factors* for the wind load and the barrier load can be entered independently.

Please note that in our experience, the Barrier load tends to be the dominant case for the design of a panel. We would therefore suggest that the panel be checked first, if subjected to barrier loading to ensure that it is satisfactory, in order to avoid abortive design of the Wi Column.

The partial factor for materials is defaulted to 2.00, in-line with the 2013 revision to the National Annex of BS EN 1996-1-1, for Class 1 execution control. For Class 2, the value can be changed to the next toggle option of 2.4. There is also the ability to enter any alternative material factor by overwriting in the cell and a warning note is then displayed stating "Note: non-standard partial material factor used".

Results

CALCULATIONS	
Unfactored moment: wind load [kNm] =	5.91
Unfactored moment: barrier distributed [kNm] =	0.00
Unfactored moment: barrier line load [kNm] =	0.00
Total applied unfactored moment ' M_{Ek} ' [kNm] =	5.91
Total applied factored moment ' M_{Ed} ' [kNm] =	8.87
Moment of resistance ' M_{Rd} ' [kNm] =	18.00
...ADOPT: 140mm thk Wembley Innovation Wi Column	

The design calculations are shown in a box to the right-hand half of the page, adjacent to the load entry box. The unfactored results for the wind load, barrier UDL and the handrail line load are shown, along with total unfactored and total factored moments. Lastly, the moment of resistance for the element is shown, followed by the determined element and its size – this should accord with the size of the wall that was

entered by the user, unless the moment of resistance is insufficient and the next size of element has been selected automatically by the Program.

If the width of the wall cannot be changed due to project constraints, another iteration will be required where the support spacing (or other inputs) have to be reduced/amended to achieve a total applied factored moment that is less than the moment of resistance.

SUMMARY OF RESULTS	
Wi Column utilisation ratio =	0.49
...ADOPT: 140mm thk Wembley Innovation Wi Column	

The results are confirmed in the "Summary of Results" box, located above the "Designer's notes" box. The utilisation ratio is given, showing the efficiency of the design and the required section size is confirmed in bold.

Iterative Design

As mentioned above, design of the infill panels and the Wi Column or Wi Beam supports is an iterative process. Some designers will "choose" to trial the infill panel length and check the Wi Column first. If this is satisfactory, then the infill panel is checked – if the panel design is overly conservative, then the span can be increased and the Wi Column re-checked for this longer span. This process can be repeated until an acceptable balance of efficiencies is achieved for the panel and support element.

Clearly, the reverse approach can be taken, where the panel is checked first at a reasonable level of efficiency and then the Wi Column justified accordingly – if the support element "fails", then the panel span may need to be reduced, if other factors cannot assist in justifying the support element, such as doubling-up.

Designer's Notes

This box allows notes to be added to describe the load case, or any particular requirements. At the bottom of the box, there is an option to colour-code the design case with a choice of 10 colours and add an associated note.

DESIGNER'S NOTES	
Wi System to be constructed in accordance with manufacturer's specification.	
Typical general case for Wall Panel A	
Loading = 0.5kN/msq	colour coding

Additional Checks

The maximum design bending moment values for the Wi Columns and Wi Beams given in the Design Guide and Table 1 below, have been determined so that no additional shear or deflection checks are necessary. Deflection limits are in excess of span/360 (in the order of span/500, from testing).

It is recommended that a shear capacity check for the adequacy of the wall ties between the Wi Column and the adjoining panels is undertaken as part of the infill panel designs. This may be included within the panel design software (as for CADS Wall Panel Designer). If not, then a manual calculation should be carried out to determine the vertical spacing of the ties which should be the equivalent of Ancon SPS (bonded) and PPS (debonded) ties. In the Lucideon tests, ties at 450mm vertical centres to the Wi Columns and 900mm centres to the panel head were found to be satisfactory for the determined moments of resistance.

Scope of Program

This Manual and the design examples outline the scope of the Program, which should cover the majority of typical cases. Other “non-standard” cases will may need to be assessed, which will require engineering judgement by the designer, who should be experienced in such design.

The most common case currently outside the scope of the Program is when a Wi Beam connects to a Wi Column as below:

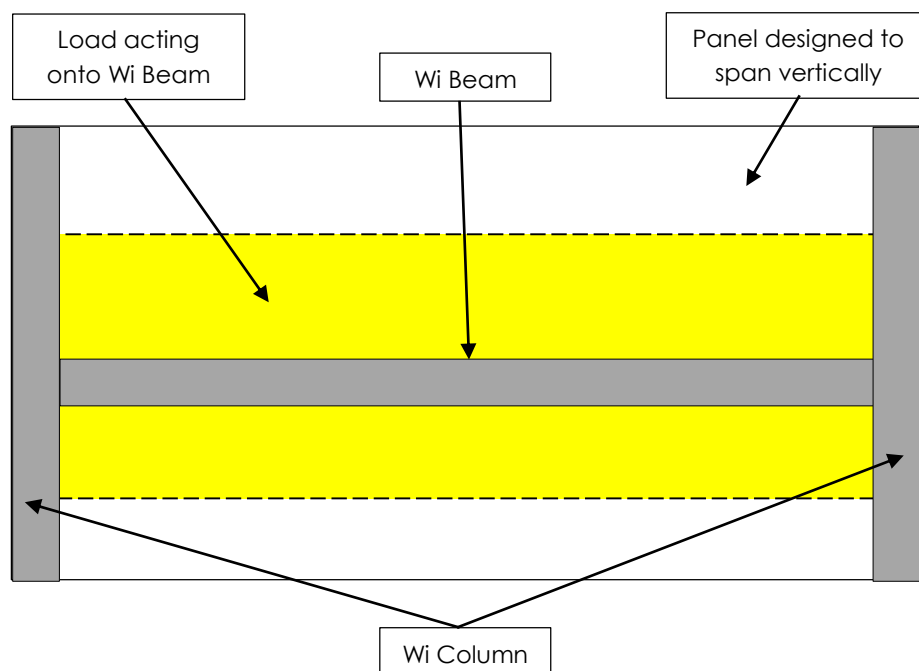


Figure 5 – Wi Beam to Wi Column Example

Figure 5 above shows a Wi Beam supporting panels above and below, which are designed to span vertically. The Wi Beam is supported by Wi Columns at either end. The unfactored point-load reaction from the Wi Beam can then be read from the "Calculations" box, to calculate (by hand, or other program) the maximum applied bending moment acting on the Wi Column (Figure 6). This can then be compared with the appropriate Moment of Resistance for the Wi Column to check if the case is acceptable. If not, then the span of the Wi Beam (i.e. the spacing of the Wi Columns) can be reduced, or double Wi Columns could be adopted.

