

**Project Information**

Reference

Date 14 September 2018

**Construction Type**

Element : Pitched roof, ceiling at rafter line - 0 Spec generator copies

Internal surface emissivity : High

External surface emissivity : High

|                                              | Thickness<br>(mm) | Thermal<br>Conductivity<br>(W/mK) | Thermal<br>Resistance<br>(m²K/W) | Pitch<br>(°) | Bridge details<br>Air gaps<br>(Level, Delta U") |
|----------------------------------------------|-------------------|-----------------------------------|----------------------------------|--------------|-------------------------------------------------|
| Outside surface resistance                   | -                 | -                                 | 0.100                            |              |                                                 |
| Pitched roof, tiles, with underlay or boards | -                 | -                                 | 0.000                            |              |                                                 |
| Airspace, heat flow upwards, 50 mm thick     | 50.0              | -                                 | 0.000                            |              |                                                 |
| Ampatex Aero                                 | -                 | -                                 | -                                |              |                                                 |
| SteicoFlex                                   | 150.0             | 0.036                             | 4.150                            |              | 9.000% Softwood<br>(150.0mm)<br>L:0 0.000W/m²K  |
| Beltermo Kombi                               | 100.0             | 0.038                             | 2.600                            |              | L:0 0.000W/m²K                                  |
| Beltermo Ultra                               | 50.0              | 0.042                             | 1.150                            |              | L:0 0.000W/m²K                                  |
| Ampatex Sinco                                | -                 | -                                 | -                                |              |                                                 |
| Airspace, heat flow upwards, 25 mm thick     | 25.0              | -                                 | 0.160                            |              |                                                 |
| Gyproc Wallboard                             | 12.5              | 0.189                             | 0.066                            |              |                                                 |
| Inside surface resistance                    | -                 | -                                 | 0.100                            |              |                                                 |
| <b>Total thickness</b>                       | <b>387.5mm</b>    |                                   |                                  |              |                                                 |

**U-value = 0.13W/m²K**

U-value, Combined Method : 0.129W/m²K (upper/lower limit 7.925 / 7.540m²K/W, dUf 0.0003, dUg 0.0000, dUp0.0000, dUr0.0000, dUrc1 0.0000, dUrc2 0.0000)

**Correction factors**

Mechanical fasteners :-

Warm pitched roof - insulation over rafters

Alpha : 0.80 per m lambda f : 17.0000W/mK nf : 6.700 per m² Af : 7.450mm² Recess : 0.0mm

Delta Uf for Beltermo Ultra : 0.0003

nf = fasteners per m² Af = fasteners cross-sectional area

Air gaps, Delta Ug = 0.000W/m²K

(Based on the combined method for determining U-values of structures containing repeating thermal bridges)

|                                              | Thickness<br>(mm) | Thermal<br>Conductivity<br>(W/mK) | Thermal<br>Resistance<br>(m <sup>2</sup> K/W) | Vapour<br>Resistivity<br>(MNs/gm) | Vapour<br>Resistance<br>(MNs/g) |
|----------------------------------------------|-------------------|-----------------------------------|-----------------------------------------------|-----------------------------------|---------------------------------|
| Outside surface resistance                   | -                 | -                                 | 0.100                                         | -                                 | -                               |
| Pitched roof, tiles, with underlay or boards | -                 | -                                 | 0.000                                         | -                                 | 0.00                            |
| Airspace, heat flow upwards, 50 mm thick     | 50.0              | -                                 | 0.000                                         | -                                 | 0.00                            |
| Ampatex Aero                                 | -                 | -                                 | -                                             | -                                 | 0.20                            |
| SteicoFlex                                   | 150.0             | 0.036                             | 4.150                                         | 5.00                              | 0.75                            |
| Beltermo Kombi                               | 100.0             | 0.038                             | 2.600                                         | 15.00                             | 1.50                            |
| Beltermo Ultra                               | 50.0              | 0.042                             | 1.150                                         | 15.00                             | 0.75                            |
| Ampatex Sinco                                | -                 | -                                 | -                                             | -                                 | 25.00                           |
| Airspace, heat flow upwards, 25 mm thick     | 25.0              | -                                 | 0.160                                         | -                                 | 0.00                            |
| Gyproc Wallboard                             | 12.5              | 0.189                             | 0.066                                         | 50.00                             | 0.63                            |
| Inside surface resistance                    | -                 | -                                 | 0.100                                         | -                                 | -                               |
| <b>Total thickness</b>                       | <b>387.5mm</b>    |                                   |                                               |                                   |                                 |

