# *Structural Design Calculations*

## *Supply Chain Logistics Building Cambridge*

*For*

***Tom Boagey***
***British Antarctic Survey***

Nov 2019
Ref: CM2126 - 02

# *Index*

***Content*** | ***Page***


| | |
|---|---|
| Introduction | 1 |
| Layout Purlins | 2 |
| Snow Load | 3 - 4 |
| Roof panel Assessment | 5 - 7 |
| Purlin Assessment | 8 - 11 |
| Portal Frame Assessment | 12 - 24 |


Should any information be missing or not clear please contact the Engineer Clive Barnes. 07713 156482.

# C R Barnes Limited
## Calculations Sheet

| Project Name | Supply Chain Logistics Building - Cambridge | | | | | Job Number | CM2126 |
|---|---|---|---|---|---|---|---|
| Calculation Sheet Number | 1 | of | | Revision | | Sub Number | 002 |
| Prepared By | CRB | | Signed | | | Date | November 2019 |
| Checked By | | | Signed | | | Date | |

| Ref | Element | Output |
|---|---|---|

**Introduction**

These calculations assess the load capacity of the existing roof, and in particular the purlins, with the view to supporting a solar panel installation with a new roof sheeting system. They make some assumptions regarding existing and proposed roofing and other assumptions as noted.

The following includes assumptions made, which may not be exhaustive, and the findings and proposed way forward. :

1. It is understood the loadings from the proposed solar panels are as follows as provided:

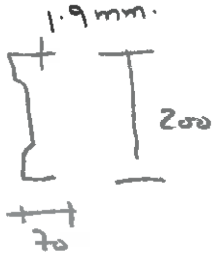
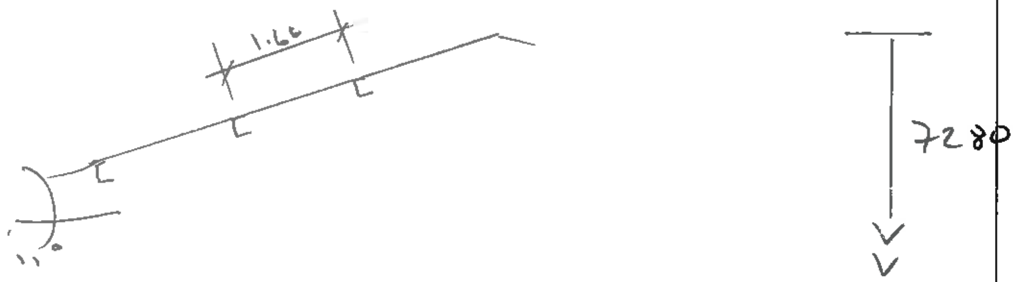
Panels –19kg for a 1.63m2 panel area or **11.66kg/m²**
Mounting System – **200g/m²**
Power Optimiser – These sit 1 every two panels, so we need to allow 1.1kg per 3.26m2 or **0.34kg/m²**
Cabling – allow **100 g per m²**.

In total we need to allow **12.3kg/m²**.

2. It is assumed the proposed new roofing panels will be Kingspan Quad Core RW Trapezoidal 100mm or similar with a self-weight of **12.2kg/m²**
3. All Purlins are spaced at approx. 1.66m on slope. All span 6m.
4. All purlins are double span and single span sleeved.
5. Purlin types are as assumed based on site measurements.
6. Existing sheeting is of a similar weight to new sheeting so wind uplift forces to purlins is not significantly increased.
7. Solar panel loading will be similar on both pitches.
8. Portal connections and foundations are adequate and original design correct. Only additional vertical loading applied.
9. In conclusion:
    a. Main portal frames are OK for the loading.
    b. Purlins should be reviewed when roof is removed to confirm assumptions are correct as this is not possible to be sure of with roof in place and the access available.
    c. If assumptions are not correct purlins may need to be strengthened or replaced with heavier duty, but based on the assumptions, which would be the norm for 6m bay portal framed buildings, the existing purlins should suffice.

# C R Barnes Limited
## Calculations Sheet

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project Name** | **Supply Chain Logistics Building - Cambridge** | | | | | **Job Number** | **CM2126** |
| **Calculation Sheet Number** | 02 | **of** | | **Revision** | | **Sub Number** | **002** |
| **Prepared By** | **CRB** | | **Signed** | | | **Date** | **November 2019** |
| **Checked By** | | | **Signed** | | | **Date** | |

| **Ref** | **Element** | **Output** |
|---|---|---|
| | Layout. | |
| | Large building purlins | |
| |   | |
| | Small building purlins 175 deep 65mm x1.9mm. Same profile | |
| | Spacing of purlins on slope 1.66m app. | |
| | Span of purlins 6m. | |
| | higher Bldg. | |
| |   | |
| | 25500. span (say 26m for frame) | |

Version 2

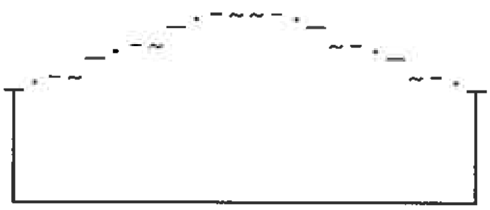
Last Updated: 1 December 2003

Location: Roof and Snow loading to BS 6399

Snow Loading on roof structures to BS6399 : Part3 : 1988

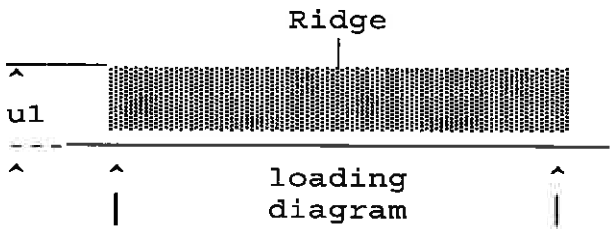
Basic snow load Sb=0.5 kN/m²
Site altitude is less than 100 metres above mean sea level.
Site snow load So=+Sb=0.5 kN/m²

Symmetrical pitched Roof



Roof section.

Proposed roof is a symmetrical pitched roof where the angle of pitch is less than or equal to 15 degrees.




For this type of roof it is only necessary to consider a single load case of a uniform layer of snow across the whole roof.

The value of the snow load shape coefficent u1 is dependent upon the angle of pitch of the roof measured from the horizontal.
This coefficent is considered to be constant across the whole roof
Angle of pitch of the roof alpha=11 degrees
Snow load shape coefficient u1=0.8
Based on the uniform snow loading to BS6399 : Part 3 Clause 7.2

Design Snow Load Sd=u1*So=0.8*0.5=0.4 kN/m²

## MINIMUM IMPOSED ROOF LOADING.

Access is not provided to the roof and allowance should be made for an imposed load equal to or greater than that which produces the worst load effect from one of the following:

1. The uniform snow loading of 0.4 $kN/m^2$ ; or
2. The redistributed snow load ; or
3. Since the roof slope is 11 degrees a uniformly distributed load of 0.6 $kN/m^2$ measured on plan; or
4. A concentrated load of 0.9 kN

No701

# C R Barnes Limited
## Calculations Sheet

| Project Name | Supply Chain Logistics Building - Cambridge | | | | | Job Number | CM2126 |
|---|---|---|---|---|---|---|---|
| Calculation Sheet Number | 05 | of | | Revision | | Sub Number | 002 |
| Prepared By | CRB | | Signed | | | Date | November 2019 |
| Checked By | | | Signed | | | Date | |

| Ref | Element | Output |
|---|---|---|
| Large Building | Assuming Roof Load is based on.<br>100 mm Quadcore<br><br>Roof slope = 11°<br>Span on slope between purlins<br>= 1660 (approx)<br>allowable live load = 4.83 kN/m²<br>say 1.8m.<br>∴ OK<br><br>Panel wt = 0.12 kN/m²<br>Solar Panels 0.12 kN/m².<br>Snow load 0.6 kN/m² << 4.83<br><br>0.84 also << 4.83<br><br>WT = say 0.84 × 1.6 = 1.35 << 4.83 | ∴ Panel OK |

