WIND LOADING (BS6399)

BUILDING DATA

Type of roof: Flat
Length of building: \( L = 12000 \) mm
Width of building: \( W = 9000 \) mm
Height to eaves: \( H = 30000 \) mm
Eaves type: Sharp
Reference height: \( H_r = 30000 \) mm

DYNAMIC CLASSIFICATION

Building type factor (Table 1): \( K_b = 1.0 \)
Dynamic augmentation factor (1.6.1): \[ C_r = \left[ K_b \times \left( \frac{H_r}{0.1 \text{ m}} \right)^{0.75} \right] / \left( 800 \times \log(\frac{H_r}{0.1 \text{ m}}) \right) = 0.04 \]

SITE WIND SPEED

Location: Brighton
Basic wind speed (Figure 6 BS6399:Pt 2): \( V_b = 22.0 \) m/s
Site altitude: \( \Delta_S = 22 \) m
Upwind distance from sea to site: \( d_{\text{sea}} = 3 \) km
Direction factor: \( S_d = 1.00 \)
Seasonal factor: \( S_s = 1.00 \)
Probability factor: \( S_p = 1.00 \)
Critical gap between buildings: \( g = 500000 \) mm
Topography not significant
Altitude factor: \( S_a = 1 + 0.001 \times \Delta_S / 1m = 1.02 \)
Site wind speed: \( V_s = V_b \times S_a \times S_d \times S_s \times S_p = 22.5 \) m/s
Terrain category: Sea
Displacement height (sheltering effect excluded): \( H_d = 0 \)mm

The velocity pressure for the windward face of the building with a 0 degree wind is to be considered as 3 parts as the height \( h \) is greater than 2b (cl.2.2.3.2)

The velocity pressure for the windward face of the building with a 90 degree wind is to be considered as 3 parts as the height \( h \) is greater than 2b (cl.2.2.3.2)

### Dynamic pressure - windward wall (lower part) - Wind 0 deg

- **Reference height (at which \( q \) is sought)**: \( H_{ref} = 12000 \)mm
- **Effective height**: \( H_p = \max(H_{ref} - H_d, 0.4 \times H_{ref}) = 12000 \)mm
- **Fetch factor (Table 22)**: \( S_c = 1.140 \)
- **Turbulence factor (Table 22)**: \( S_t = 0.170 \)
- **Gust peak factor**: \( g_t = 3.44 \)
- **Terrain and building factor**: \( S_b = S_c \times (1 + (g_t \times S_t)) + S_b) = 1.81 \)
- **Effective wind speed**: \( V_e = V_s \times S_b = 40.6 \) m/s
- **Dynamic pressure**: \( q = 0.613 \frac{kg}{m^3} \times V_e^2 = 1.010 \) kN/m²

### Dynamic pressure - windward wall, (middle part) - Wind 0 deg

- **Reference height (at which \( q \) is sought)**: \( H_{ref} = 18000 \)mm
- **Effective height**: \( H_p = \max(H_{ref} - H_d, 0.4 \times H_{ref}) = 18000 \)mm
- **Fetch factor (Table 22)**: \( S_c = 1.219 \)
- **Turbulence factor (Table 22)**: \( S_t = 0.158 \)
- **Gust peak factor**: \( g_t = 3.44 \)
- **Terrain and building factor**: \( S_b = S_c \times (1 + (g_t \times S_t)) + S_b) = 1.88 \)
- **Effective wind speed**: \( V_e = V_s \times S_b = 42.3 \) m/s
- **Dynamic pressure**: \( q = 0.613 \frac{kg}{m^3} \times V_e^2 = 1.098 \) kN/m²

### Dynamic pressure - windward wall (upper part), other walls and roof - Wind 0 deg

- **Reference height (at which \( q \) is sought)**: \( H_{ref} = 30000 \)mm
- **Effective height**: \( H_p = \max(H_{ref} - H_d, 0.4 \times H_{ref}) = 30000 \)mm
- **Fetch factor (Table 22)**: \( S_c = 1.320 \)
- **Turbulence factor (Table 22)**: \( S_t = 0.142 \)
- **Gust peak factor**: \( g_t = 3.44 \)
- **Terrain and building factor**: \( S_b = S_c \times (1 + (g_t \times S_t)) + S_b) = 1.96 \)
- **Effective wind speed**: \( V_e = V_s \times S_b = 44.2 \) m/s
- **Dynamic pressure**: \( q = 0.613 \frac{kg}{m^3} \times V_e^2 = 1.195 \) kN/m²