## Detailed U-value Calculation Results

Construction includes 1 bridged layer

### Non-bridged layers

|                                              |                          |
|----------------------------------------------|--------------------------|
| Outside surface resistance                   | 0.100 m <sup>2</sup> K/W |
| Beltermo Kombi                               | 2.600 m <sup>2</sup> K/W |
| Beltermo Ultra                               | 1.150 m <sup>2</sup> K/W |
| Airspace, heat flow upwards, 25 mm thick     | 0.160 m <sup>2</sup> K/W |
| Gyproc Wallboard                             | 0.066 m <sup>2</sup> K/W |
| Inside surface resistance                    | 0.100 m <sup>2</sup> K/W |
| Resistance of non-bridged layers, $R_{NB}$ = | 4.176 m <sup>2</sup> K/W |

### Bridged layer

SteicoFlex (L1) bridged by Softwood (B1)

Path 1 - SteicoFlex

Path 2 - Softwood

### Resistance and fraction of heat flow paths

$$R_{P1} = R_{NB} + R_{L1} = 4.176 + 4.150 = 8.326 \text{ m}^2\text{K/W} \quad F_{P1} = 91.000\%$$

$$R_{P2} = R_{NB} + R_{L2} = 4.176 + 1.154 = 5.330 \text{ m}^2\text{K/W} \quad F_{P2} = 9.000\%$$

### Upper resistance limit

$$R_{upper} = 1 / \left( (F_{P1}/R_{P1}) + (F_{P2}/R_{P2}) \right)$$

$$R_{upper} = 1 / \left( (0.910/8.326) + (0.090/5.330) \right) = 7.925 \text{ m}^2\text{K/W}$$

### Lower resistance limit

$$R_{lower} = R_{NB} + 1 / \left( (F_{L1}/R_{L1}) + (F_{B1}/R_{B1}) \right)$$

$$R_{lower} = 4.176 + 1 / \left( (0.910/4.150) + (0.090/1.154) \right) = 7.540 \text{ m}^2\text{K/W}$$

### Total resistance of roof

$$R_T = (R_{upper} + R_{lower}) / 2 = (7.925 + 7.540) / 2 = 7.73 \text{ m}^2\text{K/W}$$

### Mechanical fasteners :-

Calculations to BS EN ISO 6946:2007

Warm pitched roof - insulation over rafters

Alpha : 0.80 per m  $\lambda$  f : 17.0000W/mK nf : 6.700 per m<sup>2</sup> Af : 7.450mm<sup>2</sup> Recess : 0.0mm

Delta Uf for Beltermo Ultra : 0.0003

Correction for air gaps, Delta Ug = 0.0000W/m<sup>2</sup>K

(Delta Uf + Delta Ug + Delta Up + Delta Ur) is less than 3% of (1 / Rt) so  $U = (1 / R_T) + (\Delta U_r) + (\Delta U_{rc}) = 0.13 \text{ W/m}^2\text{K}$

Structure element : Pitched roof, ceiling at rafter line  
Condensation calculations performed in accordance with BS5250:2011

**Condensation is occurring at the following layers interfaces:-**

| Month | Int<br>(C°) | Int<br>(%RH) | Ext<br>(C°) | Ext<br>(%RH) |
|-------|-------------|--------------|-------------|--------------|
| Jan   | 21.00       | 56.10        | 5.90        | 85.50        |
| Feb   | 21.00       | 55.20        | 5.70        | 83.50        |
| Mar   | 21.00       | 55.50        | 6.90        | 82.00        |
| Apr   | 21.00       | 56.20        | 8.80        | 79.50        |
| May   | 21.00       | 59.30        | 11.50       | 79.00        |
| Jun   | 21.00       | 64.30        | 14.30       | 79.50        |
| Jul   | 21.00       | 68.80        | 16.10       | 80.50        |
| Aug   | 21.00       | 69.30        | 16.00       | 81.50        |
| Sep   | 21.00       | 66.60        | 14.30       | 83.00        |
| Oct   | 21.00       | 63.20        | 11.90       | 85.00        |
| Nov   | 21.00       | 58.20        | 8.50        | 84.50        |
| Dec   | 21.00       | 57.00        | 7.00        | 85.50        |

