DUBLIN SCHOOL OF ARCHITECTURE

DUBLIN INSTITUTE OF TECHNOLOGY

DT 9771 POSTGRADUATE CERTIFICATE IN BUILDING PERFORMANCE (ENERGY EFFICIENT DESIGN)

MODULE ENEN9105: HYGROTHERMAL RISK ASSESSMENT FOR BUILDING PERFORMANCE

Project: Assessment of the roof of an "NZEB-blitzing A2 Home" Renovation

STUDENT: [redacted]

STUDENT NO: [redacted]

Submission Date: 7th May 2018

Contents

1 Introduction

Mr. and Mrs. Black of Bla Bla townland, Askeaton, Co. Limerick, have instructed the author to carry out a desktop hygrothermal risk assessment on the roof assembly of their property, which was completed on 1st October 2018 and has now found to be showing signs on significant rot in the racking board of the assembly. The parties involved in the construction of the roof have been consulted and a number of potential causes of the damage to the wooden element of the assembly have been postulated.

It is the purpose of this report to assess the roof assembly using hygrothermal numerical modelling software, based on the information provided by the Client. Having analysed the results of the numerical simulations, potential causes for the observed degradation of the roof are offered.

The conclusions reached as a result of the numerical simulations are subject to a number of limitations, primarily the restrictions of a desktop study with regards on-site, as-built information and the limitations of the modelling software. These limitations are outlined in Section 2 to inform the Client with regards the levels of uncertainty associated with this type of study and analysis.

The following hygrothermal risk assessment is carried out using WUFI Pro; 1-Dimensional numerical modelling software by the Fraunhofer Institute for Building Physics, which simulates multi-layer building assemblies in compliance with I.S EN 15026:2007. The software performs detailed realistic simulations of combined heat and moisture transfer through building assemblies using detailed weather data.

2 Numerical Modelling

Hygrothermal risk assessment is carried out using WUFI Pro 6.1; 1-Dimensional numerical modelling software by the Fraunhofer Institute for Building Physics, which simulates multi-layer building assemblies in compliance with I.S EN 15026:2007. The software performs detailed, realistic simulations of transient heat and moisture transfer in multi-layer building envelope components, subjected to non-steady state conditions on either side. The results of these models, in combination with the professional judgement of a trained expert, can be used to assess risk of interstitial condensation, mould growth and transient hygrothermal performance of building assemblies over a specified time period.

According to the BSI White Paper (2016), moisture has become a major cause of building damage, with estimated 75-80% of all problems with building envelopes being caused to a certain extent by moisture. This highlights the need for this type of numerical simulation and the development of expertises required in this area within the construction sector.

There are, however, limitations with the technology which should be clarified prior to outlining the methodology and simulations carried out under this risk assessment.

Firstly, hygrothermal numerical simulation is not a measurement system due to limitations in its accuracy and precision. It is more so used to paint a landscape of risk around the moisture related performance of a building element, given numerous different variables, assumptions and uncertainties.
In conjunction with this, input data has inherent imprecision and inaccuracy associated with:

- External climate conditions associated with usual variation, unforeseen circumstances and climate change.
- Internal conditions and the assumptions and variations in occupant behaviour.
- Initial Conditions
- Material Properties and availability of verified material performance data.
- Variance between theoretical assumptions and As-Built-In-Service (ABIS) conditions
- Junctions and any thermal bridges associated with the assembly are outside the scope of these simulations.

3 Methodology

The hygrothermal simulation models are based on information provided by the Client. The designed roof construction consists of the following materials:

Layer	Path	Material	Thickness [mm]	Area Fraction F	Thermal Conductivity λ [W/mK]	Source of Data
		External	-			
1		Slate Tiles	19		2.2	TGD Part L Table A1
2		Softwood Timber Battens	25		0.13	TGD Part L Table A1
3		Softwood Timber Counter Battens	25		0.13	TGD Part L Table A1
4		Sarking Felt (Solitex Plus Vapour Permeably Roofing Underlay)	1		0.17	Manufacturers data
5		ACME #2 EPS Insulation	50		0.036	Manufacturers data
6		OSB Board (Racking Board and Airtight Layer)	18		0.13	BS EN 12524 : 2000
7	a	ACME #1 EPS Insulation (Between Rafters)	165	0.91	0.031	Manufacturers data
	b	Rafters	165	0.09	0.13	TGD Part L Table A1
8		PlasterBoard	12.5		0.25	TGD Part L Table A1
		Internal	-			

Table 1*: Make-up of the roof assembly as advised by Client*

3.1 Base Case

For the most part, the materials that make up the roof assembly are common construction materials used in Ireland in roof construction. The hygrothermal performance of the roof will predominantly be affected by the type of specialist insulating material used and how the materials in the roof assembly are combined. The insulating materials used in this case are 50mm ACME #2 EPS Insulation (λ=0.036 [W/mK]) installed on the outer face of the racking board and 165mm of ACME #1 EPS Insulation (λ=0.031 [W/mK]) installed between the rafters. How these insulants will affect the transfer of moisture through the assembly is determined by the "Breathability" of these materials, which in essence is a combination of their Vapour Resistivity, Hygroscopicity and Capillarity. Assuming water ingress should not be an issue if the assembly is constructed as designed, Vapour Resistivity should be the dominant property that will affect the hygrothermal performance of the assembly.

The Vapour Resistivity of the ACME EPS (70 and 100) was not provided by the Client and is not listed on the manufacturers material datasheet or NSAI Agrément Cert (Appendix A), nor was it available in the WUFI Material Database to allow exact modelling of the material. It was therefore decided use similar, comparable materials from the WUFI Database and to take a 'bracketing' approach to the simulations to the overcome the limitations of uncertainly associated with not having the exact materials to choose from. This approach gives a likely range of performance for the EPS material used, based on the comparable materials available.

To select the materials that would be used in the bracketing modelling strategy, 4 No. EPS materials from the WUFI database with appropriate thermal, density and hygrothermal performance properties were compared to select the two most appropriate.

The EPS materials used in modelling the roof assemblies were:

- LTH Lund University Sweden Polystyrene Expanded (thermal conductivity: 0.04W/mK ; density 20kg/m3 ; Vap Res 21.7) (Shown in **RED**)
- Fraunhofer-IBP EPS (thermal conductivity: 0.04W/mK ; density 15kg/m3 ; Vap Res 30) (Shown in **GREEN**)
- Fraunhofer-IBP EPS (thermal conductivity: 0.04W/mK ; density 30kg/m3 ; Vap Res 50) (Shown in **GOLD**)
- North America Database Expanded Polystyrene Insulation (thermal conductivity: 0.036W/mK ; density 14.8kg/m3 ; Vap Res 73.01) (Shown in **BLUE**)

The results are shown in *Fig 1* below:

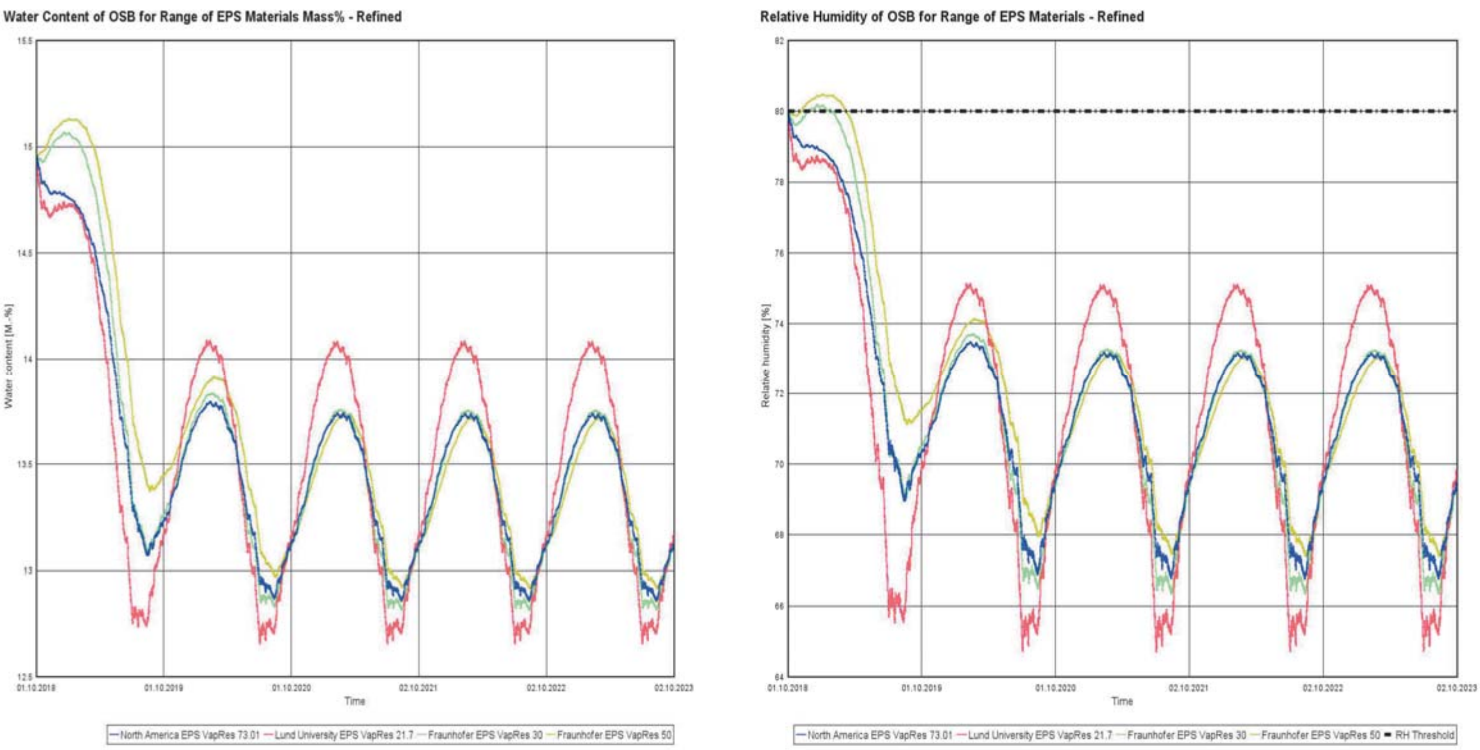


***Fig 1**: Comparison of Water Content and Relative Humidity of EPS Materials in WUFI database.*

The output of the models suggested two important findings in the context of this assessment:

1. The Racking Board for all four roof assemblies modelled performed within the acceptable range for both Water Content (Mass %) and Relative Humidity (%). The accepted risk threshold for timber rot is 18 Mass-% moisture content (as per DIN 68800) and 80% Relative Humidity (as per BS5250 guidelines). As seen from *Fig 1* above, all four assemblies perform well below this threshold. This would suggest

that the design of the Base Case should not be experiencing material degradation of the racking board, if installed in-line with the Architects design.

2. The **LTH Lund University EPS (Vap Res [µ] = 21.7)** and the **North America Database EPS (Vap Res [µ] = 73.01)** perform at the outer limits of the 4 materials modelled, primarily due to their relatively low and high Vapour Resistivity respectively. When compared to ISO10456 Table 4 (Moisture properties of thermal insulation materials materials), which gives EPS Vapour Resistance Factor (µ) = 60 (wet) – 60 (dry), their vapour resistant properties also seem to be on the upper and lower end of the spectrum. It would therefore be appropriate to use these two materials in the hygrothermal bracketing strategy, given that the hygrothermal performance of the ACME EPS would be likely to be somewhere in between these materials.

3.2 Parametric Study

From the modelled performance of the Base Case, it was shown that the roof assembly should not be experiencing issues with timber rot in the racking board under design conditions. It was therefore necessary to simulate a number of non-ideal hygrothermal conditions to stress the assembly and determine the possible causes of the racking board degradation.

3.2.1 Air Infiltration

It may be possible that the installation of the EPS100 between the rafters and the plasterboard beneath were not installed correctly and moist air from inside the house is making its way between gaps and cracks to the warm side of the OSB, which may be causing elevated moisture levels in the board.

To test this situation, a model for both the Lund EPS and North America EPS was simulated with an Air Infiltration to the inner 5mm of the OSB Board on the warm side of the board. A q50 value of $10m^3/m^2h$ was assigned to the level of air infiltration, which would be considered a realistic but high level of air infiltration (current Irish Building Regulations set a maximum allowable q50 value of $7m^3/m^2h$).

3.2.2 High Moisture Load and Air Leakage

It may be possible that the installation of the EPS100 between the rafters and the plasterboard beneath were not installed correctly and very moist air from inside the house is making its way between gaps and cracks to the warm side of the OSB, which may be causing elevated moisture levels in the board. The possibility of an unusually high moisture load may be as a result of 3 No. bathrooms and 3No. young adults in the property.

To test this situation, a model for both the Lund EPS and North America EPS was simulated with an Air Infiltration to the inner 5mm of the OSB Board on the warm side of the board (again, q50 value of $10m^3/m^2h$ was assigned) and a high mean-value for Relative Humidity of the internal climate of 60% was set. 60% is considered the upper limit of acceptable internal RH levels to maintain the health of the building envelope and its occupants.

3.2.3 Ingress of Driving Rain

It may be possible that the installation of the roof tiles and sarking was carried out incorrectly and that water infiltration is occurring when it rains. If this rain ingress is making its way to the OSB board, it could potentially be a cause of the degradation of the OSB that has been observed.

To test this situation, a model for both the Lund EPS and North America EPS was simulated with a 1% Ingress of Driving Rain to the outer 5mm of the OSB Board on the cold side of the board. A 1% fraction of driving rain would be considered a reasonable figure for potential infiltration (2% would be considered very high).

3.2.4 Saturated Racking Board

It may be possible, although no direction has been given by the Client, Architect or Builder, that the racking board was saturated with water at the time of installation, possibly due to heavy rain prior to completion of the roof assembly. If the water content and/or relative humidity of the OSB board did not then sufficiently reduce and dry-out upon completion of the roof assembly, it could over time lead to the degradation of the OSB that has been observed.

To test this situation, a model for both the Lund EPS and North America EPS was simulated with the Initial Conditions of the OSB set to a saturated condition. The water content for a saturated condition was taken from the WUFI database Moisture Storage Function which provides the material water content at 100% RH. In the case of OSB board, this is 636kg/m^3.

3.2.5 Plywood Racking Board

It was noted from the photographic evidence provided by the Client that the racking board seems to be Plywood and not OSB as specified. If this is the case, the material properties of the Plywood would differ from that of OSB at its performance under the conditions may also differ. This could potentially be a causing factor in the degradation of the racking board that has been observed.

To test this situation, a number of models using the North America EPS (more vapour resistant of the two) were simulated using both OSB and Plywood as the racking board material. The models simulated were:

- Plywood vs OSB – Base Case
- Plywood vs OSB – Ingress of Driving Rain
- Plywood vs OSB – Saturated Racking Board (Initial Conditions)

4 Input and Output Data

4.1 Input Data & Settings Selected

4.1.1.1 External Climate

Irish climate data is not available by default in the WUFI database. Meteonorm™ software has been used to produce hourly data for Shannon Airport based of data from local weather stations.

4.1.1.2 Orientation

In the case of roofs, where water ingress should not be an issue, the most vulnerable orientation is the North facing pitch which receives the lowest amount of direct sunlight and has the least opportunity to dry out. In the case where the potential of a leak is simulated, the most vulnerable orientation in Ireland is South-West due to its increased exposure to driving rain.

4.1.1.3 Internal Climate

Internal climate conditions were set to Medium Moisture Load (as per EN 15026) for the base case scenario to model how the roof assembly performed under unstressed conditions. The Client did advise however that there were three bathrooms and three young adults in the property which could elevate base internal moisture levels. To test the robustness of the assembly and simulate ingress of moist air, a simulation with an elevated Mean Relative Humidity level was run (60% mean RH).

4.1.1.4 Model Duration

The models were found to reach equilibrium over a 5 year period. Although the roof assembly has began to fail after only 3 years, it is essential in hygrothermal modelling to run the simulation until it has reached annual equilibrium to ensure all types of moisture transfer can be observed and assessed over time.

In the case where the initial conditions of the OSB were in a saturated state, the model was run for 10 years as it had not reached equilibrium after 5 years, due to the high initial moisture content.