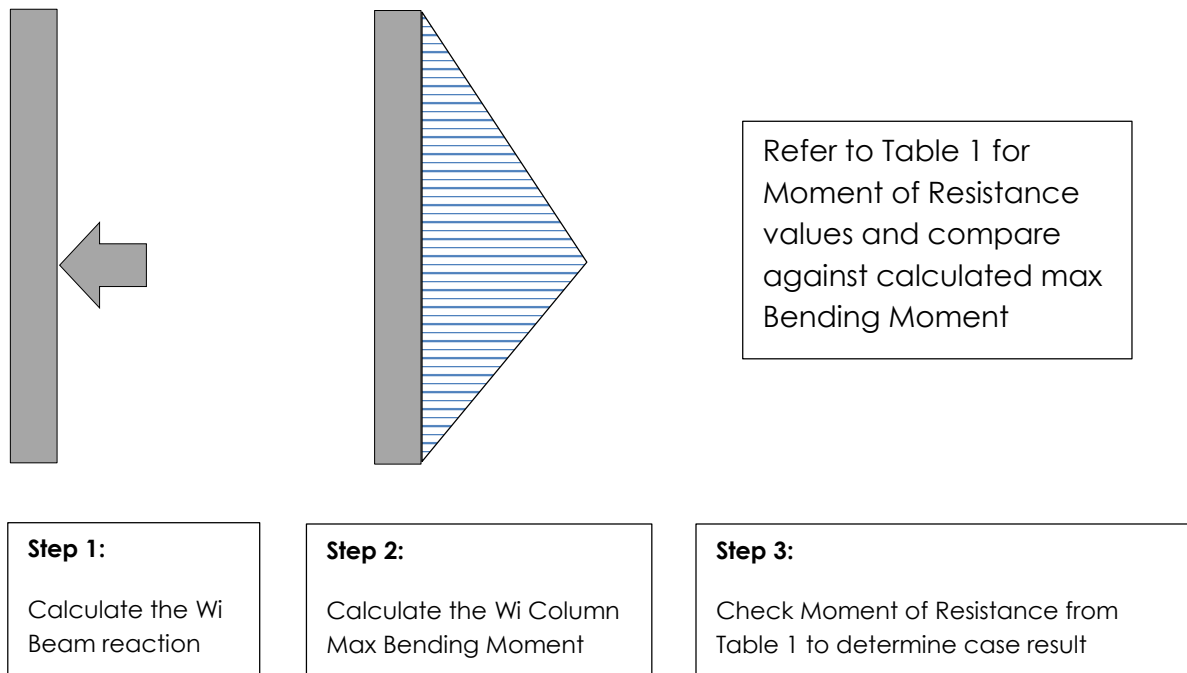


Figure 6 – Calculating the BM acting on the Wi Column

The above is one suggested approach, but experienced designers will appreciate that other options could also be adopted.

Table 1: Wi Column & Wi Beam Moments of Resistance

Block Size (mm)	Wi Column (kNm)	Wi Beam (kNm)
140	18.0	30.0
190	22.0	40.0
215	30.0	Not tested but can use 40.0

Should any assistance be required, please contact Wembley Innovation.

Wi COLUMN & BEAM PATENTS

“Wi Column”, “Slot Block”, “U-Block”, “Wi Beam” and the “Wi” device are registered Community trademarks of Wembley Innovation Ltd.

The Wi Beam / Wi Column System and its components are the subject of a number of Community design registrations (CDRs), patents and patent applications, including CDRs 881263-0001 to 0005, 992136-001, 1126635-0001 and 2391136-01 to 02; UK patent nos. 2440531, 2442543, 2054563, 2469272, 2485397, 2250323 and 1223274; International patent applications WO2009/098446, WO2014/096802 and national / regional equivalents; European Patents 2054563; Australian patents 2007280305 and 2009254997; New Zealand patents 575214 and 590165.

Any queries relating to the use of Wi Columns, Wi Beams and the associated techniques, with respect to possible patent infringement should be referred to Wembley Innovation.

© Wembley Innovation

APPENDIX

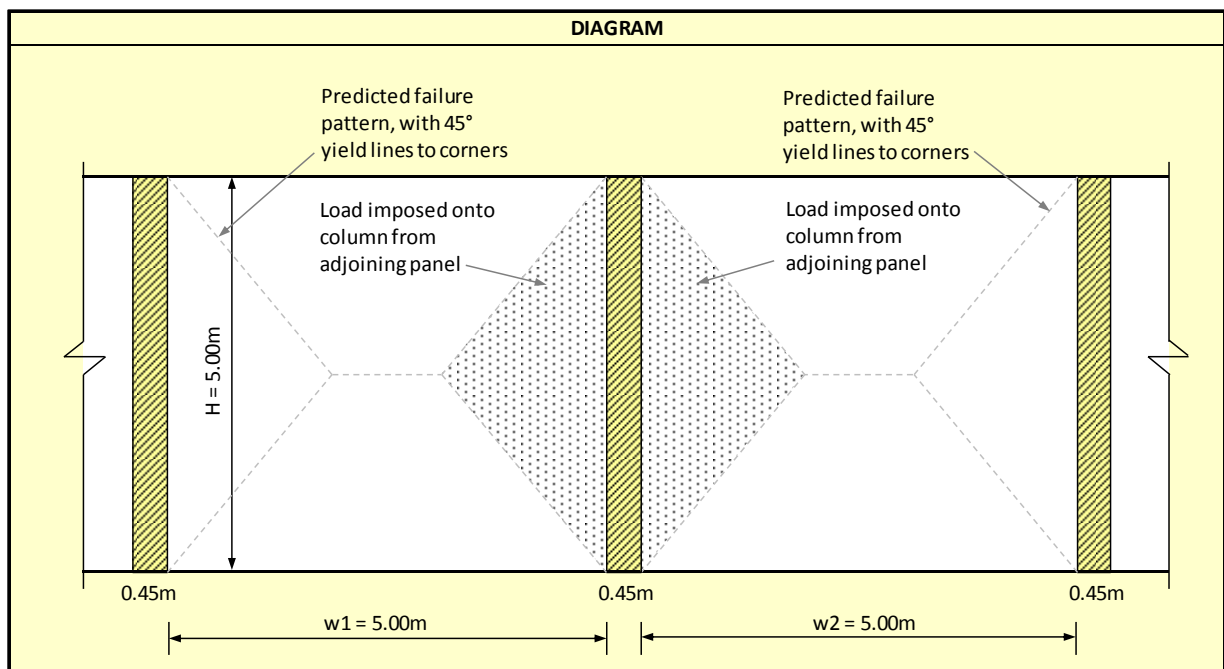
DESIGN EXAMPLES

Wi COLUMN EXAMPLE 1 – Single 140mm Wi Column & Standard Approach

INPUTS	GENERAL DATA
Element type: Wi Column	Element type: Wi Column
Design approach: Standard	Design approach: Standard

INPUTS	ELEMENT ARRANGEMENT
Wi column width: Single	Wi Column width: Single
Left side const'n type: Standard	Left side construction type: Standard
Right side const'n type: Standard	Right side construction type: Standard
Wall thickness (mm): 140	Wall thickness ' t ' [mm] = 140
Panel height (m): 5.00	Panel height ' H ' [m] = 5.00
Distance to LH col face: 5.00	Distance to left column's face ' w_1 ' [m] = 5.00
Distance to RH col face: 5.00	Distance to right column's face ' w_2 ' [m] = 5.00

INPUTS	UNFACTORED LOADING
Lateral wind load (kN/m ²): 0.50	Lateral wind load ' W_k ' [kN/m ²] = 0.50
Barrier UDL (kN/m ²): 0.00	Barrier distributed load ' W_{b_UDL} ' [kN/m ²] = 0.00
Barrier Line load (kN/m): 0.00	Barrier line load ' W_{b_line} ' [kN/m] = 0.00
Barrier height (m): 0.00	Barrier height ' h_b ' [m] = 0.00
Partial load factor wind: 1.50	Partial load factor for wind load ' γ_f ' = 1.50
Partial load factor barrier: 1.50	Partial load factor for barrier load ' γ_f ' = 1.50
Partial material factor wind: 2.00	Partial material factor ' γ_M ' = 2.00



CALCULATIONS	
Unfactored reaction btm / top 'R' [kN] =	3.69 / 3.69
Unfactored moment: wind load [kNm] =	5.91
Unfactored moment: barrier distributed [kNm] =	0.00
Unfactored moment: barrier line load [kNm] =	0.00
Total applied factored moment 'M _{Ed} ' [kNm] =	8.87
Moment of resistance 'M _{Rd} ' [kNm] =	18.00
...ADOPT: 140mm thk Wembley Innovation Wi Column	

SUMMARY OF RESULTS	
Wi Column utilisation ratio =	0.49
...ADOPT: 140mm thk Wembley Innovation Wi Column	