Gc = Monthly moisture accumulation per area at an interface

Ma = Accumulated moisture content per area at an interface

Peak accumulated moisture content per area at interface (Ma) = 0.00000 Kg/m<sup>2</sup>

Annual moisture accumulation = 0.00000 Kg/m<sup>2</sup>

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**Thermal Mass Details**

|                                              | Thickness<br>assessed (actual)<br>(mm) | Density<br>(kg/m <sup>3</sup> ) | Specific heat<br>capacity<br>(J/kgK) | Heat<br>capacity<br>(kJ/m <sup>2</sup> K) |
|----------------------------------------------|----------------------------------------|---------------------------------|--------------------------------------|-------------------------------------------|
| Pitched roof, tiles, with underlay or boards | 0.0 (-)                                | 1.2                             | 1008.0                               | 0.0                                       |
| Airspace, heat flow upwards, 50 mm thick     | 0.0 (50.0)                             | 1.2                             | 1008.0                               | 0.0                                       |
| Ampatex Aero                                 | 0.0 (-)                                | 300.0                           | 850.0                                | 0.0                                       |
| SteicoFlex                                   | 0.0 (150.0)                            | 60.0                            | 2100.0                               | 0.0                                       |
| Beltermo Kombi                               | 0.0 (100.0)                            | 110.0                           | 2100.0                               | 0.0                                       |
| Beltermo Ultra                               | 0.0 (50.0)                             | 180.0                           | 2100.0                               | 0.0                                       |
| Ampatex Sinco                                | 0.0 (-)                                | 280.0                           | 850.0                                | 0.0                                       |
| Airspace, heat flow upwards, 25 mm thick     | 25.0 (25.0)                            | 1.2                             | 1008.0                               | 30996.0                                   |
| Gyproc Wallboard                             | 12.5 (12.5)                            | 950.0                           | 850.0                                | 10093750.0                                |
| Total                                        |                                        |                                 |                                      | 10124746.0                                |
| kappa value                                  |                                        |                                 |                                      | 10.1247                                   |
| Limiting condition:                          | insulation                             |                                 |                                      |                                           |

Admittance : 1.37 W/m<sup>2</sup>K    Decrement : 0.16 factor    Decrement delay : -13.78 hours