06

# QuadCore™
# RW Trapezoidal Roof Panel

## Structural Tables

### Single Span

| Core Thickness (mm) | Load Type | Uniformly distributed imposed load, kN/m² | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Span, m | | | | | | | | | |
| | | 1.4 | 1.6 | 1.8 | 2.0 | 2.2 | 2.4 | 2.6 | 2.8 | 3.0 | 3.2 |
| 40 | Pressure | 3.24 | 2.68 | 2.26 | 1.93 | 1.50 | 1.17 | 0.91 | 0.71 | 0.56 | - |
| | Suction | 4.34 | 3.63 | 3.09 | 2.67 | 2.33 | 1.92 | 1.57 | 1.30 | 1.09 | - |
| 53 | Pressure | 3.86 | 3.27 | 2.80 | 2.43 | 2.04 | 1.63 | 1.31 | 1.06 | 0.86 | 0.69 |
| | Suction | 5.23 | 4.46 | 3.87 | 3.39 | 2.99 | 2.58 | 2.15 | 1.80 | 1.53 | 1.31 |
| 60 | Pressure | 4.21 | 3.60 | 3.11 | 2.71 | 2.34 | 1.89 | 1.54 | 1.26 | 1.03 | 0.85 |
| | Suction | 5.72 | 4.92 | 4.29 | 3.78 | 3.35 | 2.85 | 2.41 | 2.07 | 1.78 | 1.53 |
| 73 | Pressure | 4.85 | 4.19 | 3.67 | 3.23 | 2.87 | 2.38 | 1.97 | 1.64 | 1.37 | 1.15 |
| | Suction | 6.65 | 5.80 | 5.12 | 4.55 | 3.88 | 3.23 | 2.73 | 2.34 | 2.04 | 1.79 |
| 80 | Pressure | 5.19 | 4.52 | 3.98 | 3.52 | 3.13 | 2.67 | 2.22 | 1.86 | 1.56 | 1.32 |
| | Suction | 7.15 | 6.27 | 5.56 | 4.96 | 4.12 | 3.43 | 2.90 | 2.49 | 2.16 | 1.90 |
| 91 | Pressure | 5.69 | 5.00 | 4.43 | 3.94 | 3.53 | 3.11 | 2.62 | 2.22 | 1.88 | 1.60 |
| | Suction | 7.94 | 7.03 | 6.27 | 5.43 | 4.43 | 3.69 | 3.12 | 2.68 | 2.33 | 2.05 |
| 100 | Pressure | 6.14 | 5.42 | 4.83 | 4.32 | 3.87 | 3.49 | 2.96 | 2.52 | 2.15 | 1.85 |
| | Suction | 8.60 | 7.65 | 6.81 | 5.84 | 4.77 | 3.97 | 3.37 | 2.89 | 2.52 | 2.21 |
| 115 | Pressure | 6.86 | 6.11 | 5.48 | 4.93 | 4.44 | 4.01 | 3.52 | 3.03 | 2.61 | 2.26 |
| | Suction | 9.61 | 8.42 | 7.49 | 6.36 | 5.20 | 4.34 | 3.68 | 3.17 | 2.75 | 2.42 |
| 120 | Pressure | 7.09 | 6.33 | 5.68 | 5.12 | 4.62 | 4.18 | 3.71 | 3.20 | 2.77 | 2.40 |
| | Suction | 9.61 | 8.42 | 7.49 | 6.59 | 5.39 | 4.50 | 3.82 | 3.28 | 2.86 | 2.51 |
| 137 | Pressure | 7.87 | 7.08 | 6.39 | 5.78 | 5.24 | 4.76 | 4.32 | 3.80 | 3.31 | 2.90 |
| | Suction | 9.61 | 8.42 | 7.50 | 6.76 | 5.86 | 4.90 | 4.16 | 3.58 | 3.11 | 2.74 |
| 150 | Pressure | 8.47 | 7.64 | 6.93 | 6.29 | 5.71 | 5.19 | 4.73 | 4.27 | 3.74 | 3.29 |
| | Suction | 9.62 | 8.43 | 7.50 | 6.76 | 6.15 | 5.20 | 4.41 | 3.80 | 3.31 | 2.91 |

### Double Span

| Core Thickness (mm) | Load Type | Uniformly distributed imposed load, kN/m² | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Span, m | | | | | | | | | |
| | | 1.4 | 1.6 | 1.8 | 2.0 | 2.2 | 2.4 | 2.6 | 2.8 | 3.0 | 3.2 |
| 40 | Pressure | 3.24 | 2.68 | 2.24 | 1.85 | 1.56 | 1.34 | 1.16 | 1.02 | 0.90 | 0.80 |
| | Suction | 4.07 | 3.27 | 2.71 | 2.29 | 1.98 | 1.74 | 1.54 | 1.38 | 1.25 | 1.14 |
| 53 | Pressure | 3.81 | 3.02 | 2.46 | 2.05 | 1.74 | 1.50 | 1.30 | 1.15 | 1.02 | 0.91 |
| | Suction | 4.24 | 3.43 | 2.86 | 2.43 | 2.11 | 1.86 | 1.66 | 1.49 | 1.35 | 1.24 |
| 60 | Pressure | 3.97 | 3.15 | 2.58 | 2.15 | 1.83 | 1.58 | 1.38 | 1.22 | 1.08 | 0.97 |
| | Suction | 4.32 | 3.50 | 2.92 | 2.50 | 2.17 | 1.91 | 1.71 | 1.54 | 1.40 | 1.28 |
| 73 | Pressure | 4.23 | 3.38 | 2.77 | 2.33 | 1.99 | 1.72 | 1.50 | 1.33 | 1.18 | 1.06 |
| | Suction | 4.45 | 3.63 | 3.04 | 2.61 | 2.27 | 2.01 | 1.80 | 1.63 | 1.48 | 1.36 |
| 80 | Pressure | 4.38 | 3.51 | 2.88 | 2.42 | 2.07 | 1.79 | 1.57 | 1.39 | 1.24 | 1.11 |
| | Suction | 4.50 | 3.68 | 3.09 | 2.65 | 2.32 | 2.05 | 1.84 | 1.66 | 1.52 | 1.39 |
| 91 | Pressure | 4.60 | 3.70 | 3.05 | 2.57 | 2.20 | 1.91 | 1.68 | 1.49 | 1.33 | 1.19 |
| | Suction | 4.47 | 3.67 | 3.09 | 2.66 | 2.32 | 2.06 | 1.85 | 1.68 | 1.53 | 1.41 |
| 100 | Pressure | 4.78 | 3.85 | 3.18 | 2.69 | 2.30 | 2.00 | 1.76 | 1.56 | 1.40 | 1.26 |
| | Suction | 4.60 | 3.78 | 3.19 | 2.75 | 2.41 | 2.14 | 1.92 | 1.74 | 1.59 | 1.46 |
| 115 | Pressure | 5.06 | 4.09 | 3.40 | 2.87 | 2.47 | 2.15 | 1.89 | 1.68 | 1.50 | 1.35 |
| | Suction | 4.65 | 3.83 | 3.24 | 2.80 | 2.46 | 2.18 | 1.96 | 1.78 | 1.63 | 1.50 |
| 120 | Pressure | 5.15 | 4.17 | 3.46 | 2.93 | 2.52 | 2.19 | 1.93 | 1.72 | 1.54 | 1.39 |
| | Suction | 4.64 | 3.83 | 3.25 | 2.80 | 2.46 | 2.19 | 1.97 | 1.79 | 1.63 | 1.51 |
| 137 | Pressure | 5.45 | 4.44 | 3.70 | 3.14 | 2.70 | 2.36 | 2.08 | 1.85 | 1.66 | 1.49 |
| | Suction | 4.65 | 3.85 | 3.27 | 2.83 | 2.48 | 2.21 | 1.99 | 1.81 | 1.66 | 1.53 |
| 150 | Pressure | 5.68 | 4.63 | 3.86 | 3.28 | 2.83 | 2.47 | 2.18 | 1.94 | 1.74 | 1.57 |
| | Suction | 4.63 | 3.84 | 3.26 | 2.82 | 2.48 | 2.21 | 1.99 | 1.81 | 1.66 | 1.53 |

1. Values have been calculated using the method described in BS EN 14509 2013, for medium coloured panels.
2. The following deflection limits have been used:
    a. Pressure loading L/200
    b. Suction loading L/150
3. All panel thicknesses have been calculated with a minimum support width of 50mm. Larger support widths are possible.
4. The actual wind suction resisted by the panel is dependent upon the number of fasteners and the material of the supporting element.
5. The fastener calculation should be carried out in accordance with the appropriate standards.
6. For intermediate values linear interpolation may be used.
7. The allowable steelwork tolerance between bearing planes of adjacent supports is +/- 5mm.