### Dynamic pressure - windward wall (lower part) - Wind 90 deg

- **Reference height (at which \( q \) is sought)**: \( H_{ref} = 9000 \)mm
- **Effective height**: \( H_p = \max(H_{ref} - H_d, 0.4 \times H_{ref}) = 9000 \)mm
- **Fetch factor (Table 22)**: \( S_c = 1.080 \)
- **Turbulence factor (Table 22)**: \( S_t = 0.177 \)
- **Gust peak factor**: \( g_t = 3.44 \)
- **Terrain and building factor**: \( S_b = S_c \times (1 + (g_t \times S_t)) + S_b) = 1.74 \)
- **Effective wind speed**: \( V_e = V_s \times S_b = 39.1 \) m/s
- **Dynamic pressure**: \( q = 0.613 \frac{kg}{m^3} \times V_e^2 = 0.937 \) kN/m²

### Dynamic pressure - windward wall, (middle part) - Wind 90 deg

- **Reference height (at which \( q \) is sought)**: \( H_{ref} = 21000 \)mm
- **Effective height**: \( H_p = \max(H_{ref} - H_d, 0.4 \times H_{ref}) = 21000 \)mm
- **Fetch factor (Table 22)**: \( S_c = 1.248 \)
- **Turbulence factor (Table 22)**: \( S_t = 0.153 \)
Gust peak factor \( g_t = 3.44 \)

Terrain and building factor \( S_b = S_c \times (1 + (g_t \times S_t) + S_h) = 1.90 \)

Effective wind speed \( V_e = V_s \times S_b = 42.8 \text{ m/s} \)

Dynamic pressure \( q_b = 0.613 \text{ kg/m}^3 \times V_e^2 = 1.123 \text{ kN/m}^2 \)

**Dynamic pressure - windward wall (upper part), other walls and roof - Wind 90 deg**

Reference height (at which \( q \) is sought) \( H_{ref} = 30000 \text{ mm} \)

Effective height \( H_e = \max(H_{ref} - H_d, 0.4 \times H_{ref}) = 30000 \text{ mm} \)

Fetch factor (Table 22) \( S_c = 1.320 \)

Turbulence factor (Table 22) \( S_t = 0.142 \)

Gust peak factor \( g_t = 3.44 \)

Terrain and building factor \( S_b = S_c \times (1 + (g_t \times S_t) + S_h) = 1.96 \)

Effective wind speed \( V_e = V_s \times S_b = 44.2 \text{ m/s} \)

Dynamic pressure \( q_e = 0.613 \text{ kg/m}^3 \times V_e^2 = 1.195 \text{ kN/m}^2 \)

**Size effect factors**

- Diagonal dimension for gablewall \( a_{eg} = 31.3 \text{ m} \)
- External size effect factor gablewall \( C_{aeg} = 0.886 \)
- Diagonal dimension for side wall \( a_{es} = 32.3 \text{ m} \)
- External size effect factor side wall \( C_{aes} = 0.884 \)
- Diagonal dimension for roof \( a_{er} = 15.0 \text{ m} \)
- External size effect factor roof \( C_{aer} = 0.932 \)
- Diagonal dimension for top windward side \( a_{eb} = 17.0 \text{ m} \)
- External size effect factor top windward side \( C_{ae} = 0.924 \)
- Diagonal dimension for middle windward side \( a_{ems} = 13.4 \text{ m} \)
- External size effect factor middle windward side \( C_{aems} = 0.939 \)
- Diagonal dimension for bottom windward side \( a_{eb} = 17.0 \text{ m} \)
- External size effect factor bottom windward side \( C_{eb} = 0.924 \)
- Diagonal dimension for top windward gable \( a_{eg} = 12.7 \text{ m} \)
- External size effect factor top windward gable \( C_{aeg} = 0.942 \)
- Diagonal dimension for middle windward gable \( a_{emg} = 15.0 \text{ m} \)
- External size effect factor middle windward gable \( C_{aemg} = 0.932 \)
- Diagonal dimension for bottom windward gable \( a_{ebg} = 12.7 \text{ m} \)
- External size effect factor bottom windward gable \( C_{ebg} = 0.942 \)
- Room/storey volume for internal size effect factor \( V_i = 0.125 \text{ m}^3 \)
- Diagonal dimension for internal size effect factors \( a_i = 10 \times (V_i)^{1/3} = 5.000 \text{ m} \)
- Internal size effect factor \( C_{ai} = 1.000 \)