4.2 WUFI Build-Up

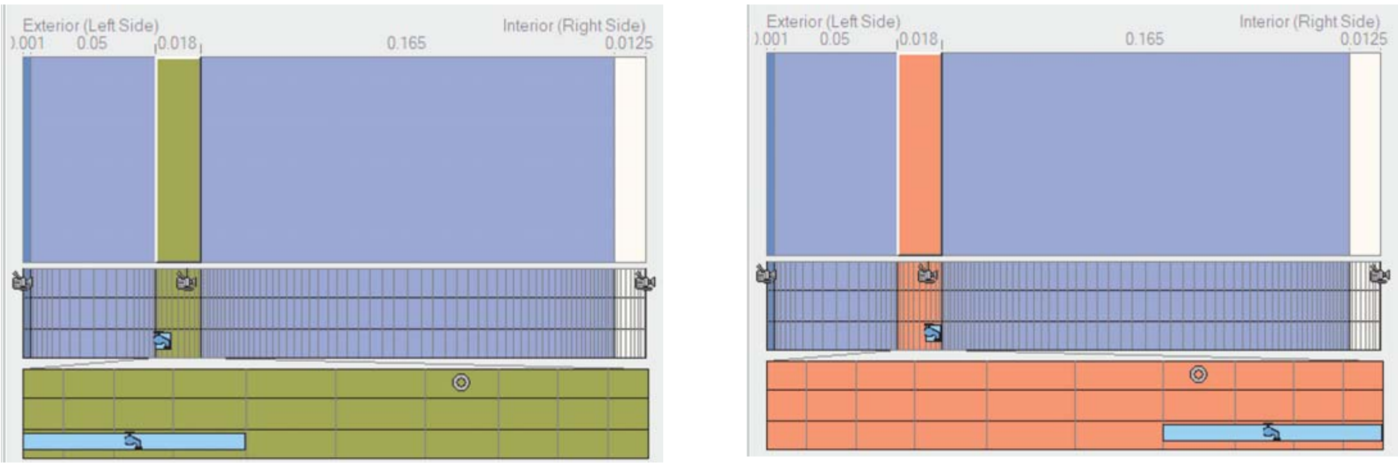


***Fig 2:** 1D WUFI Models of Roof Assembly showing OSB and Ply racking boards. Examples above show Rain Ingress and Air Infiltration conditions respectively (blue section with tap icon).*

Note: Modelling the OSB as 1x18mm board or 3x6mm board was shown to make a negligible difference to simulation outputs.

4.3 Software Output Results Accuracy - Convergence & Water Balance

The Numerical Simulation Principle in WUFI is that each layer of a multi-layered building element is subdivided into a grid with a number of elements. Differential equations are then solved for each grid element for heat and moisture storage within that grid for each unit of time.

The equations are solved simultaneously in WUFI and, as heat and moisture transport are intrinsically coupled physical processes, the heat and moisture transfer results must correspond and converge. If the results of the heat and moisture storage equations don't correspond, then numerical instability is created and the accuracy and quality of the software output becomes distorted and questionable.

In the WUFI Results, "Convergence Failures" and differences in the calculated Moisture Balances ("Balance 1" and "Balance 2") indicate poor quality results and must be minimised in simulations. This can be achieved by refining the grid to a finer mesh and, if necessary, introducing Adaptive Time Step Control to further enhance processing when WUFI encounters a modelling issue. Below is an example of a model run showing no convergence issues and minimal Moisture Balance differences. These results would suggest accurate results given the operating parameters of the software.

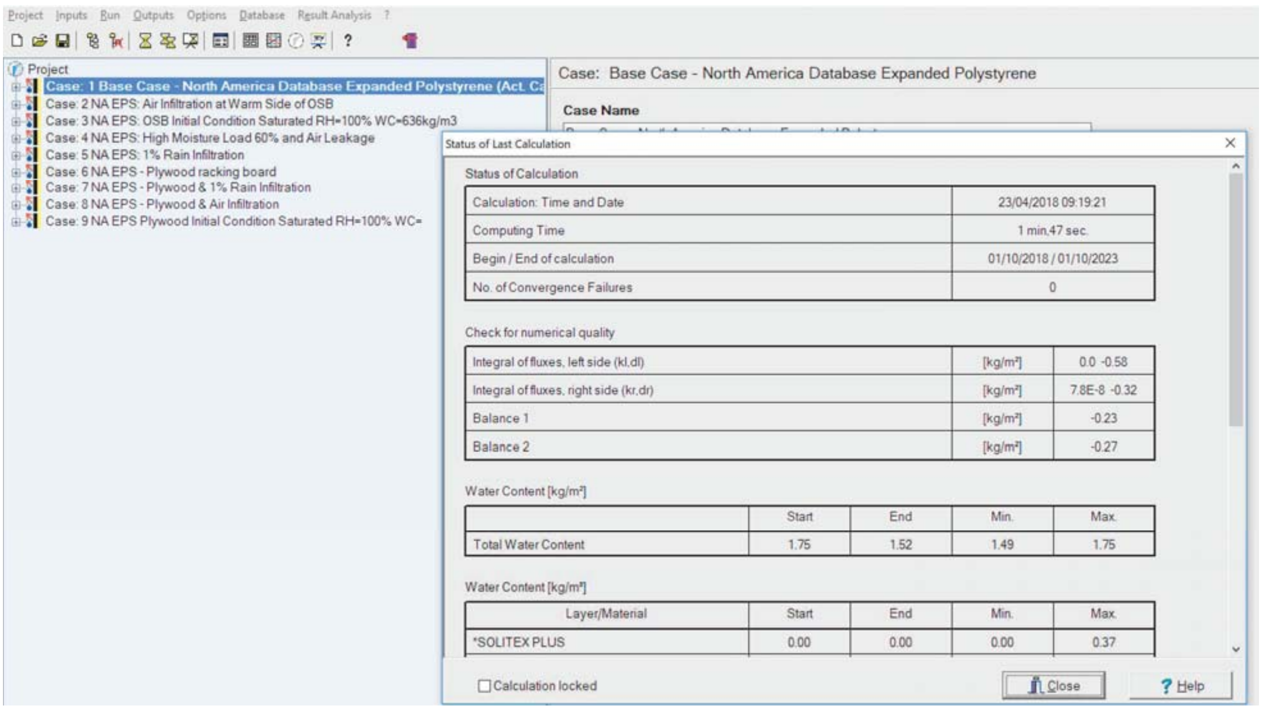


Fig 3: *Calculation Log Output for WUFI Simulation showing Convergence Failures and Water Balances*

In thes Water Content graphs and Relative Humidity graphs shown below, the effect of convergence failures and Water Balance differences can be seen in the graphical outputs from the software. Following elimination of convergence failures by refining the grid and using Adaptive Time Step Control, the improvement in accuracy of the calculations can be seen – especially in the Water Content course and Relative Humidity course for the building assembly using the Lund EPS. Because of the lower vapour resistivity of this material, moisture movement through the assembly is elevated in comparison to the other assemblies which led to calculation issues. Upon refinement of the calculation methodology within the software, a reduction in the maximum water content within the OSB board equilibrium condition can be seen as well as a levelling out of the yearly peaks.

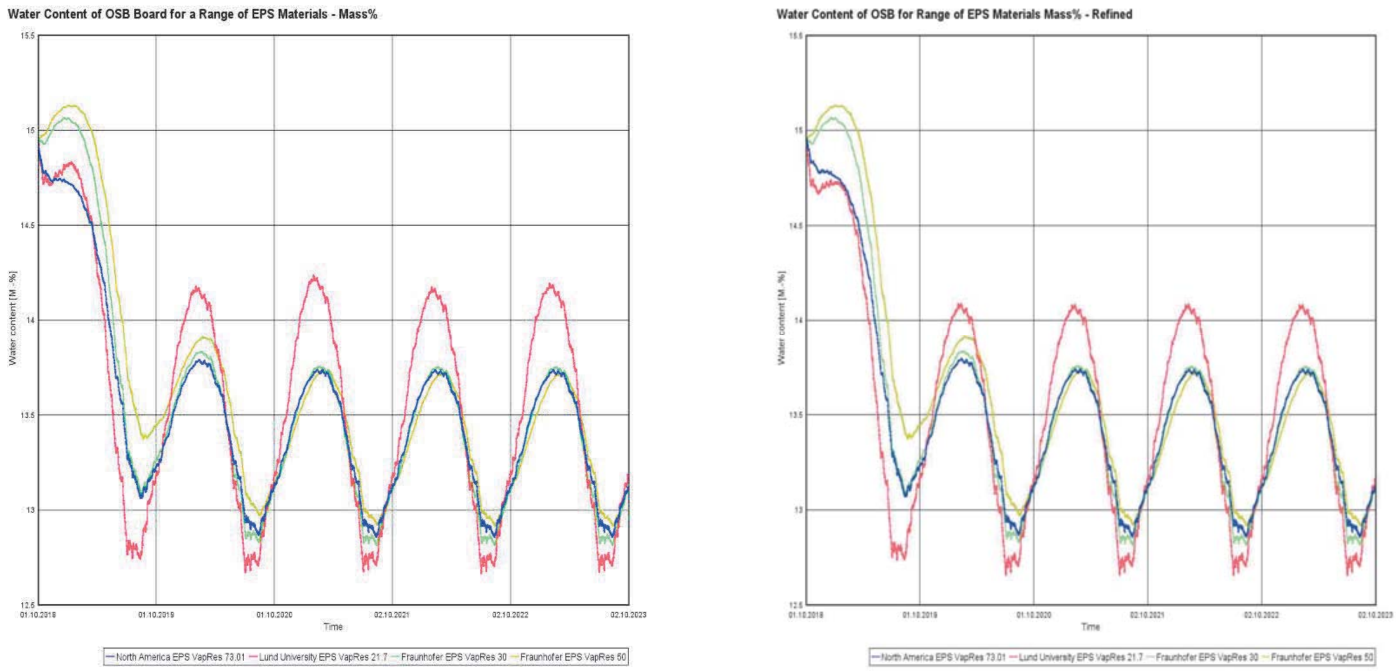


***Fig 4:** Comparison of WUFI output for Water Content when convergence failures and Water Balance divergence is minimised.*