07

# QuadCore™ RW Trapezoidal Roof Panel

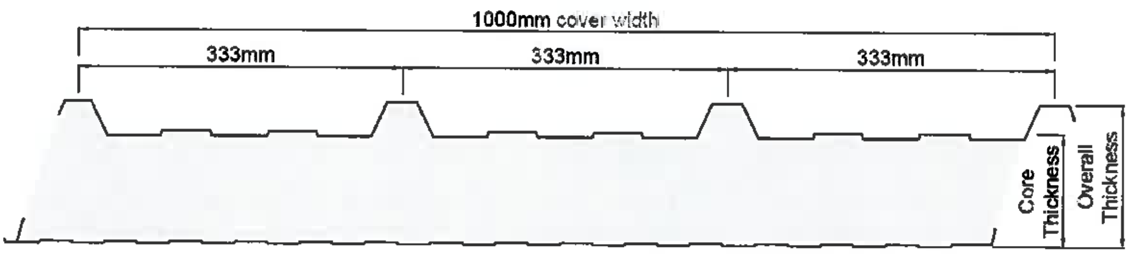
## Applications

The KS1000 RW is a through-fix trapezoidal profiled insulated roof panel which can be used for building applications with roof pitches of 4° or more after deflection.

## Available Lengths

| | |
|---|---|
| Standard Lengths | 1.8 – 14.5m |
| Longer Lengths (non-standard) | 14.5 – 29.3m |
| Shorter Lengths (non-standard) | Below 1.8m |

Note: Additional costs and transport restrictions may apply for non-standard lengths. All lengths may change for export (outside of the UK).




## Dimensions, Weight & Thermal Performance

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Core Thickness (mm) | 40 | 53 | 60 | 73 | 80 | 91 | 100 | 115 | 120 | 137 | 150 |
| Overall Thickness (mm) | 71 | 84 | 91 | 104 | 111 | 122 | 131 | 146 | 151 | 168 | 181 |
| U-value (W/m²K) | 0.47 | 0.35 | 0.31 | 0.25 | 0.23 | 0.20 | 0.18 | 0.16 | 0.15 | 0.13 | 0.12 |
| Weight kg/m² 0.5/0.4 Steel | 9.8 | 10.4 | 10.6 | 11.2 | 11.4 | 11.9 | 12.2 | 12.8 | 13.0 | 13.7 | 14.2 |
| Weight kg/m² 0.7/0.5 Alum | 5.5 | 6.0 | 6.3 | 6.8 | 7.1 | 7.6 | 7.9 | 8.5 | 8.7 | 9.4 | 9.9 |

The KS1000 RW insulated wall panels have a Thermal Transmittance (U value), calculated using the method required by the Building Regulations Part L2 (England & Wales) and Building Standards Section 6 (Scotland).

# C R Barnes Limited
## Calculations Sheet

| Project Name | Supply Chain Logistics Building - Cambridge | | | | | Job Number | CM2126 |
|---|---|---|---|---|---|---|---|
| Calculation Sheet Number | 68 | of | | Revision | | Sub Number | 002 |
| Prepared By | CRB | | Signed | | | Date | November 2019 |
| Checked By | | | Signed | | | Date | |

| Ref | Element | Output |
|---|---|---|
| | | |

Check Purlins - Assumed Kingspan Multibeam

Smallest - nearest Kingspan Ref

M175065180

Max ult load to Purlin

Services 0.1kN/m² - lighting etc (conserv.)

Ult load.

| | | | |
|---|---|---|---|
| Sheet | 0.12 x 1.4 | = 0.17 | |
| Solar | 0.12 x 1.6 | = 0.19 | — actually 9K ∴ conserv. |
| Services | 0.1 x 1.6 | = 0.16 | — vents |
| Snow | 0.6 x 1.6 on plan | = 0.96 on plan<br>= 0.94 on slope. | |
| | | 1.46 kN/m² ult | |

Total Purlin load

= 1.46 x 1.66 x 6 = 14.5 kN ult.

# C R Barnes Limited
## Calculations Sheet

C R B

| Project Name | Supply Chain Logistics Building - Cambridge | | | | | Job Number | CM2126 |
|---|---|---|---|---|---|---|---|
| Calculation Sheet Number | 09 | of | | Revision | | Sub Number | 002 |
| Prepared By | CRB | | Signed | | | Date | November 2019 |
| Checked By | | | Signed | | | Date | |

| Ref | Element | Output |
|---|---|---|
| | Capacity of Double Span system (most likely for bay spans) or slaved<br><br>= 22.93 kN with $\delta$ /180 = 16.34 kN<br><br>Both are greater than 14.5 kN<br><br>∴ Purlins OK<br><br>But check they are all Double span etc | |