Notes:

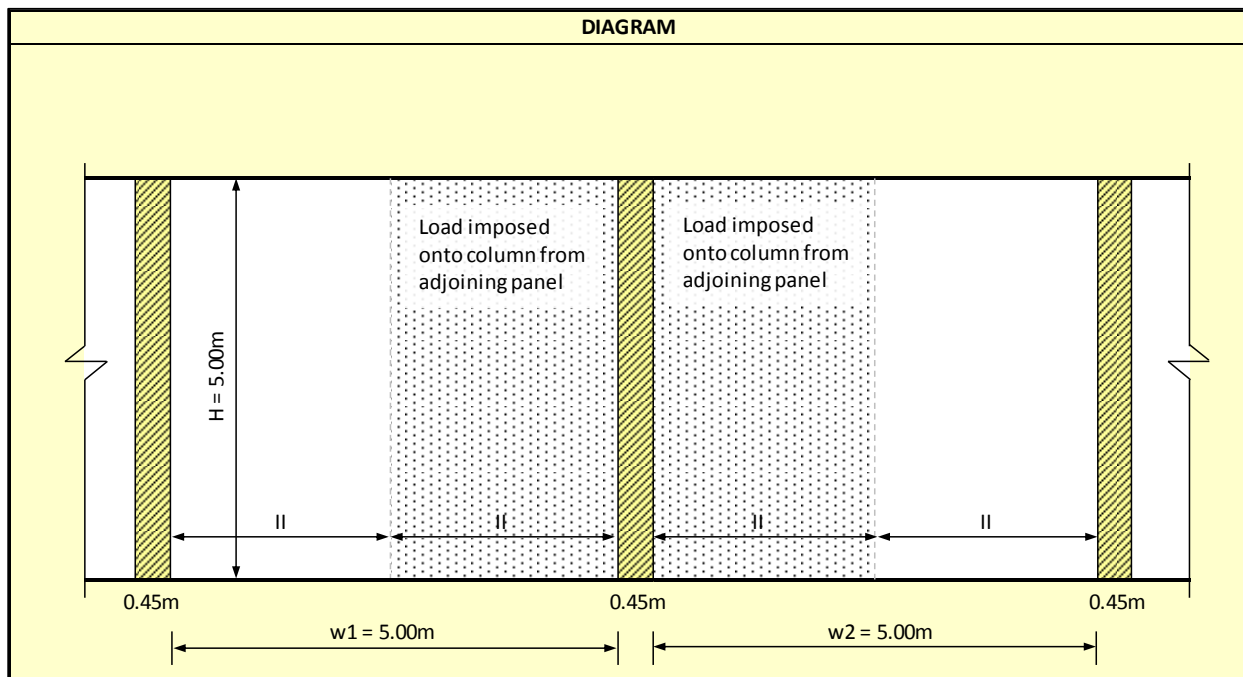
This "Standard approach" example is likely to satisfy most internal partition cases since the wind load is 0.5 kN/m², the panel height is 5.0m and the panel width is 5.0m either side of the Wi Column. Utilisation is only 0.49, indicating the residual capacity still available should the loading, column spacing or height needs to be increased.

Wi COLUMN EXAMPLE 2 – Single 140mm Wi Column & Conservative Approach

INPUTS	GENERAL DATA
Element type: Wi Column	Element type: Wi Column
Design approach: Conservative	Design approach: Conservative

INPUTS	ELEMENT ARRANGEMENT
Wi column width: Single	Wi Column width: Single
Left side const'n type: Standard	Left side construction type: Standard
Right side const'n type: Standard	Right side construction type: Standard
Wall thickness (mm): 140	Wall thickness 't' [mm] = 140
Panel height (m): 5.00	Panel height 'H' [m] = 5.00
Distance to LH col face: 5.00	Distance to left column's face 'w ₁ ' [m] = 5.00
Distance to RH col face: 5.00	Distance to right column's face 'w ₂ ' [m] = 5.00

INPUTS	UNFACTORED LOADING
Lateral wind load (kN/m ²): 0.50	Lateral wind load 'W _k ' [kN/m ²] = 0.50
Barrier UDL (kN/m ²): 0.00	Barrier distributed load 'W _{b_UDL} ' [kN/m ²] = 0.00
Barrier Line load (kN/m): 0.00	Barrier line load 'W _{b_line} ' [kN/m] = 0.00
Barrier height (m): 0.00	Barrier height 'h _b ' [m] = 0.00
Partial load factor wind: 1.50	Partial load factor for wind load 'γ _f ' = 1.50
Partial load factor barrier: 1.50	Partial load factor for barrier load 'γ _f ' = 1.50
Partial material factor wind: 2.00	Partial material factor 'γ _M ' = 2.00



CALCULATIONS	
Unfactored reaction btm / top 'R' [kN] =	6.81 / 6.81
Unfactored moment: wind load [kNm] =	8.52
Unfactored moment: barrier distributed [kNm] =	0.00
Unfactored moment: barrier line load [kNm] =	0.00
Total applied factored moment 'M _{Ed} ' [kNm] =	12.77
Moment of resistance 'M _{Rd} ' [kNm] =	18.00
...ADOPT: 140mm thk Wembley Innovation Wi Column	

SUMMARY OF RESULTS	
Wi Column utilisation ratio =	0.71
...ADOPT: 140mm thk Wembley Innovation Wi Column	

Notes:

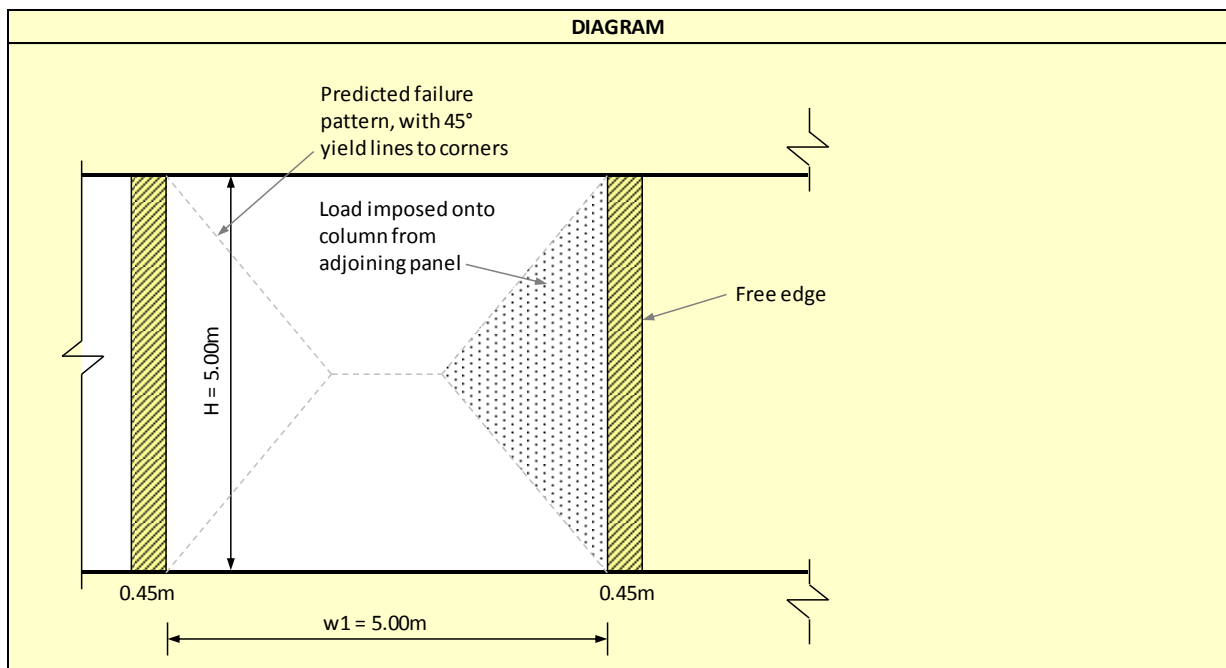
This example has the same input values as Example 1 but adopts the “Conservative” approach, which leads to a utilisation ratio of 0.71 vs 0.49. This approach would be preferred if the designer does not have confidence that the masonry panel can dissipate load to the top and bottom supports, or wants to use it for draft designs if input values are not fully confirmed – the standard approach can then be utilised for the final design once all inputs are known.