**Pressures and forces**

Net pressure \( p = q_s \times c_{pe} \times C_{aeg} - q_s \times c_{pi} \times C_{ai} \)

Net force \( F_w = p \times A_{ref} \)

**Roof load case 1 - Wind 0, \( c_{pi} 0.20, -c_{pe} \)**
### Wind Pressure Calculations

#### Project
Livingstone House, Brighton, BN3 3WZ

#### Job Ref.
15/

#### Section
Wind Pressure Calculations

#### Sheet no./rev.
4

<table>
<thead>
<tr>
<th>Zone</th>
<th>Ext pressure coefficient, $c_{pe}$</th>
<th>Dynamic pressure, $q_s$ (kN/m$^2$)</th>
<th>External size factor, $C_{ae}$</th>
<th>Net Pressure, $p$ (kN/m$^2$)</th>
<th>Area, $A_{ref}$ (m$^2$)</th>
<th>Net force, $F_w$ (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (-ve)</td>
<td>-2.00</td>
<td>1.19</td>
<td>0.932</td>
<td>-2.47</td>
<td>7.20</td>
<td>-17.75</td>
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<td>B (-ve)</td>
<td>-1.40</td>
<td>1.19</td>
<td>0.932</td>
<td>-1.80</td>
<td>7.20</td>
<td>-12.94</td>
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<td>C (-ve)</td>
<td>-0.70</td>
<td>1.19</td>
<td>0.932</td>
<td>-1.02</td>
<td>57.60</td>
<td>-58.65</td>
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<td>D (-ve)</td>
<td>-0.20</td>
<td>1.19</td>
<td>0.932</td>
<td>-0.46</td>
<td>36.00</td>
<td>-16.62</td>
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</table>

Total vertical net force $F_{w,v} = -105.96$ kN

Total horizontal net force $F_{w,h} = 0.00$ kN

#### Walls load case 1 - Wind 0, $c_{pi} 0.20, -c_{pe}$

<table>
<thead>
<tr>
<th>Zone</th>
<th>Ext pressure coefficient, $c_{pe}$</th>
<th>Dynamic pressure, $q_s$ (kN/m$^2$)</th>
<th>External size factor, $C_{ae}$</th>
<th>Net Pressure, $p$ (kN/m$^2$)</th>
<th>Area, $A_{ref}$ (m$^2$)</th>
<th>Net force, $F_w$ (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-1.30</td>
<td>1.19</td>
<td>0.886</td>
<td>-1.61</td>
<td>72.00</td>
<td>-116.27</td>
</tr>
<tr>
<td>B</td>
<td>-0.80</td>
<td>1.19</td>
<td>0.886</td>
<td>-1.09</td>
<td>198.00</td>
<td>-214.96</td>
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<tr>
<td>$w_b$</td>
<td>0.85</td>
<td>1.06</td>
<td>0.924</td>
<td>0.59</td>
<td>144.00</td>
<td>85.10</td>
</tr>
<tr>
<td>$w_m$</td>
<td>0.85</td>
<td>1.10</td>
<td>0.939</td>
<td>0.66</td>
<td>72.00</td>
<td>47.24</td>
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<tr>
<td>$w_u$</td>
<td>0.85</td>
<td>1.19</td>
<td>0.924</td>
<td>0.70</td>
<td>144.00</td>
<td>100.71</td>
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<tr>
<td>I</td>
<td>-0.50</td>
<td>1.19</td>
<td>0.884</td>
<td>-0.77</td>
<td>360.00</td>
<td>-276.12</td>
</tr>
</tbody>
</table>