# Multibeam Purlins - Load Tables

10

**Table 1:13 Double span and single span sleeved (Cont.)**

| Span (m) | Section | Weight kg/m | Ultimate UDL Gravity kN | Ultimate UDL Suction kN | Load to Produce Deflection L/180 kN |
|---|---|---|---|---|---|
| | M175065180 | 4.55 | 24.83 | 19.87 | 19.45 |
| | M175065200 | 5.08 | 28.36 | 22.69 | 21.51 |
| | M175065220 | 5.56 | 32.19 | 25.75 | 23.53 |
| | M175065250 | 6.35 | 37.65 | 30.12 | 26.52 |
| | M205065120 | 3.29 | 14.10 | 11.28 | - |
| | M205065130 | 3.58 | 16.57 | 13.25 | - |
| | M205065140 | 3.84 | 19.11 | 15.29 | - |
| | M205065150 | 4.13 | 21.68 | 17.35 | - |
| | M205065160 | 4.41 | 24.27 | 19.41 | - |
| | M205065170 | 4.67 | 26.85 | 21.17 | 26.78 |
| | M205065180 | 4.96 | 28.42 | 22.73 | 28.27 |
| | M205065200 | 5.53 | 32.71 | 26.17 | 31.28 |
| | M205065220 | 6.05 | 37.21 | 29.77 | 34.25 |
| | M205065250 | 6.91 | 43.63 | 34.90 | 38.62 |
| | M205065270 | 7.49 | 47.76 | 38.20 | 41.47 |
| | M235065130 | 3.86 | 19.67 | 15.73 | - |
| | M235065140 | 4.14 | 22.72 | 18.18 | - |
| | M235065150 | 4.45 | 25.82 | 20.66 | - |
| | M235065160 | 4.76 | 28.85 | 23.08 | - |
| | M235065170 | 5.04 | 31.42 | 25.14 | - |
| | M235065180 | 5.35 | 34.30 | 27.44 | - |
| | M235065200 | 5.97 | 39.31 | 31.43 | - |
| | M235065220 | 6.53 | 44.87 | 37.86 | - |
| | M235065250 | 7.46 | 52.72 | 44.48 | - |
| | M235065270 | 8.08 | 57.80 | 48.77 | 57.54 |
| | M265065140 | 4.46 | 25.63 | 20.49 | - |
| | M265065150 | 4.79 | 30.24 | 23.32 | - |
| | M265065160 | 5.13 | 32.74 | 24.86 | - |
| | M265065180 | 5.76 | 39.93 | 29.51 | - |
| | M265065200 | 6.43 | 46.30 | 35.06 | - |
| | M265065220 | 7.03 | 52.50 | 41.61 | - |
| | M265065250 | 8.03 | 63.76 | 49.32 | - |
| | M265065270 | 8.70 | 69.99 | 54.32 | - |
| 6.0 | M145065120 | 2.75 | 9.34 | 7.47 | 7.09 |
| | M145065130 | 2.99 | 10.92 | 8.73 | 7.67 |
| | M145065140 | 3.21 | 12.55 | 10.04 | 8.25 |
| | M145065150 | 3.45 | 14.21 | 11.37 | 8.82 |
| | M145065160 | 3.69 | 15.87 | 12.70 | 9.39 |
| | M145065180 | 4.15 | 19.14 | 15.31 | 10.52 |
| | M145065200 | 4.63 | 22.25 | 17.80 | 11.62 |
| | M145065220 | 5.06 | 25.19 | 20.15 | 12.71 |
| | M175065120 | 3.02 | 11.59 | 9.27 | 11.00 |
| | M175065130 | 3.29 | 13.57 | 10.85 | 11.91 |
| | M175065140 | 3.52 | 15.60 | 12.48 | 12.81 |
| | M175065150 | 3.79 | 17.46 | 13.97 | 13.70 |
| | M175065160 | 4.05 | 19.90 | 15.20 | 14.59 |
| | M175065180 | 4.55 | 22.93 | 18.35 | 16.34 |
| | M175065200 | 5.08 | 26.16 | 20.93 | 18.07 |
| | M175065220 | 5.56 | 29.67 | 23.74 | 19.78 |
| | M175065250 | 6.35 | 34.67 | 27.74 | 22.28 |
| | M205065120 | 3.29 | 13.14 | 10.52 | - |
| | M205065130 | 3.58 | 15.41 | 12.33 | - |
| | M205065140 | 3.84 | 17.74 | 14.20 | - |
| | M205065150 | 4.13 | 20.11 | 16.09 | 19.90 |
| | M205065160 | 4.41 | 22.48 | 17.99 | 21.19 |
| | M205065170 | 4.67 | 24.85 | 19.59 | 22.50 |
| | M205065180 | 4.96 | 26.28 | 21.02 | 23.76 |
| | M205065200 | 5.53 | 30.22 | 24.17 | 26.29 |
| | M205065220 | 6.05 | 34.34 | 27.47 | 28.78 |
| | M205065250 | 6.91 | 40.22 | 32.17 | 32.45 |
| | M205065270 | 7.49 | 44.00 | 35.20 | 34.85 |
| | M235065130 | 3.86 | 18.35 | 14.67 | - |
| | M235065140 | 4.14 | 21.16 | 16.92 | - |
| | M235065150 | 4.45 | 24.00 | 19.20 | - |
| | M235065160 | 4.76 | 26.77 | 21.42 | - |
| | M235065170 | 5.04 | 29.13 | 23.30 | - |
| | M235065180 | 5.35 | 31.77 | 25.42 | - |
| | M235065200 | 5.97 | 36.36 | 29.07 | - |
| | M235065220 | 6.53 | 41.46 | 34.97 | 39.88 |
| | M235065250 | 7.46 | 48.65 | 41.04 | 45.00 |
| | M235065270 | 8.08 | 53.30 | 44.97 | 48.35 |
| | M265065140 | 4.46 | 23.92 | 19.12 | - |
| | M265065150 | 4.79 | 28.17 | 22.29 | - |
| | M265065160 | 5.13 | 30.45 | 23.74 | - |
| | M265065180 | 5.76 | 37.04 | 28.00 | - |
| | M265065200 | 6.43 | 42.88 | 33.11 | - |
| | M265065220 | 7.03 | 48.56 | 39.15 | - |
| | M265065250 | 8.03 | 58.89 | 46.22 | - |
| | M265065270 | 8.70 | 64.59 | 50.80 | - |
| 6.5 | M175065120 | 3.02 | 10.82 | 8.66 | 9.37 |
| | M175065130 | 3.29 | 12.65 | 10.12 | 10.14 |
| | M175065140 | 3.52 | 14.53 | 11.63 | 10.91 |
| | M175065150 | 3.79 | 16.25 | 13.00 | 11.67 |
| | M175065160 | 4.05 | 17.67 | 14.13 | 12.43 |
| | M175065180 | 4.55 | 21.30 | 17.04 | 13.92 |
| | M175065200 | 5.08 | 24.28 | 19.43 | 15.40 |
| | M175065220 | 5.56 | 27.52 | 22.02 | 16.85 |
| | M175065250 | 6.35 | 32.14 | 25.71 | 18.99 |
| | M205065120 | 3.29 | 12.30 | 9.84 | - |
| | M205065130 | 3.58 | 14.40 | 11.52 | - |
| | M205065140 | 3.84 | 16.56 | 13.25 | 15.85 |
| | M205065150 | 4.13 | 18.74 | 14.99 | 16.96 |
| | M205065160 | 4.41 | 20.94 | 16.75 | 18.06 |
| | M205065170 | 4.67 | 23.13 | 18.23 | 19.17 |
| | M205065180 | 4.96 | 24.44 | 19.55 | 20.24 |
| | M205065200 | 5.53 | 28.07 | 22.46 | 22.40 |
| | M205065220 | 6.05 | 31.88 | 25.50 | 24.52 |
| | M205065250 | 6.91 | 37.30 | 29.84 | 27.65 |
| | M205065270 | 7.49 | 40.79 | 32.63 | 29.69 |
| | M235065130 | 3.86 | 17.18 | 13.74 | - |
| | M235065140 | 4.14 | 19.78 | 15.82 | - |
| | M235065150 | 4.45 | 22.40 | 17.93 | - |
| | M235065160 | 4.76 | 24.89 | 19.98 | - |
| | M235065170 | 5.04 | 27.14 | 21.71 | 26.51 |
| | M235065180 | 5.35 | 29.58 | 23.67 | 28.04 |
| | M235065200 | 5.97 | 33.81 | 27.04 | 31.03 |
| | M235065220 | 6.53 | 38.52 | 32.50 | 33.98 |
| | M235065250 | 7.46 | 45.16 | 38.10 | 38.34 |
| | M235065270 | 8.08 | 49.45 | 41.72 | 41.20 |
| | M265065140 | 4.46 | 22.41 | 17.91 | - |
| | M265065150 | 4.79 | 26.34 | 20.85 | - |
| | M265065160 | 5.13 | 28.44 | 22.65 | - |
| | M265065180 | 5.76 | 34.53 | 26.59 | - |
| | M265065200 | 6.43 | 39.92 | 31.32 | - |
| | M265065220 | 7.03 | 45.16 | 36.72 | - |
| | M265065250 | 8.03 | 54.70 | 43.12 | 51.24 |
| | M265065270 | 8.70 | 59.96 | 47.27 | 55.07 |
| | M300090150 | 5.86 | 27.41 | 20.99 | - |
| | M300090160 | 6.27 | 31.68 | 24.38 | - |
| | M300090180 | 7.05 | 41.69 | 31.45 | - |

*- Indicates the load to produce a deflection of span/180 exceeds ultimate UDL capacity*



Kingspan.

# Product Dimensions and References

11

## Multibeam Purlins

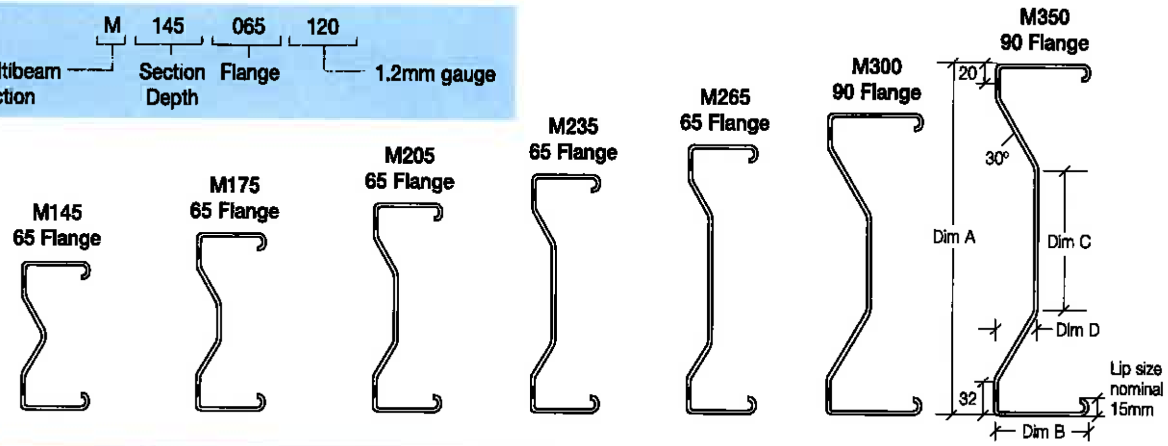
**Table 1:6 Multibeam Purlin Product Dimensions and References**