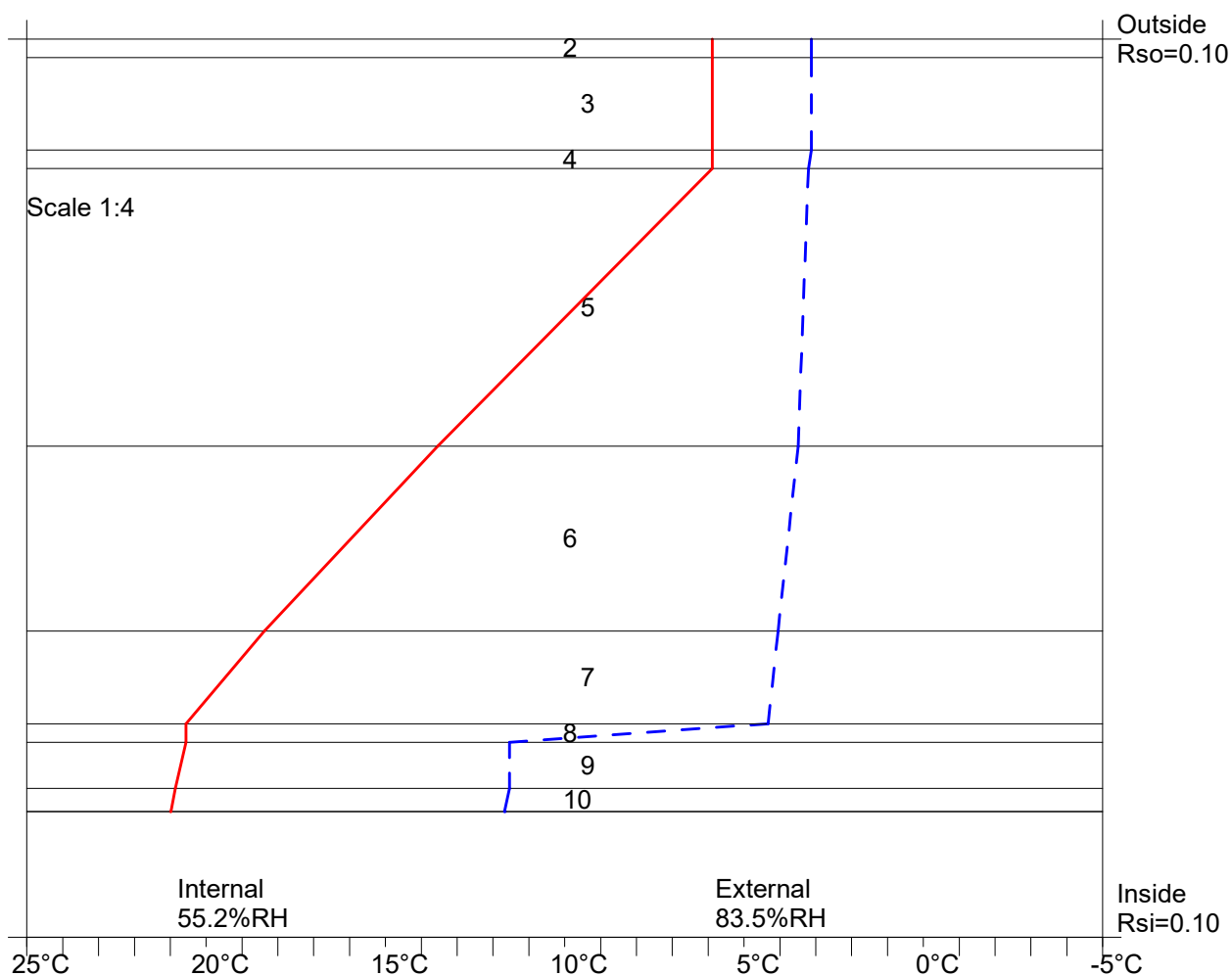
## Condensation Risk Analysis (no account taken of thermal bridges)

### 3 - Dwellings with low occupancy

| Jan         | Feb (worst) | Mar         | Apr         | May         | Jun         | Jul         | Aug         | Sep         | Oct         | Nov         | Dec         |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| 21.0C 56.1% | 21.0C 55.2% | 21.0C 55.5% | 21.0C 56.2% | 21.0C 59.3% | 21.0C 64.3% | 21.0C 68.8% | 21.0C 69.3% | 21.0C 66.6% | 21.0C 63.2% | 21.0C 58.2% | 21.0C 57.0% |
| 5.9C 85.5%  | 5.7C 83.5%  | 6.9C 82.0%  | 8.8C 79.5%  | 11.5C 79.0% | 14.3C 79.5% | 16.1C 80.5% | 16.0C 81.5% | 14.3C 83.0% | 11.9C 85.0% | 8.5C 84.5%  | 7.0C 85.5%  |