Wi COLUMN EXAMPLE 3 – Single 140mm Wi Column & Standard Approach with Free Edge

INPUTS		GENERAL DATA	
Element type:	Wi Column	Element type:	Wi Column
Design approach:	Standard	Design approach:	Standard

INPUTS		ELEMENT ARRANGEMENT	
Wi column width:	Single	Wi Column width:	Single
Left side const'n type:	Standard	Left side construction type:	Standard
Right side const'n type:	Free Edge	Right side construction type:	Free edge
Wall thickness (mm):	140	Wall thickness 't' [mm] =	140
Panel height (m):	5.00	Panel height 'H' [m] =	5.00
Distance to LH col face:	5.00	Distance to left column's face 'w ₁ ' [m] =	5.00
Distance to RH col face:	None	Distance to right column's face 'w ₂ ' [m] =	N/A

INPUTS		UNFACTORED LOADING	
Lateral wind load (kN/m ²):	0.50	Lateral wind load 'W _k ' [kN/m ²] =	0.50
Barrier UDL (kN/m ²):	0.00	Barrier distributed load 'W _{b_UDL} ' [kN/m ²] =	0.00
Barrier Line load (kN/m):	0.00	Barrier line load 'W _{b_line} ' [kN/m] =	0.00
Barrier height (m):	0.00	Barrier height 'h _b ' [m] =	0.00
Partial load factor wind:	1.50	Partial load factor for wind load 'γ _f ' =	1.50
Partial load factor barrier:	1.50	Partial load factor for barrier load 'γ _f ' =	1.50
Partial material factor wind:	2.00	Partial material factor 'γ _M ' =	2.00



CALCULATIONS	
Unfactored reaction btm / top 'R' [kN] =	2.13 / 2.13
Unfactored moment: wind load [kNm] =	3.31
Unfactored moment: barrier distributed [kNm] =	0.00
Unfactored moment: barrier line load [kNm] =	0.00
Total applied factored moment 'M _{Ed} ' [kNm] =	4.96
Moment of resistance 'M _{Rd} ' [kNm] =	18.00
...ADOPT: 140mm thk Wembley Innovation Wi Column	

SUMMARY OF RESULTS	
Wi Column utilisation ratio =	0.28
...ADOPT: 140mm thk Wembley Innovation Wi Column	

Notes:

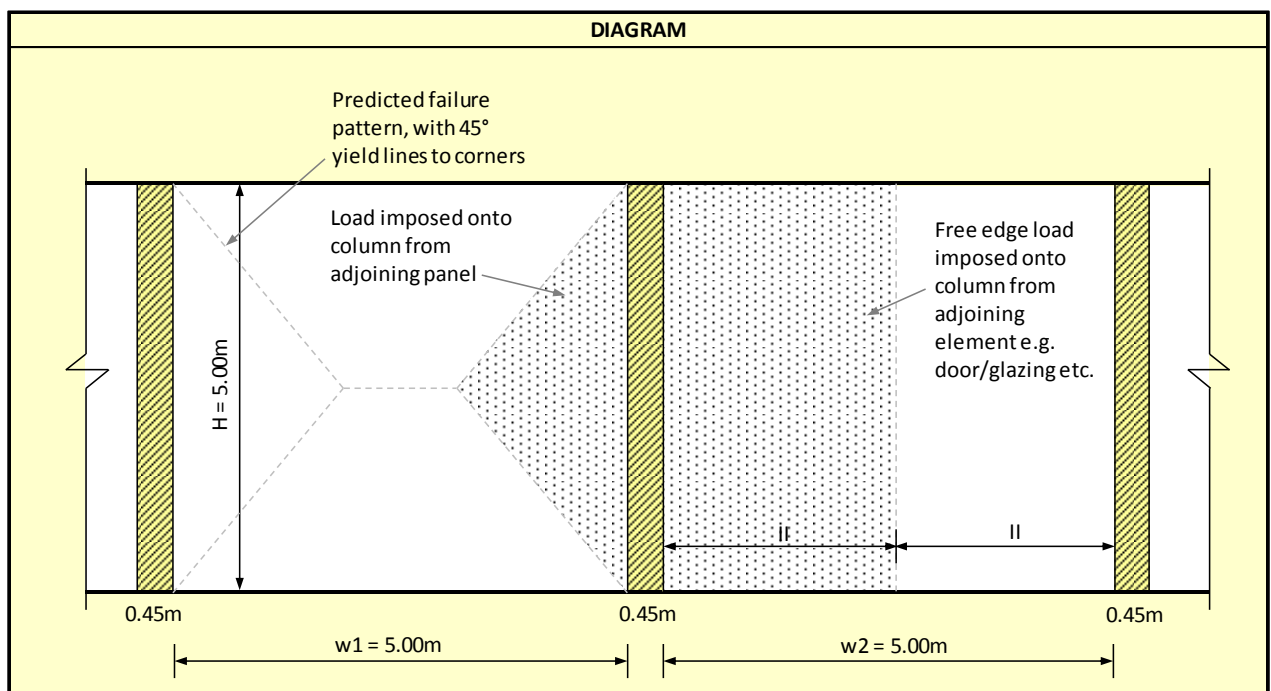
This example would represent a Wi Column that is located at the end of a wall, effectively forming a "free edge". Accordingly, load can only be applied from the attached panel.

Wi COLUMN EXAMPLE 4 – Single 140mm Wi Column & Standard Approach with Free Edge Load

INPUTS		GENERAL DATA	
Element type:	Wi Column	Element type:	Wi Column
Design approach:	Standard	Design approach:	Standard

INPUTS		ELEMENT ARRANGEMENT	
Wi column width:	Single	Wi Column width:	Single
Left side const'n type:	Standard	Left side construction type:	Standard
Right side const'n:	Free Edge Load	Right side construction type:	Free edge load
Wall thickness (mm):	140	Wall thickness 't' [mm] =	140
Panel height (m):	5.00	Panel height 'H' [m] =	5.00
Distance to LH col face:	5.00	Distance to left column's face 'w ₁ ' [m] =	5.00
Distance to RH col face:	None	Distance to right column's face 'w ₂ ' [m] =	5.00

INPUTS		UNFACTORED LOADING	
Lateral wind load (kN/m ²):	0.50	Lateral wind load 'W _k ' [kN/m ²] =	0.50
Barrier UDL (kN/m ²):	0.00	Barrier distributed load 'W _{b,UDL} ' [kN/m ²] =	0.00
Barrier Line load (kN/m):	0.00	Barrier line load 'W _{b,line} ' [kN/m] =	0.00
Barrier height (m):	0.00	Barrier height 'h _b ' [m] =	0.00
Partial load factor wind:	1.50	Partial load factor for wind load 'γ _f ' =	1.50
Partial load factor barrier:	1.50	Partial load factor for barrier load 'γ _f ' =	1.50
Partial material factor wind:	2.00	Partial material factor 'γ _M ' =	2.00