| References | Weight Kg/m | Dims (mm) A | B | C | D | Gauge (mm) |
|---|---|---|---|---|---|---|
| M145065120 | 2.75 | 145 | 65 | 8 | 20 | 1.20 |
| M145065130 | 2.99 | 145 | 65 | 8 | 20 | 1.30 |
| M145065140 | 3.21 | 145 | 65 | 8 | 20 | 1.40 |
| M145065150 | 3.45 | 145 | 65 | 8 | 20 | 1.50 |
| M145065160 | 3.69 | 145 | 65 | 8 | 20 | 1.60 |
| M145065180 | 4.15 | 145 | 65 | 8 | 20 | 1.80 |
| M145065200 | 4.63 | 145 | 65 | 8 | 20 | 2.00 |
| M145065220 | 5.06 | 145 | 65 | 8 | 20 | 2.20 |
| M175065120 | 3.02 | 175 | 65 | 38 | 20 | 1.20 |
| M175065130 | 3.29 | 175 | 65 | 38 | 20 | 1.30 |
| M175065140 | 3.52 | 175 | 65 | 38 | 20 | 1.40 |
| M175065150 | 3.79 | 175 | 65 | 38 | 20 | 1.50 |
| M175065160 | 4.05 | 175 | 65 | 38 | 20 | 1.60 |
| M175065180 | 4.55 | 175 | 65 | 38 | 20 | 1.80 |
| M175065200 | 5.08 | 175 | 65 | 38 | 20 | 2.00 |
| M175065220 | 5.56 | 175 | 65 | 38 | 20 | 2.20 |
| M175065250 | 6.35 | 175 | 65 | 38 | 20 | 2.50 |
| M205065120 | 3.29 | 205 | 65 | 68 | 20 | 1.20 |
| M205065130 | 3.58 | 205 | 65 | 68 | 20 | 1.30 |
| M205065140 | 3.84 | 205 | 65 | 68 | 20 | 1.40 |
| M205065150 | 4.13 | 205 | 65 | 68 | 20 | 1.50 |
| M205065160 | 4.41 | 205 | 65 | 68 | 20 | 1.60 |
| M205065170 | 4.67 | 205 | 65 | 68 | 20 | 1.70 |
| M205065180 | 4.96 | 205 | 65 | 68 | 20 | 1.80 |
| M205065200 | 5.53 | 205 | 65 | 68 | 20 | 2.00 |
| M205065220 | 6.05 | 205 | 65 | 68 | 20 | 2.20 |
| M205065250 | 6.91 | 205 | 65 | 68 | 20 | 2.50 |
| M205065270 | 7.49 | 205 | 65 | 68 | 20 | 2.70 |
| M235065130 | 3.86 | 235 | 65 | 98 | 20 | 1.30 |
| M235065140 | 4.14 | 235 | 65 | 98 | 20 | 1.40 |
| M235065150 | 4.45 | 235 | 65 | 98 | 20 | 1.50 |
| M235065160 | 4.76 | 235 | 65 | 98 | 20 | 1.60 |
| M235065170 | 5.04 | 235 | 65 | 98 | 20 | 1.70 |
| M235065180 | 5.35 | 235 | 65 | 98 | 20 | 1.80 |
| M235065200 | 5.97 | 235 | 65 | 98 | 20 | 2.00 |
| M235065220 | 6.53 | 235 | 65 | 98 | 20 | 2.20 |
| M235065250 | 7.46 | 235 | 65 | 98 | 20 | 2.50 |
| M235065270 | 8.08 | 235 | 65 | 98 | 20 | 2.70 |
| M265065140 | 4.46 | 265 | 65 | 128 | 20 | 1.40 |
| M265065150 | 4.79 | 265 | 65 | 128 | 20 | 1.50 |
| M265065160 | 5.13 | 265 | 65 | 128 | 20 | 1.60 |
| M265065180 | 5.76 | 265 | 65 | 128 | 20 | 1.80 |
| M265065200 | 6.43 | 265 | 65 | 128 | 20 | 2.00 |
| M265065220 | 7.03 | 265 | 65 | 128 | 20 | 2.20 |
| M265065250 | 8.03 | 265 | 65 | 128 | 20 | 2.50 |
| M265065270 | 8.70 | 265 | 65 | 128 | 20 | 2.70 |
| M300090150 | 5.86 | 300 | 90 | 94 | 40 | 1.50 |
| M300090160 | 6.27 | 300 | 90 | 94 | 40 | 1.60 |
| M300090180 | 7.05 | 300 | 90 | 94 | 40 | 1.80 |
| M300090200 | 7.86 | 300 | 90 | 94 | 40 | 2.00 |
| M300090250 | 9.82 | 300 | 90 | 94 | 40 | 2.50 |
| M300090270 | 10.64 | 300 | 90 | 94 | 40 | 2.70 |
| M350090150 | 6.43 | 350 | 90 | 144 | 40 | 1.50 |
| M350090160 | 6.87 | 350 | 90 | 144 | 40 | 1.60 |
| M350090180 | 7.72 | 350 | 90 | 144 | 40 | 1.80 |
| M350090200 | 8.62 | 350 | 90 | 144 | 40 | 2.00 |
| M350090250 | 10.77 | 350 | 90 | 144 | 40 | 2.50 |
| M350090270 | 11.66 | 350 | 90 | 144 | 40 | 2.70 |

**Reference Key**

M 145 065 120

Multibeam Section — M; Section Depth — 145; Flange — 065; 1.2mm gauge — 120




| Gauges | Gauges | Gauges | Gauges | Gauges | Gauges | Gauges |
|---|---|---|---|---|---|---|
| 1.2 | 1.2 | 1.2 | - | - | - | - |
| 1.3 | 1.3 | 1.3 | 1.3 | - | - | - |
| 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | - | - |
| 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 |
| - | - | 1.7 | 1.7 | - | - | - |
| 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 |
| 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | - | - |
| - | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| - | - | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 |

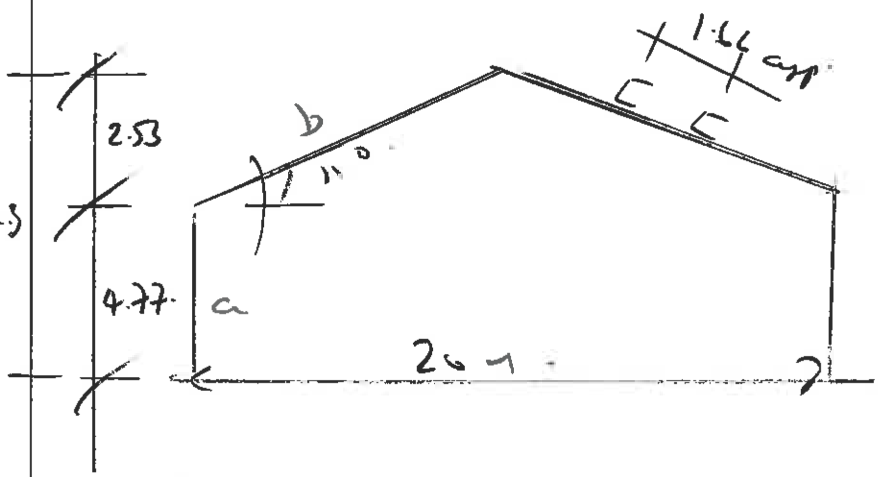


Kingspan

# C R Barnes Limited
## Calculations Sheet

| Project Name | Supply Chain Logistics Building - Cambridge | | | | Job Number | CM2126 |
|---|---|---|---|---|---|---|
| Calculation Sheet Number | 12 | of | | Revision | Sub Number | 002 |
| Prepared By | CRB | Signed | | | Date | November 2019 |
| Checked By | | Signed | | | Date | |

| Ref | Element | Output |
|---|---|---|
| | Check Portal frames for Load | |
| | Check max Axial 1.4gk + 1.6qk only | |
| | Assume portals are All designed correctly | |
| | for sway Loading etc + connections. | |
| | Sizes of members are based on remote measurements | |
| | & min weights assumed — Approx Dims | |




4.77 = 3.7 on smaller portal

| Ref | Large Portal | Small Portal |
|---|---|---|
| a | UKB 533 x 210 x 82 | UKB 533 x 210 x 82 |
| b | UKB 457 x 152 x 67 | UKB 406 x 178 x 54 |

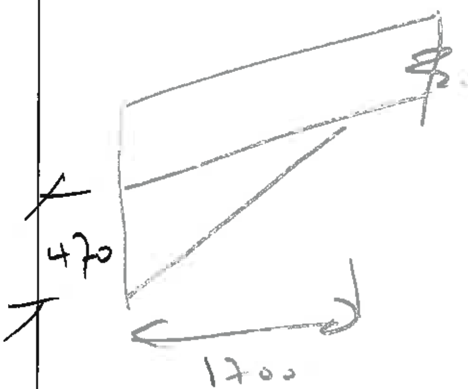
All Based on remote Measure. (Conserv sections taken)

# *C R Barnes Limited*
## Calculations Sheet

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project Name** | **Supply Chain Logistics Building - Cambridge** | | | | | **Job Number** | **CM2126** |
| **Calculation Sheet Number** | 13 | **of** | | **Revision** | | **Sub Number** | **002** |
| **Prepared By** | **CRB** | | **Signed** | | | **Date** | **November 2019** |
| **Checked By** | | | **Signed** | | | **Date** | |

| **Ref** | **Element** | **Output** |
|---|---|---|

Haunch on big portal ÷




Small portal visually similar.