|                                                | Interface Temp. °C | Dewpoint Temp. °C | Vapour Pressure (kPa) | Saturated V.P. (kPa) | Worst Cond. (g/m <sup>2</sup> ) | Peak Buildup (g/m <sup>2</sup> ) | Condensation |
|------------------------------------------------|--------------------|-------------------|-----------------------|----------------------|---------------------------------|----------------------------------|--------------|
| 1 Outside surface resistance                   |                    |                   |                       |                      |                                 |                                  |              |
| 2 Pitched roof, tiles, with underlay or boards | 5.9                | 3.1               | 0.76                  | 0.93                 |                                 |                                  | No           |
| 3 Airspace, heat flow upwards, 50 mm thick     | 5.9                | 3.1               | 0.76                  | 0.93                 |                                 |                                  | No           |
| 4 Ampatex Aero                                 | 5.9                | 3.1               | 0.76                  | 0.93                 |                                 |                                  | No           |
| 5 SteicoFlex                                   | 5.9                | 3.2               | 0.77                  | 0.93                 |                                 |                                  | No           |
| 6 Beltermo Kombi                               | 13.5               | 3.5               | 0.78                  | 1.55                 |                                 |                                  | No           |
| 7 Beltermo Ultra                               | 18.4               | 4.1               | 0.82                  | 2.11                 |                                 |                                  | No           |
| 8 Ampatex Sinco                                | 20.6               | 4.3               | 0.83                  | 2.42                 |                                 |                                  | No           |
| 9 Airspace, heat flow upwards, 25 mm thick     | 20.6               | 11.5              | 1.36                  | 2.42                 |                                 |                                  | No           |
| 10 Gyproc Wallboard                            | 20.9               | 11.5              | 1.36                  | 2.46                 |                                 |                                  | No           |
| 11 Inside surface resistance                   | 21.0               | 11.7              | 1.37                  | 2.48                 |                                 |                                  | No           |

Worst case internal / external conditions for graph : 21.0°C @ 55.2%RH / 5.7°C @ 83.5%RH



## Condensation Risk Analysis (no account taken of thermal bridges)

### 3 - Dwellings with low occupancy

| Jan         | Feb (worst) | Mar         | Apr         | May         | Jun         | Jul         | Aug         | Sep         | Oct         | Nov         | Dec         |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| 21.0C 56.1% | 21.0C 55.2% | 21.0C 55.5% | 21.0C 56.2% | 21.0C 59.3% | 21.0C 64.3% | 21.0C 68.8% | 21.0C 69.3% | 21.0C 66.6% | 21.0C 63.2% | 21.0C 58.2% | 21.0C 57.0% |
| 5.9C 85.5%  | 5.7C 83.5%  | 6.9C 82.0%  | 8.8C 79.5%  | 11.5C 79.0% | 14.3C 79.5% | 16.1C 80.5% | 16.0C 81.5% | 14.3C 83.0% | 11.9C 85.0% | 8.5C 84.5%  | 7.0C 85.5%  |

|                                                | Interface Temp. °C | Dewpoint Temp. °C | Vapour Pressure (kPa) | Saturated V.P. (kPa) | Worst Cond. (g/m <sup>2</sup> ) | Peak Buildup (g/m <sup>2</sup> ) | Condensation |
|------------------------------------------------|--------------------|-------------------|-----------------------|----------------------|---------------------------------|----------------------------------|--------------|
| 1 Outside surface resistance                   |                    |                   |                       |                      |                                 |                                  |              |
| 2 Pitched roof, tiles, with underlay or boards | 16.2               | 12.8              | 1.47                  | 1.84                 |                                 |                                  | No           |
| 3 Airspace, heat flow upwards, 50 mm thick     | 16.2               | 12.8              | 1.47                  | 1.84                 |                                 |                                  | No           |
| 4 Ampatex Aero                                 | 16.2               | 12.8              | 1.47                  | 1.84                 |                                 |                                  | No           |
| 5 SteicoFlex                                   | 16.2               | 12.8              | 1.47                  | 1.84                 |                                 |                                  | No           |
| 6 Beltermo Kombi                               | 18.6               | 12.8              | 1.48                  | 2.14                 |                                 |                                  | No           |
| 7 Beltermo Ultra                               | 20.2               | 13.0              | 1.49                  | 2.36                 |                                 |                                  | No           |
| 8 Ampatex Sinco                                | 20.9               | 13.0              | 1.50                  | 2.46                 |                                 |                                  | No           |
| 9 Airspace, heat flow upwards, 25 mm thick     | 20.9               | 15.0              | 1.70                  | 2.46                 |                                 |                                  | No           |
| 10 Gyproc Wallboard                            | 21.0               | 15.0              | 1.70                  | 2.48                 |                                 |                                  | No           |
| 11 Inside surface resistance                   | 21.0               | 15.1              | 1.71                  | 2.48                 |                                 |                                  | No           |

Worst case internal / external conditions for graph : 21.0°C @ 68.8%RH / 16.1°C @ 80.5%RH