CALCULATIONS	
Unfactored reaction btm / top 'R' [kN] =	5.25 / 5.25
Unfactored moment: wind load [kNm] =	7.21
Unfactored moment: barrier distributed [kNm] =	0.00
Unfactored moment: barrier line load [kNm] =	0.00
Total applied factored moment 'M _{Ed} ' [kNm] =	10.82
Moment of resistance 'M _{Rd} ' [kNm] =	18.00
...ADOPT: 140mm thk Wembley Innovation Wi Column	

SUMMARY OF RESULTS	
Wi Column utilisation ratio =	0.60
...ADOPT: 140mm thk Wembley Innovation Wi Column	

Notes:

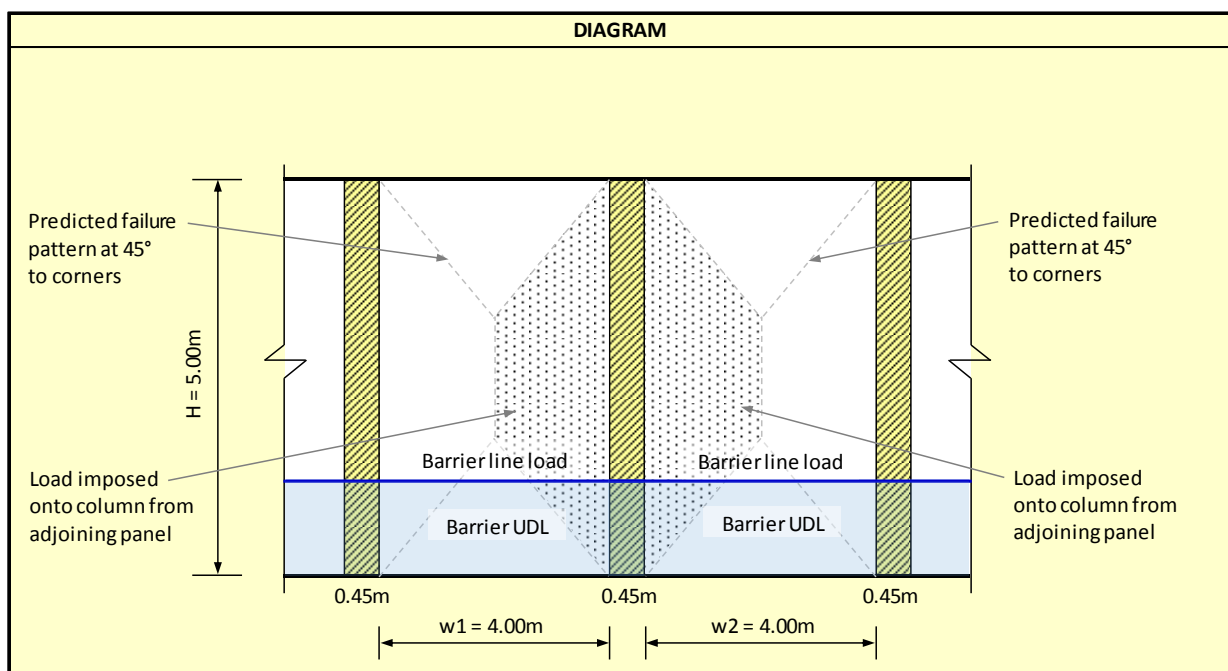
This example represents a situation where a Wi Column supports a door opening or cladding to one side and a masonry panel to the other. As such, the door/cladding side is modelled with a “conservative” approach to the loading applied to the column, which may be slightly overestimated if the door or cladding does not extend full height. However, this does simplify the modelling and should not unduly affect the result.

Wi COLUMN EXAMPLE 5 – Single 190mm Wi Column & Standard Approach + Barrier loads

INPUTS	GENERAL DATA
Element type: Wi Column	Element type: Wi Column
Design approach: Standard	Design approach: Standard

INPUTS	ELEMENT ARRANGEMENT
Wi column width: Single	Wi Column width: Single
Left side const'n type: Standard	Left side construction type: Standard
Right side const'n type: Standard	Right side construction type: Standard
Wall thickness (mm): 190	Wall thickness 't' [mm] = 190
Panel height (m): 5.00	Panel height 'H' [m] = 5.00
Distance to LH col face: 4.00	Distance to left column's face 'w ₁ ' [m] = 4.00
Distance to RH col face: 4.00	Distance to right column's face 'w ₂ ' [m] = 4.00

INPUTS	UNFACTORED LOADING
Lateral wind load (kN/m ²): 0.50	Lateral wind load 'W _k ' [kN/m ²] = 0.50
Barrier UDL (kN/m ²): 1.20	Barrier distributed load 'W _{b_UDL} ' [kN/m ²] = 1.20
Barrier Line load (kN/m): 1.50	Barrier line load 'W _{b_line} ' [kN/m] = 1.50
Barrier height (m): 1.10	Barrier height 'h _b ' [m] = 1.10
Partial load factor wind: 1.50	Partial load factor for wind load 'γ _f ' = 1.50
Partial load factor barrier: 1.50	Partial load factor for barrier load 'γ _f ' = 1.50
Partial material factor wind: 2.00	Partial material factor 'γ _M ' = 2.00



CALCULATIONS	
Unfactored reaction btm / top 'R' [kN] =	11.28 / 5.46
Unfactored moment: wind load [kNm] =	4.73
Unfactored moment: barrier distributed [kNm] =	1.46
Unfactored moment: barrier line load [kNm] =	4.99
Total applied factored moment 'M _{Ed} ' [kNm] =	16.78
Moment of resistance 'M _{Rd} ' [kNm] =	22.00
...ADOPT: 190mm thk Wembley Innovation Wi Column	

SUMMARY OF RESULTS	
Wi Column utilisation ratio =	0.76
...ADOPT: 190mm thk Wembley Innovation Wi Column	

Notes:

This example includes the combination of barrier UDL and handrail line load as well as wind load.

Wi COLUMN EXAMPLE 6 – Double 190mm Wi Column & Standard Approach + Barrier loads

INPUTS	
Element type:	Wi Column
Design approach:	Standard

Try single Wi column first:

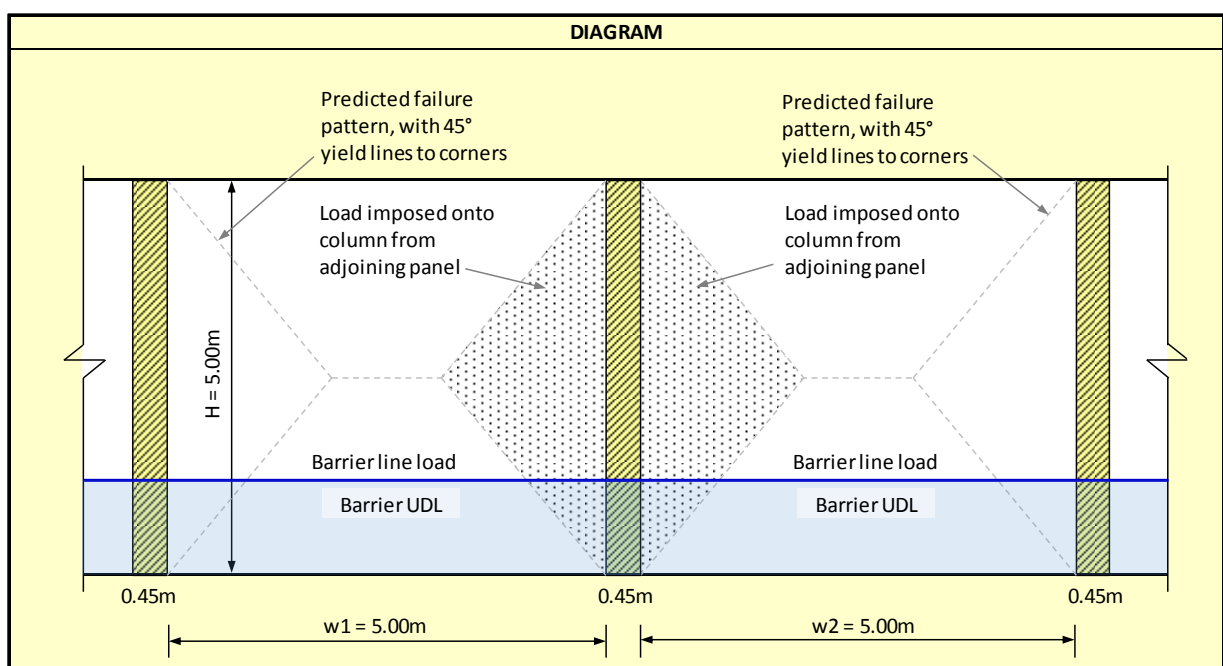
INPUTS	
Wi column width:	Single
Left side const'n type:	Standard
Right side const'n type:	Standard
Wall thickness (mm):	190
Panel height (m):	5.00
Distance to LH col face:	5.00
Distance to RH col face:	5.00