Version 2

Last Updated: 1 December 2003

(14)

Sci ? 252

# 4 LOADING

The loads and load combinations described in this Section should be considered in the design of a steel portal frame. Imposed, wind, and snow loads are given in BS 6399-1 to BS 6399-3[3].

## 4.1 Dead loads

Where possible, unit weights of materials should be obtained from manufacturers' data. Where information is not available, basic unit weights of materials can be obtained from BS 648[6]. Alternatively, the figures given in Table 4.1 may be taken as typical of roofing materials used in portal frame construction. The self weight of the steel frame is typically 0.2 to 0.4 kN/m$^2$, expressed over the plan area.

**Table 4.1** *Typical weights of roofing materials*

| Material | Weight (kN/m$^2$) |
|---|---|
| Steel roof sheeting (single skin) | 0.07 - 0.12 |
| Aluminium roof sheeting (single skin) | 0.04 |
| Insulation (boards, per 25 mm thickness) | 0.07 |
| Insulation (glass fibre, per 100 mm thickness) | 0.01 |
| Liner trays (0.4 mm – 0.7 mm thickness) | 0.04 - 0.07 |
| Composite panels (40 mm – 100 mm thickness) | 0.1 - 0.15 |
| Purlins (distributed over the roof area) | 0.03 |
| Steel decking | 0.2 |
| Three layers of felt with chippings | 0.29 |
| Slates | 0.4/0.5 |
| Tiling (clay or plain concrete) | 0.6 - 0.8 |
| Tiling (concrete interlocking) | 0.5 - 0.8 |
| Timber battens (including timber rafters) | 0.1 |

✓ OK

## 4.2 Service loads

Loading due to services will vary greatly, depending on the use of the building. In a portal frame structure, heavy point loads may occur from such items as suspended walkways, air handling units, and runway and lifting beams. In certain situations, it may be more appropriate to use a truss or lattice girder, rather than a portal frame, to support heavy local loads.

At the preliminary design stage:

- Service loading is to be taken as a dead load according to BS 6399-1. ✓ OK
- Assume a service loading over the whole of the roof area of between 0.1 and 0.25 kN/m$^2$ on plan, depending on the use of the building and whether or not a sprinkler system is provided. ✓ OK

15

- Recognise that some dead load may be removed in the life of the structure and, where service loads have a beneficial effect in opposing wind uplift, use no more than 0.15 kN/m².
- Identify other sources of loading.

At the final design stage, the structure should be checked for the precise service loads, if known. Where the specified service loads are of the order of 0.5 kN/m² or more, it is probable that the attachment loads will exceed the capacity of some proprietary attachment systems.

## 4.3 Imposed roof loads

only ded.

BS 6399-3 defines six types of imposed roof load:

- A minimum load of 0.6 kN/m² (on plan) for roof slopes less than 30°, where no access other than for cleaning and maintenance is provided. ✓ 0.6
- A concentrated load of 0.9 kN - this will only affect sheeting design.
- A uniformly distributed load due to snow over the complete roof area. The value of the load depends on the building's location and height above sea level.
- Asymmetric snow load due to *major* redistribution of snow. This occurs when the wind transports snow from the windward to the leeward roof area. This load condition only applies to roof pitches greater than 15° (see Clause 7.2.3.3 of BS 6399-3).
- Asymmetric snow load due to *artificial* redistribution of snow. This occurs as a result of excessive heat loss through a small section of the roof or manual clearance of snow to maintain access to a service door (see Clause 4.5 of BS 6399-3).

  Generally, industry practice is *not* to consider this type of loading except where specifically requested.
- Non-uniform loads caused by snow drifting in areas of obstruction or abrupt changes in height, such as parapet walls or walls of adjacent buildings. The magnitude of this loading can be much larger than the uniform snow loading, but is localised and is more likely to affect the purlins and sheeting than the overall design of the structure. Snow drifting is regarded by BS 6399-3 as an exceptional load and it should be assumed that there is no snow on the rest of the roof. Reduced load factor of 1.05 may therefore be used (see Section 4.9). Frames with abrupt changes in roof height may be affected by this condition.

A detailed explanation of the background and use of BS 6399-3 is given in the BRE *Handbook of imposed roof loads*[7].

16

Table 14.1 *Recommended deflection limits (taken from Steelwork design guide to BS 5950 - Volume 4: Essential data for designers[30])*

a) Horizontal deflection at eaves level - due to unfactored wind load or unfactored imposed load or 80% of unfactored (wind and imposed) loads

| Type of cladding | Absolute deflection | Differential deflection relative to adjacent frame |
|---|---|---|
| **Side cladding:** | | |
| Profiled metal sheeting | $\leq h/100$ | – Spread |
| Fibre reinforced sheeting | $\leq h/150$ | – |
| Brickwork | $\leq h/300$ | $\leq (h^2 + b^2)^{0.5}/660$ |
| Hollow concrete blockwork | $\leq h/200$ | $\leq (h^2 + b^2)^{0.5}/500$ |
| Precast concrete units | $\leq h/200$ | $\leq (h^2 + b^2)^{0.5}/330$ |
| **Roof cladding:** | | |
| Profiled metal sheeting | – | $\leq b/200$ |
| Fibre reinforced sheeting | – | $\leq b/250$ |
| Felted metal decking | – | $\leq b/400$ |

b) Vertical deflection at ridge (for rafter slopes ≥ 3°) - due to unfactored wind load or unfactored imposed load or 80% of unfactored (wind and imposed) loads

| Type of roof cladding | Differential deflection relative to adjacent frame |
|---|---|
| Profiled metal sheeting | $\leq b/100$ and $\leq (b^2 + s^2)^{0.5}/125$ |
| Fibre reinforced sheeting | $\leq b/100$ and $\leq (b^2 + s^2)^{0.5}/165$ |
| Felted metal decking | |
| - supported on purlins | $\leq b/100$ and $\leq (b^2 + s^2)^{0.5}/125$ |
| - supported on rafter | $\leq b/200$ and $\leq (b^2 + s^2)^{0.5}/250$ |

General: The above values are provisional recommendations from *Steelwork design guide to BS 5950 - Volume 4: Essential data for designers*; feedback has suggested that some of the values may be more stringent than necessary.

The values of *h*, *b*, and *s* are defined in Figure 14.1.

total $\delta$ $L/200$ BS5950

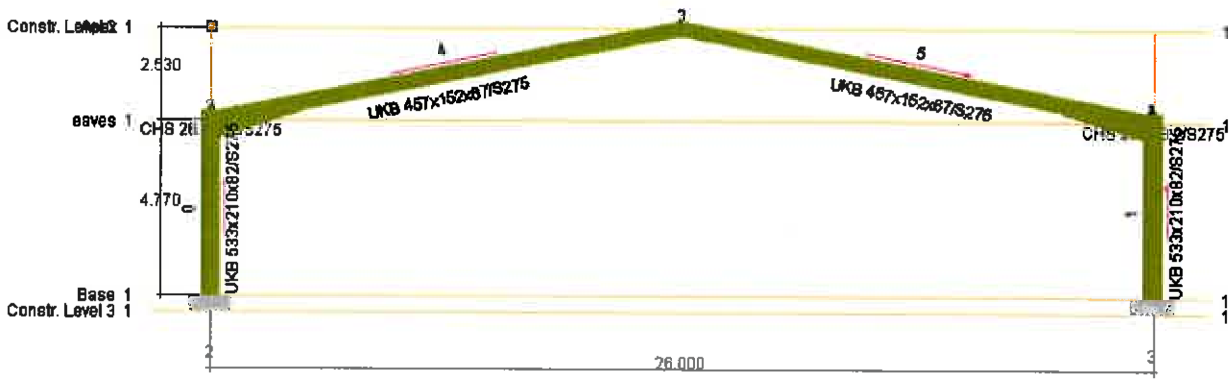
# *C R Barnes Limited*

## Calculations Sheet

| Project Name | Supply Chain Logistics Building - Cambridge | | | | | Job Number | CM2126 |
|---|---|---|---|---|---|---|---|
| Calculation Sheet Number | 17 | of | | Revision | | Sub Number | 002 |
| Prepared By | CRB | | Signed | | | Date | November 2019 |
| Checked By | | | Signed | | | Date | |