Overall loading

- Equiv leeward net force for upper section $F_l=F_{w,wi}/A_{ref,wi} \times A_{ref,ui} = -110.4$ kN
- Net windward force for upper section $F_w = F_{w,ui} = 100.7$ kN
- Overall loading upper section $F_{w,ui} = 0.85 \times (1 + C_r) \times (F_w - F_l + F_{w,h}) = 186.0$ kN
- Equiv leeward net force for middle section $F_l=F_{w,mi}/A_{ref,mi} \times A_{ref,um} = -55.2$ kN
- Net windward force for middle section $F_w = F_{w,um} = 47.2$ kN
- Overall loading middle section $F_{w,um} = 0.85 \times (1 + C_r) \times (F_w - F_l) = 90.3$ kN
- Equiv leeward net force for bottom section $F_l=F_{w,bi}/A_{ref,bi} \times A_{ref,ub} = -110.4$ kN
- Net windward force for bottom section $F_w = F_{w,ub} = 85.1$ kN
- Overall loading bottom section $F_{w,ub} = 0.85 \times (1 + C_r) \times (F_w - F_l) = 172.3$ kN

#### Roof load case 2 - Wind 0, $c_{pi} -0.3, +c_{pe}$

<table>
<thead>
<tr>
<th>Zone</th>
<th>Ext pressure coefficient, $c_{pe}$</th>
<th>Dynamic pressure, $q_s$ (kN/m$^2$)</th>
<th>External size factor, $C_{ae}$</th>
<th>Net Pressure, $p$ (kN/m$^2$)</th>
<th>Area, $A_{ref}$ (m$^2$)</th>
<th>Net force, $F_w$ (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (+ve)</td>
<td>-2.00</td>
<td>1.19</td>
<td>0.932</td>
<td>-1.87</td>
<td>7.20</td>
<td>-13.45</td>
</tr>
<tr>
<td>B (+ve)</td>
<td>-1.40</td>
<td>1.19</td>
<td>0.932</td>
<td>-1.20</td>
<td>7.20</td>
<td>-8.64</td>
</tr>
<tr>
<td>C (+ve)</td>
<td>-0.70</td>
<td>1.19</td>
<td>0.932</td>
<td>-0.42</td>
<td>57.60</td>
<td>-24.23</td>
</tr>
<tr>
<td>D (+ve)</td>
<td>0.20</td>
<td>1.19</td>
<td>0.932</td>
<td>0.58</td>
<td>36.00</td>
<td>20.92</td>
</tr>
</tbody>
</table>

Total vertical net force $F_{w,v} = -25.40$ kN

Total horizontal net force $F_{w,h} = 0.00$ kN

#### Walls load case 2 - Wind 0, $c_{pi} -0.3, +c_{pe}$

[Further calculations and values are provided in the document, but they are not repeated here for brevity.]
### Zone | Ext pressure coefficient, \(c_{pe}\) | Dynamic pressure, \(q_s\) (kN/m²) | External size factor, \(C_{ae}\) | Net Pressure, \(p\) (kN/m²) | Area, \(A_{ref}\) (m²) | Net force, \(F_w\) (kN)
---|---|---|---|---|---|---
A | -1.30 | 1.19 | 0.886 | -1.02 | 72.00 | -73.25
B | -0.80 | 1.19 | 0.886 | -0.49 | 198.00 | -96.67
\(w_b\) | 0.85 | 1.01 | 0.924 | 1.10 | 144.00 | 157.81
\(w_m\) | 0.85 | 1.10 | 0.939 | 1.20 | 72.00 | 86.75
\(w_u\) | 0.85 | 1.19 | 0.924 | 1.30 | 144.00 | 186.75
I | -0.50 | 1.19 | 0.884 | -0.17 | 360.00 | -61.04

**Overall loading**

Equiv leeward net force for upper section
\[
F_l = \frac{F_{w,ul}}{A_{ref,ul}} \times A_{ref,uu} = -24.4 \text{ kN}
\]