For the graphs above and below, the following EPS materials from the WUFI database are shown:

- LTH Lund University Sweden Polystyrene Expanded (Shown in **RED**)
- Fraunhofer-IBP EPS (Shown in **GREEN**)
- Fraunhofer-IBP EPS (Shown in **GOLD**)
- North America Database Expanded Polystyrene Insulation (Shown in **BLUE**)

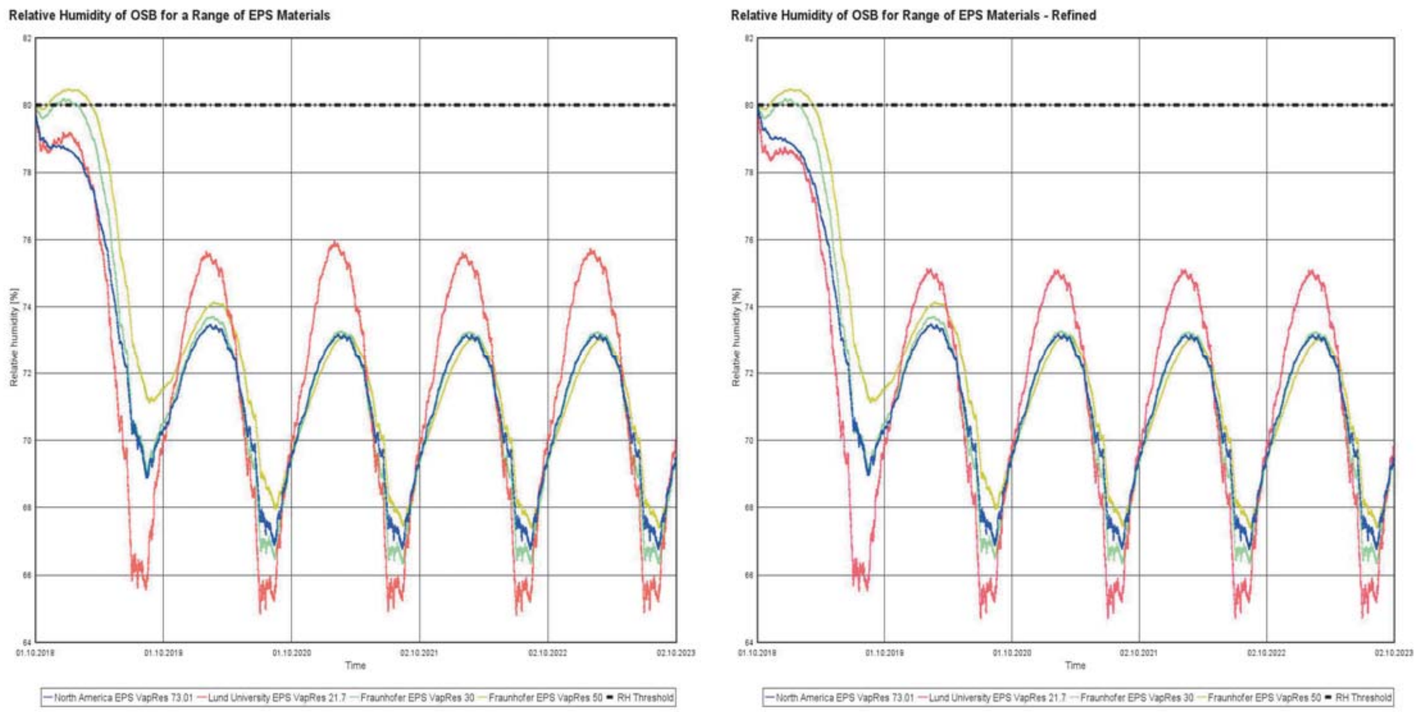


***Fig 5:** Comparison of WUFI output for Relative Humidity when convergence failures and Water Balance divergence is minimised*

5 Results & Analysis

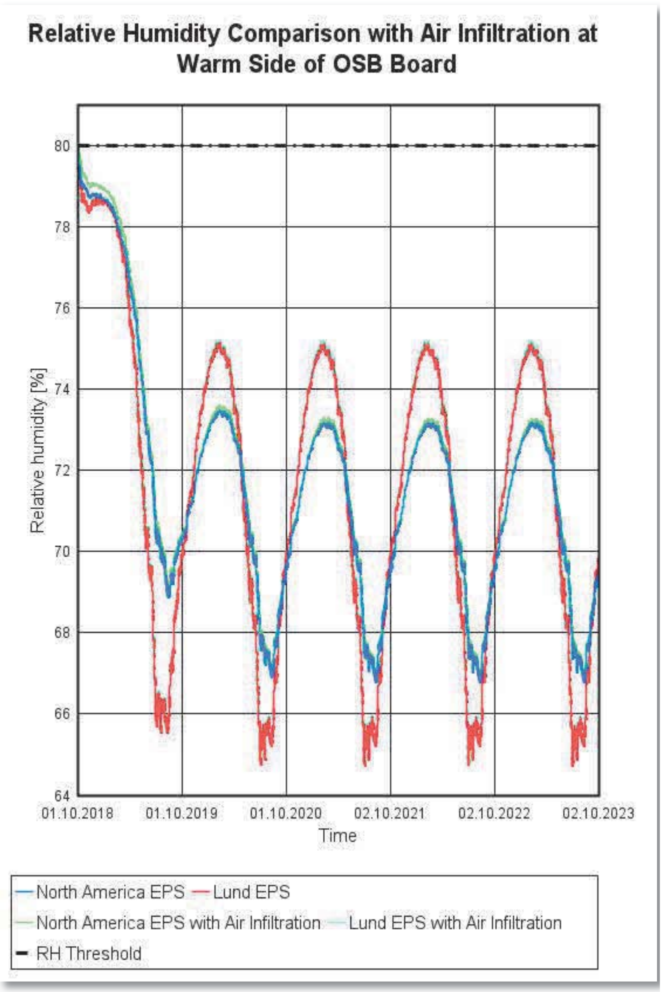
In accordance with BS5250, analysis should assess the risk of surface condensation, mould growth and interstitial condensation using three criteria for assessment:

1. The average Relative Humidity at internal surfaces does not exceed 80%, the limit for mould growth
2. Any interstitial condensation which might occur in winter should evaporate during the following summer, preventing an accumulation of moisture year on year.
3. The risk of degradation of materials should be assessed in terms of the maximum level of condensate which might occur.

In relation to point No. 3 above, the accepted risk threshold for timber rot is 18 Mass-% moisture content (as per DIN 68800).

Therefore, in the analysis of the simulations undertaken on the roof assembly, the analysis was focused on assessing the Relative Humidity within the Racking Board across a range of initial and operating conditions and also assessing whether the Moisture Content in the board exceeded 18% for extended periods without sufficient evaporation occurring in the summer months.

5.1 Air Infiltration



It may be possible that the installation of the EPS between the rafters and the plasterboard beneath was not installed correctly and moist air from inside the house is making its way between gaps and cracks to the warm side of the OSB, which may be causing elevated moisture levels in the board.

To test this situation, a model for both the Lund EPS and North America EPS was simulated with an Air Infiltration to the inner 5mm of the OSB Board on the warm side of the board. A q50 value of $10m^3/m^2h$ was assigned to the level of air infiltration, which would be considered a realistic but high level of air infiltration (current Irish Building Regulations set a maximum allowable q50 value of $7m^3/m^2h$).

A simulation of this situation, monitored within the OSB board, for the Lund and North America EPS was compared to the Base Case for both EPS materials.