| Ref | Element | Output |
|---|---|---|

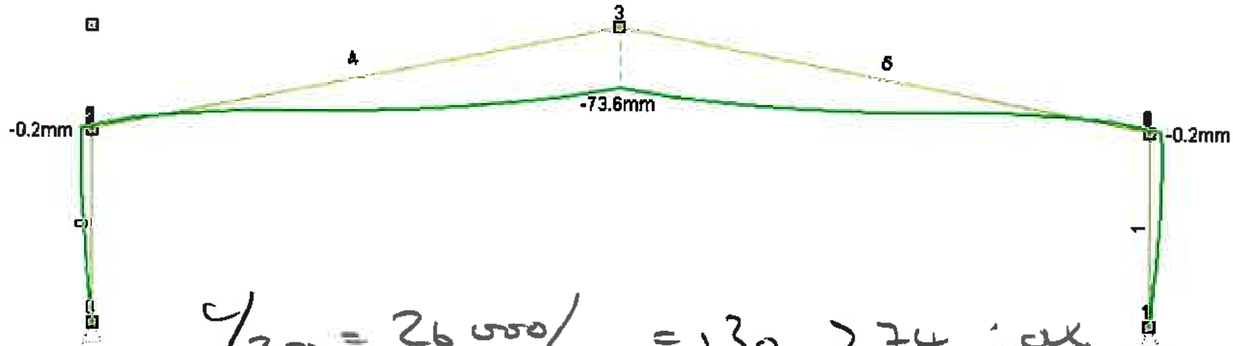
**Large Building Frame Layout**



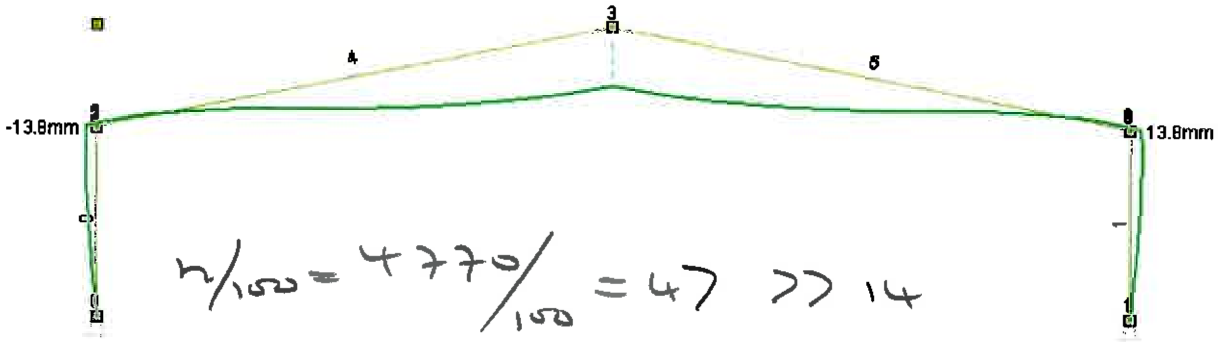
# *C R Barnes Limited*
## Calculations Sheet

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project Name** | **Supply Chain Logistics Building - Cambridge** | | | | | **Job Number** | **CM2126** |
| **Calculation Sheet Number** | 18 | **of** | | **Revision** | | **Sub Number** | **002** |
| **Prepared By** | **CRB** | | **Signed** | | | **Date** | **November 2019** |
| **Checked By** | | | **Signed** | | | **Date** | |

| **Ref** | **Element** | **Output** |
|---|---|---|
| | **Large Building Frame Deflections** | |




$L/200 = 26000/200 = 130 > 74 \therefore$ ok




$h/100 = 4770/100 = 47 >> 14$

$\therefore$ ok..

δ ok

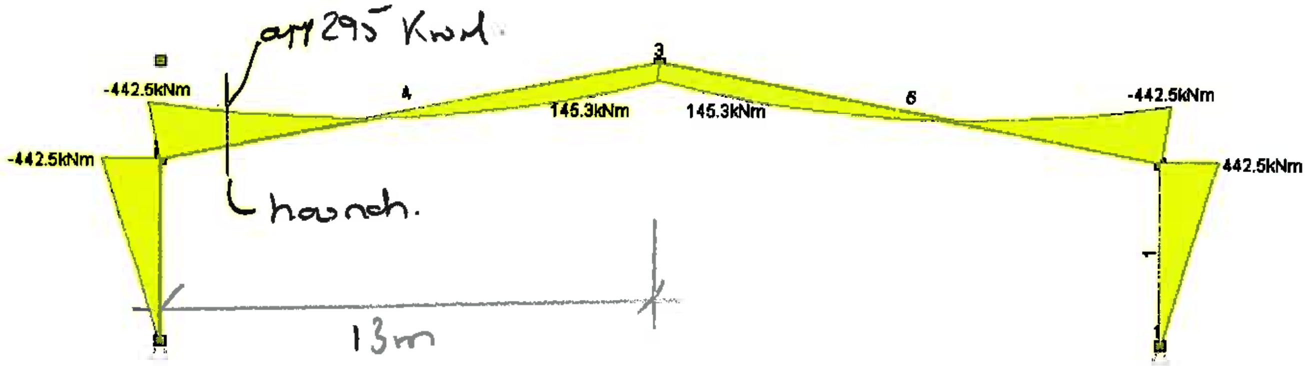
# *C R Barnes Limited*
## Calculations Sheet

| Project Name | Supply Chain Logistics Building - Cambridge | | | | Job Number | CM2126 |
|---|---|---|---|---|---|---|
| Calculation Sheet Number | 19. | of | | Revision | Sub Number | 002 |
| Prepared By | CRB | Signed | | | Date | November 2019 |
| Checked By | | Signed | | | Date | |

| Ref | Element | Output |
|---|---|---|

**Large Building Frame Moments** ULT 1.4+1.6

elastic Analysis - conservative.




Capacity of 457x152x67 = 342 > 295 ∴ ok.

∴ frame with sheet & solar panel on for Roofs

increase in load $= \frac{0.19}{1.46} \times 100 = 13\%$

Service loads high for lights only ∴ 13% ✓ conservative

Bolts have 18% from nominal to exact ∴ exact OK.

533x210x82 has m capacity 545 >> 442 ∴ ok.

## Applied Loading

### Loadcases

### Dead

#### Sloped Items

#### Beam Loads

| ID | Beam Reference | Load Type | F\M [kN] [kNm] | g1 [kN/m] | g2 [kN/m] | a [m] | b [m] | Load Cond. |
|---|---|---|---|---|---|---|---|---|
| 1 | PfR 3/1/2-4/1/4 | Full UDL | | 2.0 | | | | Norm. |
| 2 | PfR 4/1/4-3/1/3 | Full UDL | | 2.0 | | | | Norm. |

### Live

#### Sloped Items

0.34x6 = 2.0

#### ˋeam Loads

| ID | Beam Reference | Load Type | F\M [kN] [kNm] | g1 [kN/m] | g2 [kN/m] | a [m] | b [m] | Load Cond. | Lg Term [%] |
|---|---|---|---|---|---|---|---|---|---|
| 1 | PfR 3/1/2-4/1/4 | Full UDL | | 3.6 | | | | Norm. | 33.00 |
| 2 | PfR 4/1/4-3/1/3 | Full UDL | | 3.6 | | | | Norm. | 33.00 |

### Combinations

0.6x6 = 3.6

#### 1.4D+1.6I

| Loadcase Title | Strength Factor | Service Factor |
|---|---|---|
| Self weight - excluding slabs | 1.4000 | 1.0000 |
| Dead | 1.4000 | 1.0000 |
| Live | 1.6000 | 1.0000 |

#### 1.4D+1.6I+NHF X+

| Loadcase Title | Strength Factor | Service Factor |
|---|---|---|
| Self weight - excluding slabs | 1.4000 | 1.0000 |
| Dead | 1.4000 | 1.0000 |
| Live | 1.6000 | 1.0000 |
| NHF X+ | 1.0000 | |