Net windward force for upper section
\[
F_w = F_{w,uu} = 186.7 \text{ kN}
\]

Overall loading upper section
\[
F_{w,u} = 0.85 \times (1 + C_r) \times (F_w - F_l + F_{w,h}) = 186.0 \text{ kN}
\]

Equiv leeward net force for middle section
\[
F_l = \frac{F_{w,um}}{A_{ref,um}} \times A_{ref,um} = -12.2 \text{ kN}
\]

Net windward force for middle section
\[
F_w = F_{w,um} = 86.7 \text{ kN}
\]

Overall loading middle section
\[
F_{w,m} = 0.85 \times (1 + C_r) \times (F_w - F_l) = 87.2 \text{ kN}
\]

Equiv leeward net force for bottom section
\[
F_l = \frac{F_{w,wb}}{A_{ref,wb}} \times A_{ref,wb} = -24.4 \text{ kN}
\]

Net windward force for bottom section
\[
F_w = F_{w,wb} = 157.8 \text{ kN}
\]

Overall loading bottom section
\[
F_{w,b} = 0.85 \times (1 + C_r) \times (F_w - F_l) = 160.5 \text{ kN}
\]

**Roof load case 3 - Wind 90, \(c_{pi} = 0.20\), \(-c_{pe}\)**

### Zone | Ext pressure coefficient, \(c_{pe}\) | Dynamic pressure, \(q_s\) (kN/m²) | External size factor, \(C_{ae}\) | Net Pressure, \(p\) (kN/m²) | Area, \(A_{ref}\) (m²) | Net force, \(F_w\) (kN)
---|---|---|---|---|---|---
A (-ve) | -2.00 | 1.19 | 0.932 | -2.47 | 4.05 | -9.98
B (-ve) | -1.40 | 1.19 | 0.932 | -1.80 | 4.05 | -7.28
C (-ve) | -0.70 | 1.19 | 0.932 | -1.02 | 32.40 | -32.99
D (-ve) | -0.20 | 1.19 | 0.932 | -0.46 | 67.50 | -31.16

Total vertical net force
\[
F_{w,v} = -81.41 \text{ kN}
\]

Total horizontal net force
\[
F_{w,h} = 0.00 \text{ kN}
\]

**Walls load case 3 - Wind 90, \(c_{pi} = 0.20\), \(-c_{pe}\)**

### Zone | Ext pressure coefficient, \(c_{pe}\) | Dynamic pressure, \(q_s\) (kN/m²) | External size factor, \(C_{ae}\) | Net Pressure, \(p\) (kN/m²) | Area, \(A_{ref}\) (m²) | Net force, \(F_w\) (kN)
---|---|---|---|---|---|---
A | -1.30 | 1.19 | 0.884 | -1.61 | 54.00 | -87.04
B | -0.80 | 1.19 | 0.884 | -1.08 | 216.00 | -234.11
C | -0.50 | 1.19 | 0.884 | -0.77 | 90.00 | -69.03
\(w_b\) | 0.85 | 0.94 | 0.942 | -0.77 | 90.00 | 71.80
\(w_m\) | 0.85 | 1.12 | 0.932 | 0.56 | 81.00 | 45.58
\(w_u\) | 0.85 | 1.19 | 0.942 | 0.72 | 81.00 | 58.12
I | -0.50 | 1.19 | 0.886 | -0.77 | 270.00 | -207.40

**Overall loading**

Equiv leeward net force for upper section
\[
F_l = \frac{F_{w,ul}}{A_{ref,ul}} \times A_{ref,uu} = -62.2 \text{ kN}
\]

Net windward force for upper section
\[
F_w = F_{w,uu} = 58.1 \text{ kN}
\]
Overall loading upper section  \[ F_{w,u} = 0.85 \times (1 + C_r) \times (F_{w} - F_{l} + F_{w,h}) = 106.0 \, \text{kN} \]

Equiv leeward net force for middle section  \[ F_{l} = F_{w,ml} / A_{rot,ml} \times A_{ref,wm} = 83.0 \, \text{kN} \]