GENERAL DATA	
Element type:	Wi Column
Design approach:	Standard

ELEMENT ARRANGEMENT	
Wi Column width:	Single
Left side construction type:	Standard
Right side construction type:	Standard
Wall thickness 't' [mm] =	190
Panel height 'H' [m] =	5.00
Distance to left column's face 'w ₁ ' [m] =	5.00
Distance to right column's face 'w ₂ ' [m] =	5.00

INPUTS	
Lateral wind load (kN/m ²):	0.50
Barrier UDL (kN/m ²):	1.50
Barrier Line load (kN/m):	3.00
Barrier height (m):	1.10
Partial load factor wind:	1.50
Partial load factor barrier:	1.50
Partial material factor wind:	2.00

UNFACTORED LOADING	
Lateral wind load 'W _k ' [kN/m ²] =	0.50
Barrier distributed load 'W _{b_UDL} ' [kN/m ²] =	1.50
Barrier line load 'W _{b_line} ' [kN/m] =	3.00
Barrier height 'h _b ' [m] =	1.10
Partial load factor for wind load 'γ _f ' =	1.50
Partial load factor for barrier load 'γ _f ' =	1.50
Partial material factor 'γ _M ' =	2.00



CALCULATIONS	
Unfactored reaction btm / top 'R' [kN] =	20.28 / 7.94
Unfactored moment: wind load [kNm] =	3.70
Unfactored moment: barrier distributed [kNm] =	2.57
Unfactored moment: barrier line load [kNm] =	14.03
Total applied factored moment 'M _{Ed} ' [kNm] =	30.45
Moment of resistance 'M _{Rd} ' [kNm] =	ERROR
Applied load is too high. Wi Column not suitable.	

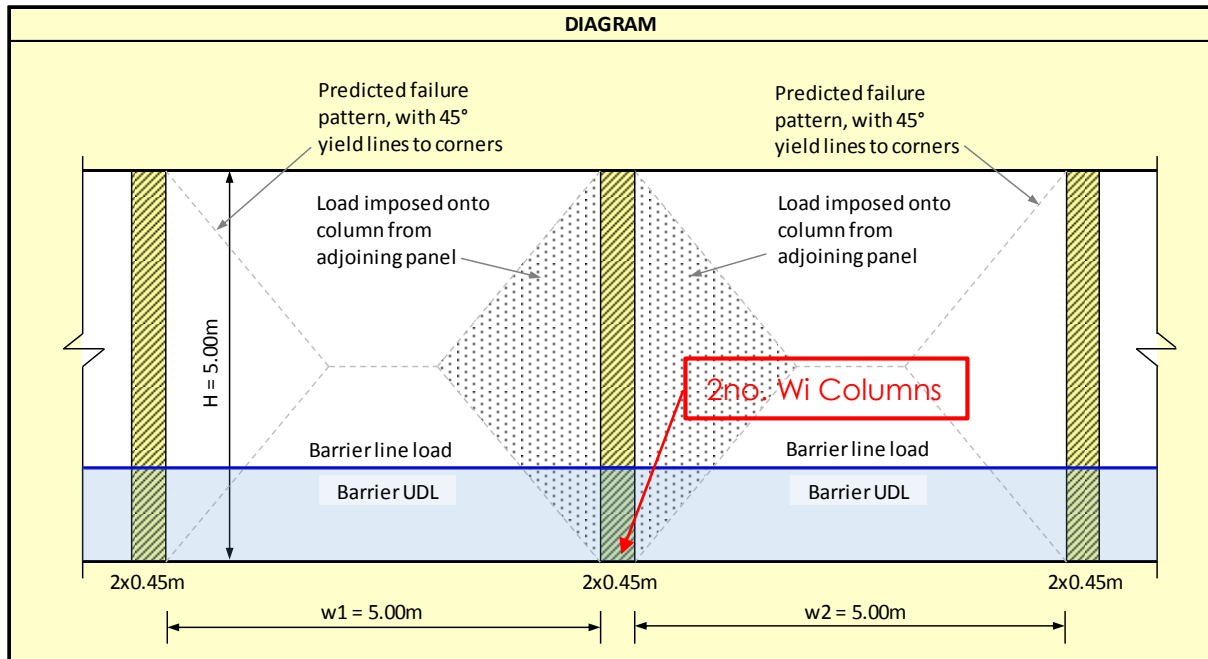
As load is too high for a single Wi Column, try double Wi Columns:

ELEMENT ARRANGEMENT	
Wi Column width:	Doubled
Left side construction type:	Standard
Right side construction type:	Standard
Wall thickness 't' [mm] =	190
Panel height 'H' [m] =	5.00
Distance to left column's face 'w ₁ ' [m] =	5.00
Distance to right column's face 'w ₂ ' [m] =	5.00

This time, 2no. 190 Wi Columns are satisfactory:

CALCULATIONS	
Unfactored reaction btm / top 'R' [kN] =	22.21 / 8.86
Unfactored moment: wind load [kNm] =	4.18
Unfactored moment: barrier distributed [kNm] =	2.78
Unfactored moment: barrier line load [kNm] =	15.19
Total applied factored moment 'M _{Ed} ' [kNm] =	33.23
Moment of resistance 'M _{Rd} ' [kNm] =	44.00
...ADOPT: 2x190mm thk Wembley Innovation Wi Column	

SUMMARY OF RESULTS	
Wi Column utilisation ratio =	0.76
...ADOPT: 2x190mm thk Wembley Innovation Wi Column	



Notes:

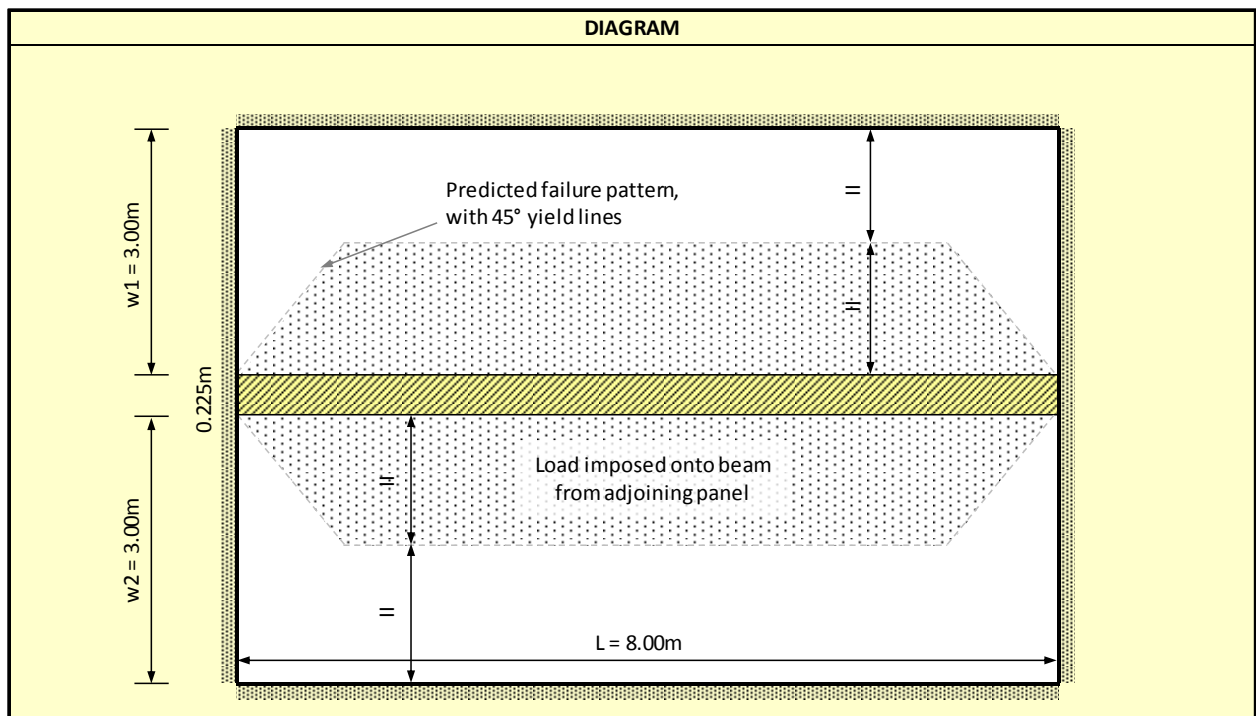
This example includes the combination of barrier UDL and handrail line load as well as wind load. The first iteration calculates that a single Wi Column is overstressed and unsuitable. Therefore a second iteration is carried out adopting double Wi Columns, which are satisfactory.

Wi BEAM EXAMPLE 7 – 140mm Wi Beam & Standard Approach

INPUTS		GENERAL DATA	
Element type:	Wi Beam	Element type:	Wi Beam
Design approach:	Standard	Design approach:	Standard

INPUTS		ELEMENT ARRANGEMENT	
Wi Beam width:	Single	Wi Beam height:	Single
Upper section const'n:	Standard	Upper section construction type:	Standard
Lower section const'n:	Standard	Lower section construction type:	Standard
Wall thickness (mm):	140	Wall thickness 't' [mm] =	140
Panel length (m):	8.00	Panel length 'L' [m] =	8.00
Distance to top support's face:	3.00	Distance to top support's face 'w ₁ ' [m] =	3.00
Distance to bot support's face:	3.00	Distance to bottom support's face 'w ₂ ' [m] =	3.00

INPUTS		UNFACTORED LOADING	
Lateral wind load (kN/m ²):	0.50	Lateral wind load 'W _k ' [kN/m ²] =	0.50
Barrier UDL (kN/m ²):	0.00	Barrier distributed load 'W _{b_UDL} ' [kN/m ²] =	0.00
Barrier Line load (kN/m):	0.00	Barrier line load 'W _{b_line} ' [kN/m] =	0.00
Barrier height (m):	0.00	Barrier height 'h _b ' [m] =	0.00
Partial load factor wind:	1.50	Partial load factor for wind load 'γ _f ' =	1.50
Partial load factor barrier:	1.50	Partial load factor for barrier load 'γ _f ' =	1.50
Partial material factor wind:	2.00	Partial material factor 'γ _M ' =	2.00



CALCULATIONS	
Unfactored reaction left / right 'R' [kN] =	5.33 / 5.33
Unfactored moment: wind load [kNm] =	12.34
Unfactored moment: barrier distributed [kNm] =	0.00
Unfactored moment: barrier line load [kNm] =	0.00
Total applied factored moment 'M _{Ed} ' [kNm] =	18.51
Moment of resistance 'M _{Rd} ' [kNm] =	30.00
...ADOPT: 140mm thk Wembley Innovation Wi Beam	

SUMMARY OF RESULTS	
Wi Beam utilisation ratio =	0.62
...ADOPT: 140mm thk Wembley Innovation Wi Beam	

Notes:

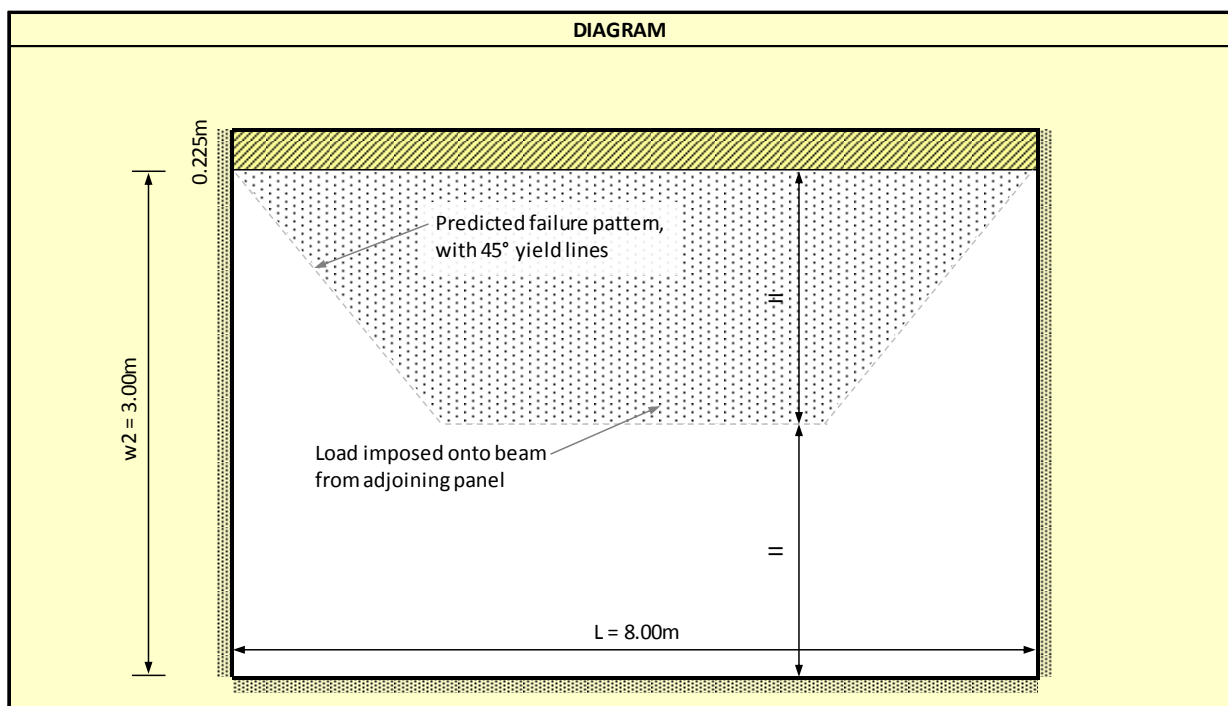
This is a standard Wi Beam example with supports to all four sides, with only wind loading. A Wi Beam can be used as an alternative to the Wi Column by splitting the panel into two vertical subpanels which span vertically.