In all situations, the simulation showed that RH levels in the OSB after the initial drying out period (year 1), was maintained below the risk RH threshold of 80% with RH levels peaking in the winter and falling off over the summer months

5.2 High Moisture Load and Air Leakage

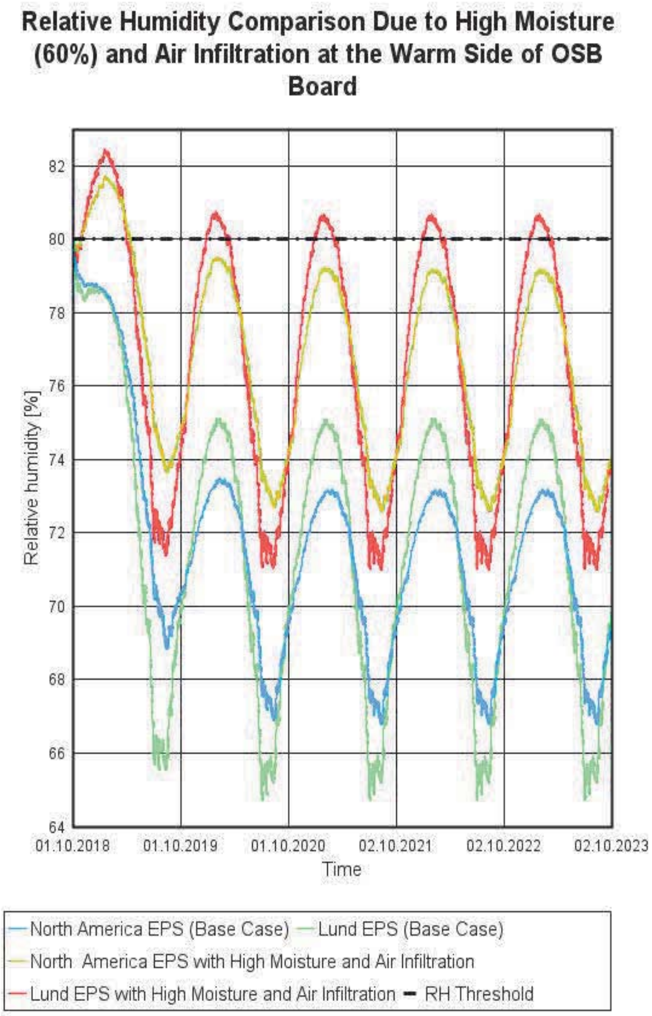


Fig 7: *RH Comparison with High Moisture content and Air Infiltration*

It may be possible that the installation of the EPS100 between the rafters and the plasterboard beneath was not installed correctly and very moist air from inside the house is making its way between gaps and cracks to the warm side of the OSB, which may be causing elevated moisture levels in the board. The possibility of an unusually high moisture load may be as a result of 3 No. bathrooms and 3No. young adults in the property.

A simulation of this situation, monitored within the OSB board, for the Lund and North America EPS was compared to the Base Case for both EPS materials.

It can be seen that for elevated moisture conditions within the property (mean RH = 60%), the OSB board experiences high levels of RH for both the EPS materials, especially in year 1. In the case of the Lund EPS, the RH exceeds the 80% threshold each winter thereafter, but diminishes during the summer, year on year.

The amplitude of the Lund EPS (μ=21.7) exceeds that of the North America EPS (μ=73.01) as it has a lower Vapour Resistivity and therefore allows moisture to pass through it more easily. In this situation, moist air can more easily penetrate through to the EPS during winter, but during summer it can more easily evaporate out from the OSB board.

Given that the ACME EPS material used is likely to perform in the region between the Lund EPS and the North America EPS, it is likely that it will approach the 80% threshold for a short duration each year. There is therefore some risk that interstitial condensation is occurring in the OSB during the winter due to infiltration of moisture laden air, but would be on or near the threshold and only exists for a short duration before evaporating. It is therefore unlikely that this situation is the cause of a large moisture problem and a badly rotting racking board observed after only three years of service.

5.3 Ingress of Driving Rain

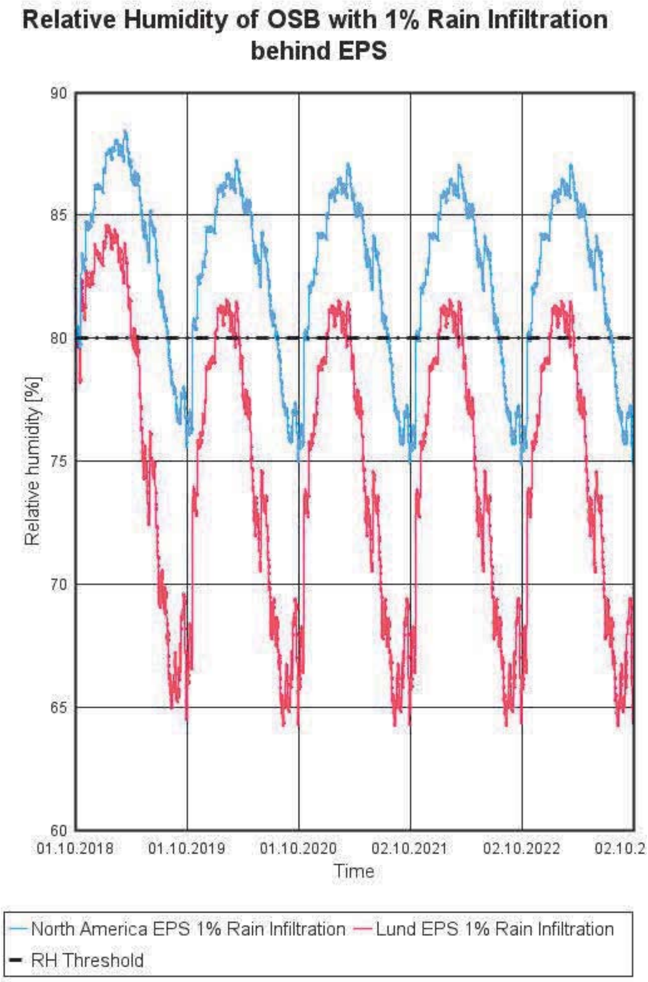


Fig 8: *RH Comparison with Infiltration of Driving Rain*

It may be possible that the installation of the roof tiles and sarking was carried out incorrectly and that water infiltration is occurring when it rains. If this rain ingress is making its way to the OSB board, it could potentially be a cause of the degradation of the OSB that has been observed.

To test this situation, a model for both the Lund EPS and North America EPS was simulated with a 1% Ingress of Driving Rain to the outer 5mm of the OSB Board on the cold side of the board. A 1% fraction of driving rain would be considered a reasonable figure for potential infiltration (2% would be considered very high).

It can be seen that a potential ingress of rain to the OSB board results in a substantial increase in Relative Humidity within the board, especially in the North America EPS.

Due to the high vapour resistivity of the North America EPS, the rain absorbed by the OSB board takes a considerable amount to time to evaporate when temperatures rise within the assembly as the EPS resists the movement of moisture internally and externally.

Given that the ACME EPS material used is likely to perform in the region between the Lund EPS and the North America EPS, it is likely that this situation would cause elevated RH levels in the OSB board for large portions of the year. While the RH falls below the threshold during the peak summer months, it is likely that the racking board will begin to degrade due to high moisture levels, above the accepted risk threshold, for large portions of the year – especially if the ACME EPS vapour resistivity is closer to that of the North America EPS than the Lund EPS.

The risk of potential timber rot due to elevated RH in the OSB board would suggest that it would be worthwhile investigating if there is a leak in the roof. This may turn out to be a localised issue with the roof installation or a recurring issue which could be causing more widespread damage to the racking board.

5.4 Saturated Racking Board

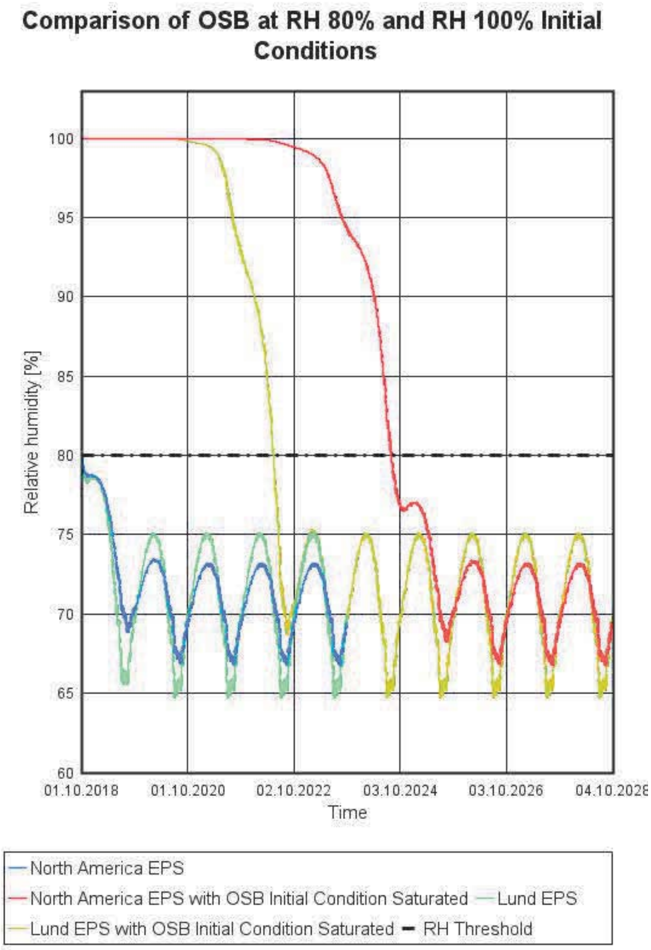


***Fig 9:** RH Comparison with Saturated Racking Board*

It may be possible, although no direction has been given by the Client, Architect or Builder, that the racking board was saturated with water at the time of installation, possibly due to heavy rain prior to completion of the roof assembly. If the water content and/or relative humidity of the OSB board did not then sufficiently reduce and dry-out upon completion of the roof assembly, it could over time lead to the degradation of the OSB that has been observed.