Net windward force for middle section  \[ F_{w} = F_{w,wm} = 71.8 \, \text{kN} \]

Overall loading middle section  \[ F_{w,m} = 0.85 \times (1 + C_r) \times (F_{w} - F_{l}) = 136.3 \, \text{kN} \]

Equiv leeward net force for bottom section  \[ F_{l} = F_{w,bl} / A_{rot,bl} \times A_{ref,wb} = 62.2 \, \text{kN} \]

Net windward force for bottom section  \[ F_{w} = F_{w,wb} = 45.6 \, \text{kN} \]

Overall loading bottom section  \[ F_{w,b} = 0.85 \times (1 + C_r) \times (F_{w} - F_{l}) = 95.0 \, \text{kN} \]

### Roof load case 4 - Wind 90, \( c_{pl} = -0.3 \), \( -c_{pe} \)

<table>
<thead>
<tr>
<th>Zone</th>
<th>Ext pressure coefficient, ( C_{pe} )</th>
<th>Dynamic pressure, ( q_s ) (kN/m(^2))</th>
<th>External size factor, ( C_{ao} )</th>
<th>Net Pressure, ( p ) (kN/m(^2))</th>
<th>Area, ( A_{ref} ) (m(^2))</th>
<th>Net force, ( F_w ) (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (-ve)</td>
<td>-2.00</td>
<td>1.19</td>
<td>0.932</td>
<td>-1.87</td>
<td>4.05</td>
<td>-7.56</td>
</tr>
<tr>
<td>B (-ve)</td>
<td>-1.40</td>
<td>1.19</td>
<td>0.932</td>
<td>-1.20</td>
<td>4.05</td>
<td>-4.86</td>
</tr>
<tr>
<td>C (-ve)</td>
<td>-0.70</td>
<td>1.19</td>
<td>0.932</td>
<td>-0.42</td>
<td>32.40</td>
<td>-13.63</td>
</tr>
<tr>
<td>D (-ve)</td>
<td>-0.20</td>
<td>1.19</td>
<td>0.932</td>
<td>0.14</td>
<td>67.50</td>
<td>9.17</td>
</tr>
</tbody>
</table>

Total vertical net force  \[ F_{w,v} = -16.89 \, \text{kN} \]

Total horizontal net force  \[ F_{w,h} = 0.00 \, \text{kN} \]

### Walls load case 4 - Wind 90, \( c_{pl} = -0.3 \), \( -c_{pe} \)

<table>
<thead>
<tr>
<th>Zone</th>
<th>Ext pressure coefficient, ( C_{pe} )</th>
<th>Dynamic pressure, ( q_s ) (kN/m(^2))</th>
<th>External size factor, ( C_{ao} )</th>
<th>Net Pressure, ( p ) (kN/m(^2))</th>
<th>Area, ( A_{ref} ) (m(^2))</th>
<th>Net force, ( F_w ) (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-1.30</td>
<td>1.19</td>
<td>0.884</td>
<td>-1.01</td>
<td>54.00</td>
<td>-54.78</td>
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<tr>
<td>B</td>
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<td>1.19</td>
<td>0.884</td>
<td>-0.49</td>
<td>216.00</td>
<td>-105.05</td>
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<tr>
<td>C</td>
<td>-0.50</td>
<td>1.19</td>
<td>0.884</td>
<td>-0.17</td>
<td>90.00</td>
<td>-15.26</td>
</tr>
<tr>
<td>( w_b )</td>
<td>0.85</td>
<td>0.94</td>
<td>0.942</td>
<td>1.03</td>
<td>81.00</td>
<td>83.54</td>
</tr>
<tr>
<td>( w_m )</td>
<td>0.85</td>
<td>1.12</td>
<td>0.932</td>
<td>1.23</td>
<td>108.00</td>
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</tr>
<tr>
<td>( w_u )</td>
<td>0.85</td>
<td>1.19</td>
<td>0.942</td>
<td>1.32</td>
<td>81.00</td>
<td>106.52</td>
</tr>
<tr>
<td>l</td>
<td>-0.50</td>
<td>1.19</td>
<td>0.886</td>
<td>-0.17</td>
<td>270.00</td>
<td>-46.09</td>
</tr>
</tbody>
</table>