#### 1.4D+1.6I+NHF X-

| Loadcase Title | Strength Factor | Service Factor |
|---|---|---|
| Self weight - excluding slabs | 1.4000 | 1.0000 |
| Dead | 1.4000 | 1.0000 |
| Live | 1.6000 | 1.0000 |
| NHF X- | 1.0000 | |

#### 1.4D+1.6I+NHF Y+

| Loadcase Title | Strength Factor | Service Factor |
|---|---|---|
| Self weight - excluding slabs | 1.4000 | 1.0000 |
| Dead | 1.4000 | 1.0000 |
| Live | 1.6000 | 1.0000 |
| NHF Y+ | 1.0000 | |

#### 1.4D+1.6I+NHF Y-

| Loadcase Title | Strength Factor | Service Factor |
|---|---|---|
| Self weight - excluding slabs | 1.4000 | 1.0000 |
| Dead | 1.4000 | 1.0000 |

| Loadcase Title | Strength Factor | Service Factor |
|---|---|---|
| Live | 1.6000 | 1.0000 |
| NHF Y- | 1.0000 | |

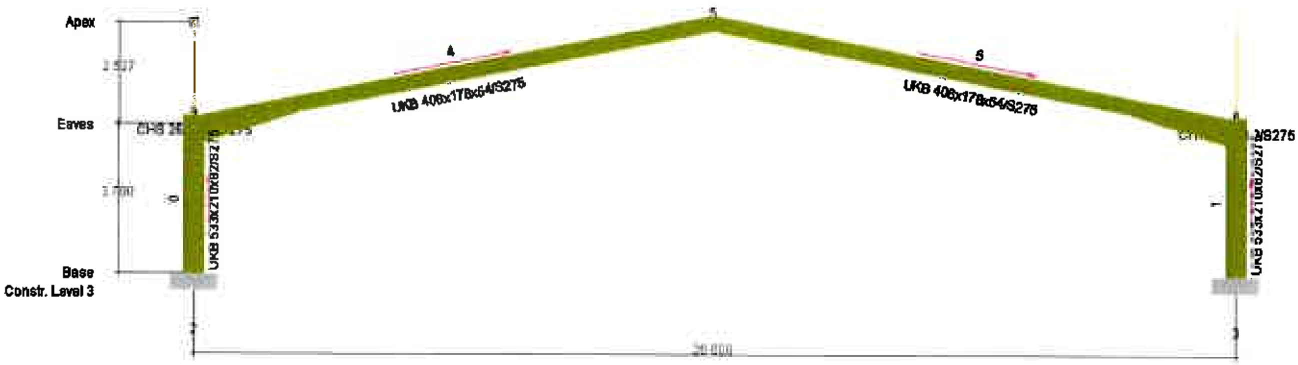
# *C R Barnes Limited*

## Calculations Sheet

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project Name** | **Supply Chain Logistics Building - Cambridge** | | | | | **Job Number** | **CM2126** |
| **Calculation Sheet Number** | 22 | **of** | | **Revision** | | **Sub Number** | **002** |
| **Prepared By** | **CRB** | | **Signed** | | | **Date** | **November 2019** |
| **Checked By** | | | **Signed** | | | **Date** | |

| **Ref** | **Element** | **Output** |
|---|---|---|

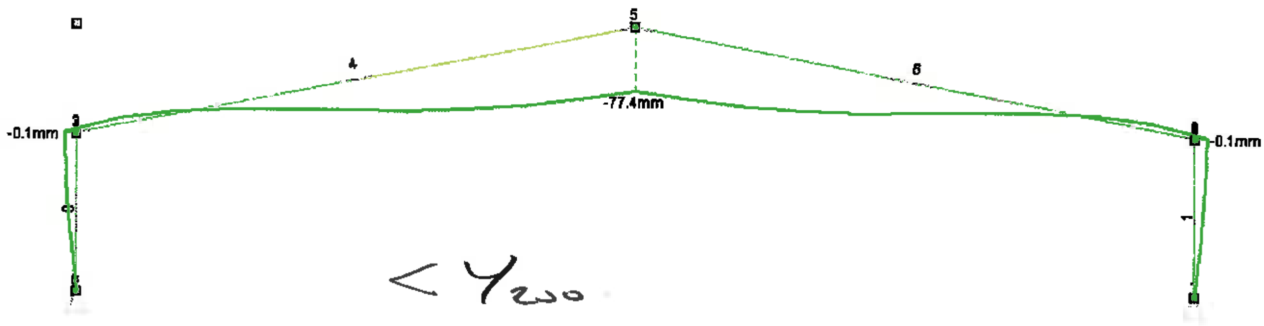
**Small Building Frame Layout**



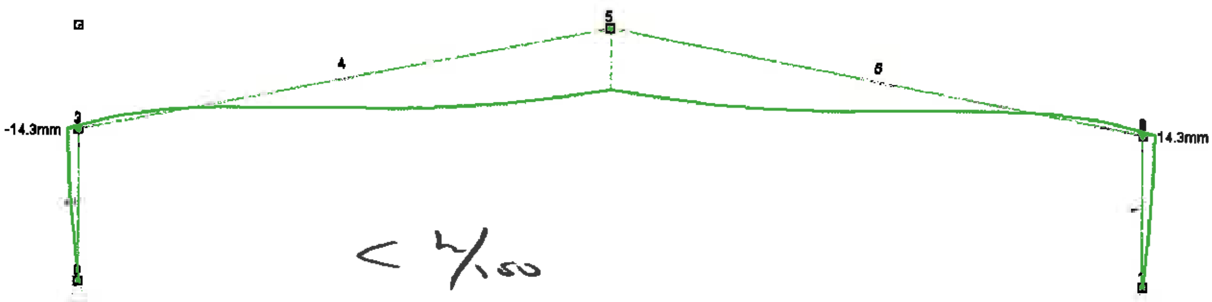
# *C R Barnes Limited*
## Calculations Sheet

| Project Name | Supply Chain Logistics Building - Cambridge | | | | | Job Number | CM2126 |
|---|---|---|---|---|---|---|---|
| Calculation Sheet Number | 23 | of | | Revision | | Sub Number | 002 |
| Prepared By | CRB | | Signed | | | Date | November 2019 |
| Checked By | | | Signed | | | Date | |

| Ref | Element | Output |
|---|---|---|
| | **Small Building Frame Deflections** | |




< L/200




< L/150

∴ defl OK.

# *C R Barnes Limited*

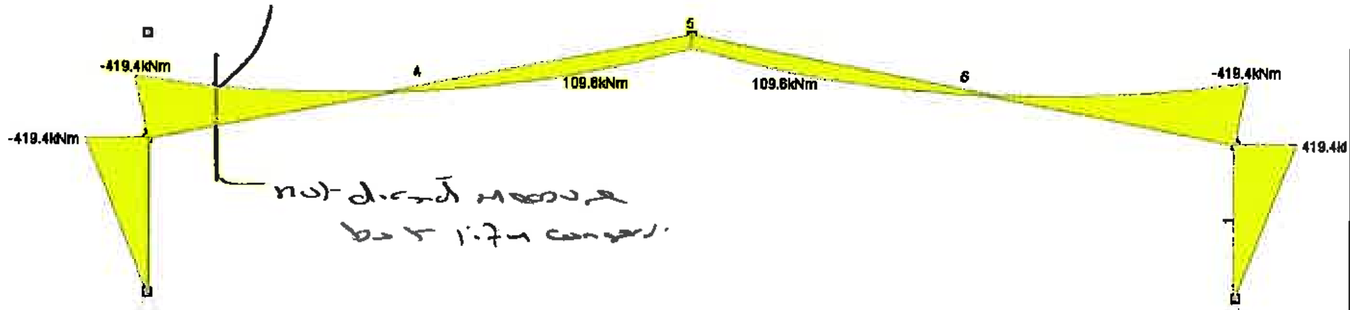
## Calculations Sheet

| Project Name | Supply Chain Logistics Building - Cambridge | | | | | Job Number | CM2126 |
|---|---|---|---|---|---|---|---|
| Calculation Sheet Number | 24 | of | | Revision | | Sub Number | 002 |
| Prepared By | CRB | | Signed | | | Date | November 2019 |
| Checked By | | | Signed | | | Date | |

| Ref | Element | Output |
|---|---|---|

**Small Building Frame Moments**

mt haunch ÷ 270




Capacity 406x178x54 = 280 > 270 ∴ ok.

This is close but elastic analysis
conservative as is service load.
∴ accept.

Cols ok see previous