To test this situation, a model for both the Lund EPS and North America EPS was simulated with the Initial Conditions of the OSB set to a saturated condition. The water content for a saturated condition was taken from the WUFI database Moisture Storage Function which provides the material water content at 100% RH. In the case of OSB board, this is 636kg/m^3.

The base cases for the Lund and North America EPS are shown in green and blue on the adjacent graph. When compared to the saturated OSB condition, it is clear that there is a dramatic increase in the risk to the OSB board if the initial conditions are saturated.

In the case of the more vapour permeable Lund EPS (Gold line), it still takes over 3 years for the OSB RH to drop below the 80% risk threshold. In the case of the more vapour resistant North America EPS, this takes almost six year (Red line). The OSB would certainly experience significant timber rot if these conditions were realised.

It is almost certain that the OSB in the roof assembly with the ACME EPS would experience similar moisture issues if the initial condition was saturated. It should be investigated whether or not this could be the case as it would be extremely likely to be the cause of the observed rot in the Racking Board. The Builder, the domestic roofing subcontractor and the Architect should be consulted in this regard.

5.5 Plywood Racking Board

It was noted from the photographic evidence provided by the Client that the racking board material seems to be Plywood and not OSB as specified. If this is the case (although this has not been confirmed by the Client), the material properties of the Plywood would differ from that of OSB at its performance under varying conditions may also differ. This could potentially be a causing factor in the degradation of the racking board that has been observed.

To test this situation, a number of models were simulated for comparison. The models that were shown to present the greatest risk of condensation in the examples above were re-run with Plywood as the racking board material and compared to the performance of the OSB where it has been shown to be problematic. The models were run with the North America EPS as the insulant, as it's the more vapour resistant of the two EPS modelled and was therefore found to present the greater risk profile. The simulated models were:

- Plywood vs OSB – Base Case
- Plywood vs OSB – Ingress of Driving Rain
- Plywood vs OSB – Saturated Racking Board (Initial Conditions)

In all conditions, it was observed that the level of risk associated with the OSB was greater than that of the Plywood.

From the graphs in *Fig 10* below it can be seen that the assembly containing Plywood (represented by the Red line) initially performs worse than the OSB assembly, but by year 3 has reached equilibrium in both cases and poses a lower risk than OSB. For the condition where there is an infiltration of rain is present, the risk of timber rot is still present and should be investigated, similar to the recommendations in Section 5.3 above.