Overall loading

Equiv leeward net force for upper section  \[ F_{l} = F_{w,ul} / A_{rot,ul} \times A_{ref,wu} = -13.8 \, \text{kN} \]

Net windward force for upper section  \[ F_{w} = F_{w,wu} = 106.5 \, \text{kN} \]

Overall loading upper section  \[ F_{w,u} = 0.85 \times (1 + C_r) \times (F_{w} - F_{l} + F_{w,h}) = 106.0 \, \text{kN} \]

Equiv leeward net force for middle section  \[ F_{l} = F_{w,ml} / A_{rot,ml} \times A_{ref,wm} = -18.4 \, \text{kN} \]

Net windward force for middle section  \[ F_{w} = F_{w,wm} = 132.5 \, \text{kN} \]

Overall loading middle section  \[ F_{w,m} = 0.85 \times (1 + C_r) \times (F_{w} - F_{l}) = 132.9 \, \text{kN} \]

Equiv leeward net force for bottom section  \[ F_{l} = F_{w,bl} / A_{rot,bl} \times A_{ref,wb} = -13.8 \, \text{kN} \]

Net windward force for bottom section  \[ F_{w} = F_{w,wb} = 83.5 \, \text{kN} \]

Overall loading bottom section  \[ F_{w,b} = 0.85 \times (1 + C_r) \times (F_{w} - F_{l}) = 85.8 \, \text{kN} \]
FROM ABOVE CALCULATIONS,

**WORST CASE** MAXIMUM WIND LOADINGS ONTO WALL = 1.61 kN/sq.m

2.576 kN/sq.m Factored
From the initial discussions with Alsecco, the proposed panels appear to be fixed back to the existing structure by means of adhesive supplemented by mechanical fixings at an average concentration of 5.0 fixings per sq.m.

For the base of these calculations however the adhesive element of the system will not be taken into account.

If we use the factored wind load of 2.576 kN/sq.m, then the maximum pull-out loading per fixing is $\frac{2.576}{5.0} = 0.515$ kN per fixing.

From the field Pull-Out test results provided by Alsecco and dated 26/06/2014 an average pull-out failure load of 1.93kN was achieved (the lowest being 1.6kN).

From Table 6 of the relevant BBA Certificate (96/3238), The typical pull-out resistance for a Ejot NTK-U fixing with a 60mm washer will be at least 0.6 KN (600 N).

As such the total resistance of each fixing in this particular application will be the lowest figure presented by the average field test result, the lowest field test result, or the recommended figure given in Table 6 of the BBA Certificate = 0.600 kN per fixing.

In addition, the adhesive bond between the sub-strate and the insulation board has a value of 0.08 N/sq.mm, which over a 60mm dia. washer provides a further resistance of $0.08 \times (30^2 \times \pi) - (3^2 \times \pi)$ and therefore equates to an additional resistance force of 223.9 N per fixing.

The total Pull-Out Resistance of each fixing will therefore be $(600 + 223.9) = 823.9$ N

If fixings are provided at a concentration of 5 no. fixings/square metre into the particle board, then the actual loading per fixing will be $\frac{2.576}{5} = 0.515$ kN or 515 N

The resistance per fixing (823.9N) is in excess of the actual loading (515 N), therefore the system is adequate in Local Pull-Out.

Similarly, if we look at the more global DIN situation, with reference to DIB-t Z-33.47-832 the adhesive alone can provide a resistance to wind load of 2.2 kN/sq.m (incomparision with an un_factored actual wind load of 1.61kN/m2, and that as such the mechanical fixings can be considered redundant in pull-out.
As such, 60mm dia washers and fixings at a concentration of 5 No. per square metre are adequate to cater for the pull-out loads.

CONCLUDE:
SYSTEM IS MORE THAN ADEQUATE UNDER PULL-OUT LOADING WITH 5(No) EJOT NTK-U BEING UTILISED IN EACH Sq/M OF INSULATION PANEL.