Wi BEAM EXAMPLE 8 – 140mm Wi Beam & Standard Approach, with Free Edge (eg Ring Beam)

INPUTS		GENERAL DATA	
Element type:	Wi Beam	Element type:	Wi Beam
Design approach:	Standard	Design approach:	Standard

INPUTS		ELEMENT ARRANGEMENT	
Wi Beam width:	Single	Wi Beam height:	Single
Upper section const'n:	Free Edge	Upper section construction type:	Free edge
Lower section const'n:	Standard	Lower section construction type:	Standard
Wall thickness (mm):	140	Wall thickness 't' [mm] =	140
Panel length (m):	8.00	Panel length 'L' [m] =	8.00
Distance to top support:	N/A	Distance to top support's face 'w ₁ ' [m] =	N/A
Distance to bot support:	3.00	Distance to bottom support's face 'w ₂ ' [m] =	3.00

INPUTS		UNFACTORED LOADING	
Lateral wind load (kN/m ²):	0.50	Lateral wind load 'W _k ' [kN/m ²] =	0.50
Barrier UDL (kN/m ²):	0.00	Barrier distributed load 'W _{b_UDL} ' [kN/m ²] =	0.00
Barrier Line load (kN/m):	0.00	Barrier line load 'W _{b_line} ' [kN/m] =	0.00
Barrier height (m):	0.00	Barrier height 'h _b ' [m] =	0.00
Partial load factor wind:	1.50	Partial load factor for wind load 'γ _f ' =	1.50
Partial load factor barrier:	1.50	Partial load factor for barrier load 'γ _f ' =	1.50
Partial material factor wind:	2.00	Partial material factor 'γ _M ' =	2.00



CALCULATIONS	
Unfactored reaction left / right 'R' [kN] =	2.89 / 2.89
Unfactored moment: wind load [kNm] =	6.62
Unfactored moment: barrier distributed [kNm] =	0.00
Unfactored moment: barrier line load [kNm] =	0.00
Total applied factored moment 'M _{Ed} ' [kNm] =	9.93
Moment of resistance 'M _{Rd} ' [kNm] =	30.00
...ADOPT: 140mm thk Wembley Innovation Wi Beam	

SUMMARY OF RESULTS	
Wi Beam utilisation ratio =	0.33
...ADOPT: 140mm thk Wembley Innovation Wi Beam	

Notes:

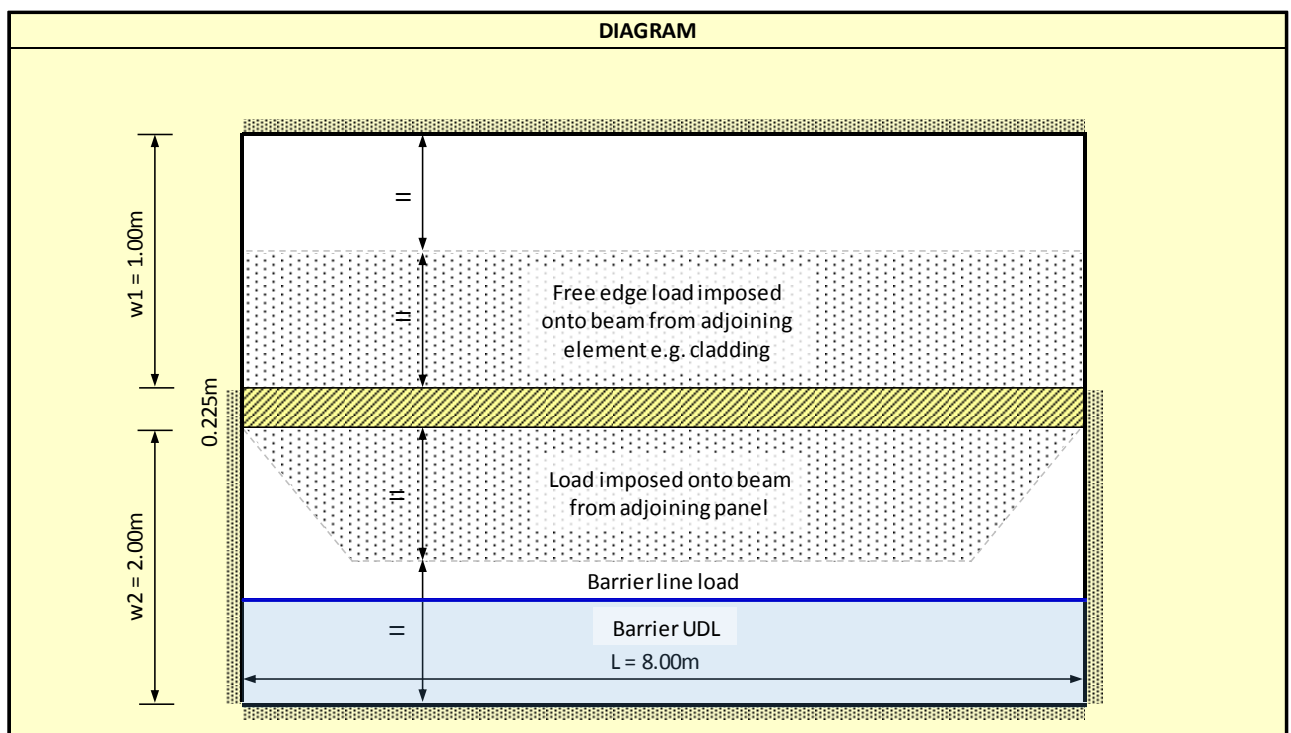
This example models a ring or top beam. This would be useful in situations where the panel cannot be fixed to a slab soffit, or for standalone structures where the roof cannot provide structural restraint to the panel(s). In such a case, Wi Beams can be used to form a ring beam, "tying" the structure together at the head of the panels.

Wi BEAM EXAMPLE 9 – 140mm Wi Beam & Standard Approach, with Barrier & Free Edge Loads (eg Barrier Beam + Cladding load)

INPUTS		GENERAL DATA	
Element type:	Wi Beam	Element type:	Wi Beam
Design approach:	Standard	Design approach:	Standard

INPUTS		ELEMENT ARRANGEMENT	
Wi Beam width:	Single	Wi Beam height:	Single
Upper section const'n:	Free Edge Load	Upper section construction type:	Free edge load
Lower section const'n type:	Standard	Lower section construction type:	Standard
Wall thickness (mm):	190	Wall thickness 't' [mm] =	190
Panel length (m):	8.00	Panel length 'L' [m] =	8.00
Distance to top support's face:	1.00	Distance to top support's face 'w ₁ ' [m] =	1.00
Distance to bot support's face:	2.00	Distance to bottom support's face 'w ₂ ' [m] =	2.00

INPUTS		UNFACTORED LOADING	
Lateral wind load (kN/m ²):	0.50	Lateral wind load 'W _k ' [kN/m ²] =	0.50
Barrier UDL (kN/m ²):	1.20	Barrier distributed load 'W _{b,UDL} ' [kN/m ²] =	1.20
Barrier Line load (kN/m):	3.00	Barrier line load 'W _{b,line} ' [kN/m] =	3.00
Barrier height (m):	1.20	Barrier height 'h _b ' [m] =	1.20
Partial load factor wind:	1.50	Partial load factor for wind load 'γ _f ' =	1.50
Partial load factor barrier:	1.50	Partial load factor for barrier load 'γ _f ' =	1.50
Partial material factor wind:	2.00	Partial material factor 'γ _M ' =	2.00



CALCULATIONS	
Unfactored reaction left / right 'R' [kN] =	11.65 / 11.65
Unfactored moment: wind load [kNm] =	6.82
Unfactored moment: barrier distributed [kNm] =	3.27
Unfactored moment: barrier line load [kNm] =	13.63
Total applied factored moment 'M _{Ed} ' [kNm] =	35.58
Moment of resistance 'M _{Rd} ' [kNm] =	40.00
...ADOPT: 190mm thk Wembley Innovation Wi Beam	

SUMMARY OF RESULTS	
Wi Beam utilisation ratio =	0.89
...ADOPT: 190mm thk Wembley Innovation Wi Beam	

Notes:

This example models a parapet wall, or an upstand wall that supports cladding or glazing which is supported by at its top edge by the structure, or a different element. Barrier UDL and a line load are applied to a height of 1.2m, whilst a general wind load is also applied to the panel and cladding.