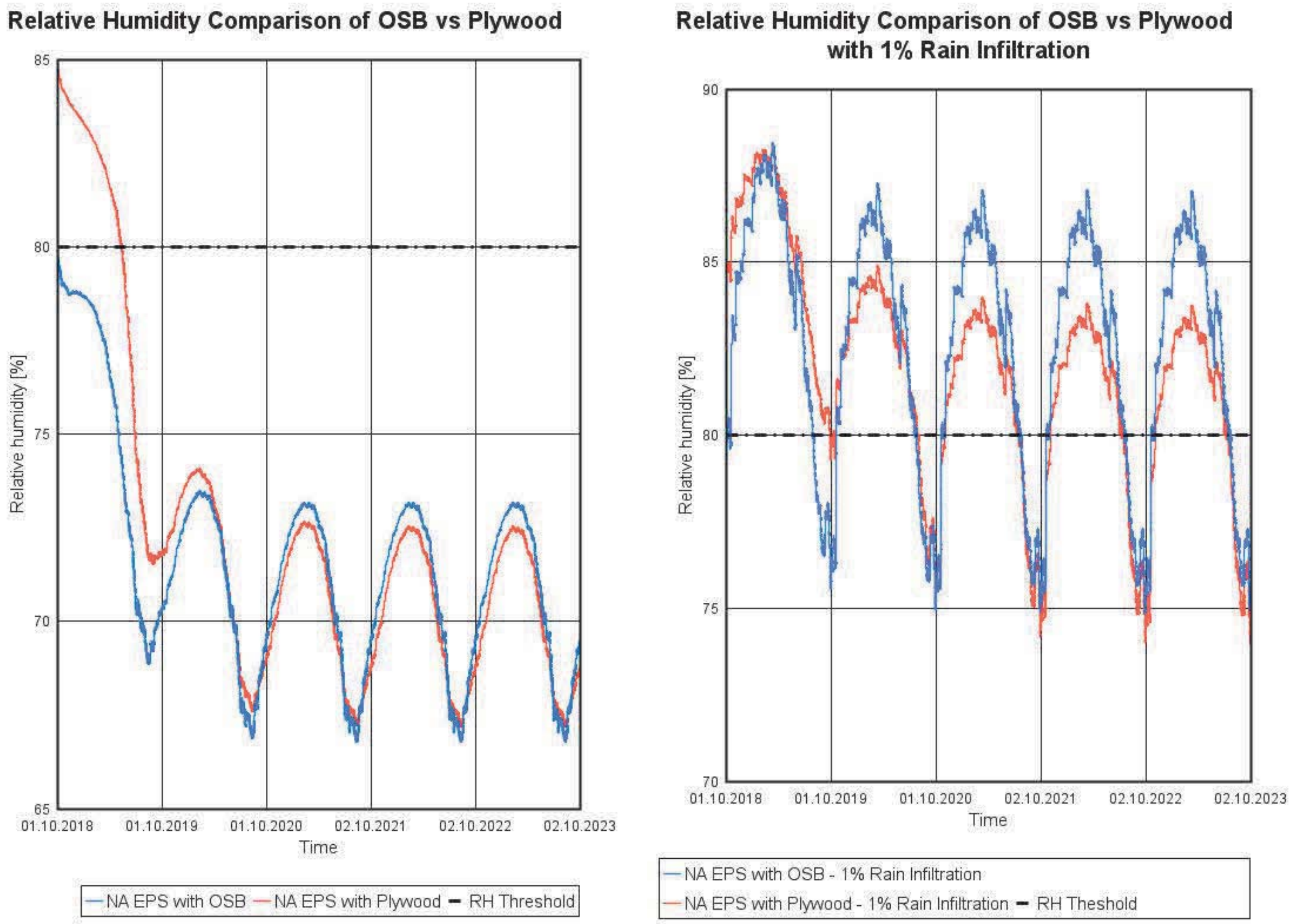


Fig 10: *RH Comparison of Plywood vs OSB under different conditions*

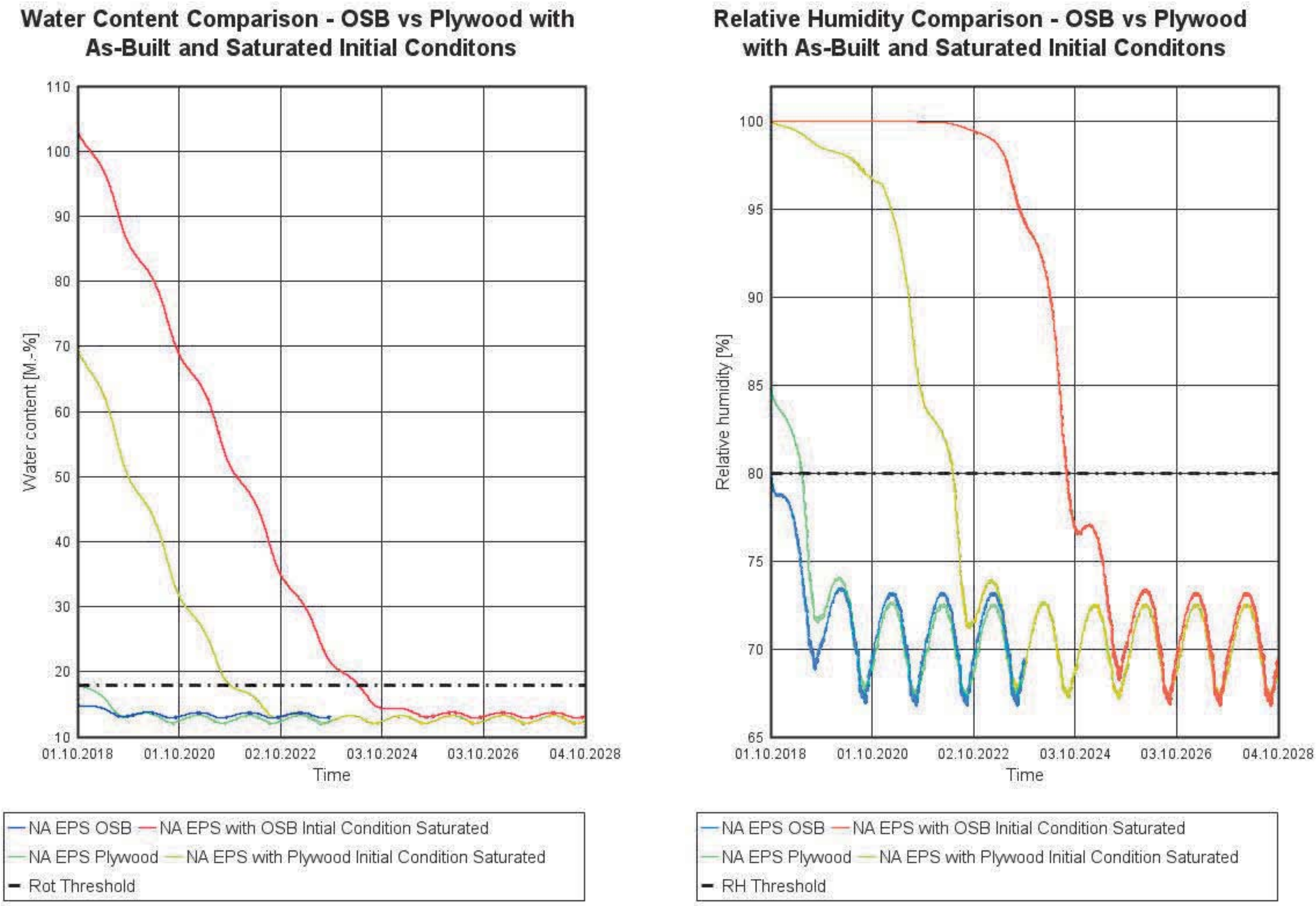


Fig 11: *RH Comparison of Plywood vs OSB under different conditions* ***(contd)***

From the graphs in *Fig 11* above it can be seen that the assembly containing Plywood (represented by the Gold line in the stressed conditions) again performs better than the OSB where initially the board is in a saturated condition, both in terms of Water Content and Relative Humidity.

However, for the saturated initial condition, the timeframe to dry out a point where the overall Water Content is less than 18% by Mass and the Relative Humidity is less than 80%, is 3-4 years into the lifetime of the assembly. The risk of timber rot is therefore still present and, in fact, quite likely and should be investigated further similar to the recommendations in Section 5.4 above.

6 Conclusions

Using the information provided by the Client with regards assembly build-up, materials used, observed damage and within the limitations of the hygrothermal numerical modelling software outlines in Section 2 above, the assessment concludes that:

- The designed build-up of the roof assembly (referred to as the 'Base Case' throughout) appears to perform within acceptable moisture limits if constructed as-designed.
- If the assembly is stressed to simulate air-ingress from the internal space to the warm side of the racking board, most likely caused by gaps and cracks from imperfect construction, the assembly should still perform within acceptable limits. In the case where the air infiltration is heavily laden with moisture (60% mean RH), there is a heightened risk of condensation within the racking board, however there is no accumulation year on year and the assembly should dry out relatively quickly following the peak winter months.
- If the assembly experiences ingress of water due to driving rain, most likely due to a leak in or across the roof structure, the risk of damage to the racking board and the likelihood of timber rot is high. The roof tiles and sarking should be inspected to assess whether there is an avenue for water ingress to the racking board.
- If, during the construction of the roof, the racking board was subjected to high water ingress prior to shielding from the external climate, the simulation suggests that the construction of the assembly would not allow for the racking board to dry out quickly enough to avoid timber rot. In this case, the conditions would almost certainly lead to the significant rot being observed on-site currently. The Builder, the domestic roofing subcontractor and the Architect should be consulted in this regard.
- From the photographic evidence provided by the Client, Plywood appears to have been used as the racking board material instead of the OSB specified. If this is the case, it would not have a detrimental effect on the performance of the assembly, however the risks highlighted above would still be valid and should be investigated.

7 Disclaimer

The content of this report, which has been commissioned by Mr. & Mrs. Black, of Bla Bla townland, Askeaton, Co. Limerick, is the property of the commissioners and shall be for their use only.

As set out in Section 2 above, the area of hygrothermal risk assessment of moisture transfer through building assemblies is an emerging area of risk evaluation and contains inherent uncertainties and assumptions. Indeed, hygrothermal numerical simulation, carried out in compliance with IS EN 15026, is not a measurement system due to limitations in its accuracy and precision. While every care is taken in the evaluation of simulations using competent professional judgement, the author shall not be liable for any consequential incident or damage associated with the use of the information provided in this report. It is purely the opinion of the author operating within the parameters of the information provided, the limitations of the software being utilised and the professional experience of same author.

8 Caveat & Context

Hygrothermal risk assessment is carried out using WUFI Pro 6.1; 1-Dimensional numerical modelling software by the Fraunhofer Institute for Building Physics, which simulates multi-layer building assemblies in compliance with I.S EN 15026:2007.

The WUFI software has been validated against measured data and materials used in the software are as close as possible to the real materials being used in the building assembly. While we endeavour to be as accurate as possible, there will be some divergence between the actual assembly performance and the simulated results. It is not possible to claim that the simulations match reality exactly. It is the objective of the author to match simulation and reality as closely as possible and use professional judgement to reflect reality as closely as possible.

The greatest impact on the output will come from the accuracy of the initial conditions and inputs. How and where the assembly with be located and the conditions it will experience will have the greatest impact on its performance. It is vital therefore, to maximise precision and accuracy by ensuring that the initial inputs reflect reality as closely as possible.

Appendix A – Source Materials

CI/SfB | (29)

IRISH AGRÉMENT BOARD
CERTIFICATE NO. 05/0235

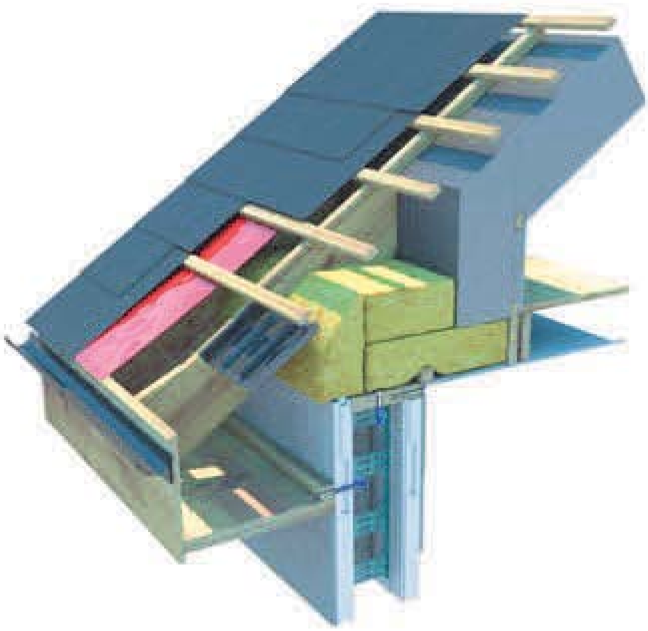
KORE Insulation,
Kilnaleck, Co. Cavan, Ireland.
T: +353 (0)49 4336998
F: +353 (0)49 4336823
E: info@kore-icf.com
W: www.kore-system.com

KORE Lock Roof Insulation

Isolant en polystyrene expancé pour planchers des-de-chausseés
Fußboden - Warmedämmung

NSAI Agrément (Irish Agrément Board) is designated by Government to issue European Technical Approvals.

NSAI Agrément Certificates establish proof that the certified products are **'proper materials'** suitable for their intended use under Irish site conditions, and in accordance with the **Building Regulations 1997 to 2017**.



PRODUCT DESCRIPTION:
This Certificate relates to KORE Lock expanded polystyrene insulation system, manufactured in accordance with IS EN 13163:2012+A1:2015 *Thermal insulation products for buildings – Factory made expanded polystyrene (EPS) products – Specification*.

This Certificate certifies compliance with the requirements of the Building Regulations 1997 to 2017.

USE:
The system consists of KORE Lock variable width panels, friction fitted between rafters, with KORE Lock liner panel below, to provide a tight fitting insulation envelope in warm and cold roof applications. The system will accommodate most width variations in rafter spacing ensuring optimum performance and allowing a necessary clear airspace above the level of insulation. The product is used for the thermal insulation of pitched and tiled roofs constructed in accordance with SR 82:2017 *Slating and tiling – Code of practice*. It also facilitates the control of surface and interstitial condensation in roofs.

MANUFACTURE AND MARKETING:
The products are manufactured and marketed by:

KORE Insulation,
Kilnaleck,
Co. Cavan.
T: +353 (0)49 4336998
F: +353 (0)49 4336823
E: info@kore-icf.com
W: www.kore-system.com

Readers are advised to check that this Certificate has not been withdrawn or superseded by a later issue by contacting NSAI Agrément, NSAI, Santry, Dublin 9 or online at http://www.nsai.ie

1.1 ASSESSMENT

In the opinion of NSAI Agrément, KORE Lock Roof Insulation System if used in accordance with this Certificate can meet the requirements of the Building Regulations 1997 to 2017, as indicated in Section 1.2 of this Irish Agrément Certificate.

1.2 BUILDING REGULATIONS 1997 to 2017

REQUIREMENTS:

Part D – Materials and Workmanship

D3 – KORE Lock Roof Insulation System, as certified in this Certificate, is comprised of 'proper materials' fit for their intended use (see Part 4 of this Certificate).

D1 – KORE Lock Roof Insulation System, as certified in this Certificate, meets the requirements of the building regulations for workmanship.

Part B – Fire Safety

Part B Vol 2 – Fire Safety

B2 & B7– Internal Fire Spread (Linings)

As the KORE Lock Roof Insulation System comprises an insulation panel finished with plasterboard liner, it will achieve a Class O performance classification. It may therefore be used on the internal surfaces of buildings of every purpose group.

Roofs using KORE Lock meet this requirement provided the completed roofs comply with the conditions described in Section 4.1 of this Certificate.

B4 & B9 – External Fire Spread

The KORE Lock Roof Insulation System will not affect the external fire rating of roofs in which it is incorporated.

Part C – Site Preparation and Resistance to Moisture

C4 – Resistance to Weather and Ground Moisture

The KORE Lock Roof Insulation System, when installed in compliance with the conditions indicated in Part 2 of this Certificate, will not promote the passage of moisture and will minimise the risk of surface or interstitial condensation.

Part F – Ventilation

F2 – Condensation in Roofs

The KORE Lock Roof Insulation System meets these requirements when designed and installed in accordance with Section 2.4 and Part 3 of this Certificate.

Part J – Heat Producing Appliances

J3 – Protection of Building

In the opinion of NSAI Agrément, the KORE Lock Roof Insulation System, if used in accordance with this Certificate, can meet the requirements of Part J of the Building Regulations 1997 to 2017.

Part L – Conservation of Fuel and Energy

L1 – Conservation of Fuel and Energy

Based on the measured thermal conductivity of KORE Lock referred to in this Certificate, the current 'U-value' requirements can be achieved (see Section 4 of this Certificate).

2.1 PRODUCT DESCRIPTION

This Certificate relates to the KORE Lock Roof Insulation System for warm and cold roof applications. KORE Lock variable width panels are friction fitted between the rafters ensuring the inner face of the panel is flush with the bottom of the rafters. KORE Lock liner panels are applied to the underside of the rafters with suitable fixings, ensuring all joints are tightly sealed. The panels are then faced with minimum 500 gauge polyethylene vapour barrier.

KORE Lock Variable Width Panels	
Length	1200mm x 377mm
Thickness	Up to 150mm
Width	To suit rafter design
Density	SD: 15kg/m^3 HD: 20kg/m^3 EHD: 25kg/m^3 UHD: 30kg/m^3 Grey SD: 15.9kg/m^3 Grey HD: 20kg/m^3
KORE Lock Liner Panels	
Length	240mm x 1200mm
Thickness	In 5mm increments
Width	To suit rafter design
Density	SD: 15kg/m^3 HD: 20kg/m^3 EHD: 25kg/m^3 UHD: 30kg/m^3 Grey SD: 15.9kg/m^3 Grey HD: 20kg/m^3

Table 1: Product Range

2.2 MANUFACTURE

KORE Lock Roof Insulation System boards are manufactured from expanded polystyrene and has a flame retardant additive (FRA). KORE Lock insulation boards are manufactured using no HCFC or CFC gases and have zero Ozone Depletion Potential.

2.2.1 Quality Control

Quality control checks are carried out on the incoming raw materials, during production and on the finished product. These checks include board dimensions, density, compressive strength and thermal conductivity.

2.3 DELIVERY, STORAGE AND MARKING

Every pack shows the manufacturer's name, NSAI Agrément identification mark and NSAI Agrément Certificate number.

Boards should be protected in transit and in storage from damage caused by ropes and tie straps. Boards should be protected from prolonged exposure to UV light and should be stored under cover or protected with polyethylene. Care must be taken to avoid contact with solvents and with materials containing volatile organic components such as coal tar and timbers newly treated with creosote etc.

The boards must not be exposed to a naked flame or other ignition sources.

2.4 INSTALLATION

2.4.1 General

Installation must be in accordance with the relevant clauses if SR 82:2017 (for installation in cold roof applications) and the manufacturer's instructions, and can be carried out in all conditions normal for roof and timber frame wall construction.

KORE Lock insulation boards are light to handle and can be easily cut or shaped. The boards will not support the weight of operatives and care must be taken during tiling.

Where the system is installed in traditional and timber frame construction, cavity barriers at the junction of the external wall and roof space should be provided in accordance with the requirements of Part B of the Building Regulations 1997 to 2017.

2.4.2 Procedure

Ensure that the cavity wall insulation has been continued to roof height to engage with the roof insulation. The insulation must be continuous to provide a complete envelope to reduce the risk of thermal bridging and condensation.

Commence by fitting KORE Lock variable width panels between each rafter, following completion of roof cladding, keeping panels flush with the underside face of the rafter and closely butted at ends. This will ensure the necessary clear air space between the insulation and the sarking felt.

Fix first row of KORE Lock panels to roof line at junction with vertical stud walls, beginning with first slot. Secure in position by nailing through batten and insulation into rafters. Repeat procedure until entire area is insulated.

Continue installation of KORE Lock panels to vertical studding and ceiling collars to completion.

Ensure a 50mm clear space is maintained above the insulation to provide the correct level of ventilation.

Apply KORE Lock liner panels to the underside of the rafters with suitable fixings, ensuring all joints are tightly sealed. Face with minimum 500 gauge polyethylene vapour barrier.

Part Three / Design Data 3

3.1 GENERAL

KORE Lock Roof Insulation System, when installed in accordance with this Certificate, is effective in reducing the U-value (thermal transmittance) of new and existing pitched roof constructions. It is essential that such roofs are designed and constructed to prevent moisture penetration having regards to the Driving Rain Index.

Roofs subject to the relevant requirements of the Building Regulations 1997 to 2017 should be constructed in accordance with SR 82:2017.

When installed in accordance with this Certificate, the KORE Lock Roof Insulation System will contribute to the buckling and racking strength of the roof as described in SR 82:2017. However, it is not recommended that they be considered as an alternative to cross-bracing.

During installation, boards must not be walked on except over supporting timbers. The boards have insufficient nail holding ability to be considered as an alternative to timber sarking.

Roof tile underlays must be approved by the manufacturer and be appropriately CE marked.

Moisture entering the roof must be minimised using a minimum of 500 gauge polyethylene with sealed gaps, placed under the inclined ceiling. Gaps in the ceiling should be minimised and service openings should be sealed.

As with all types of insulation, the construction detailing should comply with good practice.

4.1 BEHAVIOUR IN FIRE

Combustibility – Although KORE Lock insulation boards are products of limited combustibility, when used in the context of this Certificate the increase in fire load in the building consequent to its use is negligible.

The use of the KORE Lock Roof Insulation System will not affect the fire rating obtained by the tiled/slated roof when assessed or tested to BS 476-3:2004 *Fire tests on building materials and structures – Classification and method of test for external fire exposure to roofs*.

Toxicity – Negligible when used in protected roof situation.

KORE Lock insulation is manufactured without the use of CFCs and HCFCs and there is no release of such gas on burning.

4.2 STRENGTH

KORE Lock Roof Insulation System when installed in accordance with the manufacturer's instructions and this Certificate, will resist the loads likely to be met during installation and in service.

4.3 RESISTANCE TO WIND LOAD

The resistance to wind uplift depends on many factors peculiar to each project. The effect of wind loading should be calculated in accordance with IS EN 1991-1-4:2005+A1:2010 *Eurocode 1: Actions on structures – Part 1-4: General actions – Wind actions (including Irish National Annex)* using the appropriate basic wind speed shown in TGD to Part A of the Building Regulations 1997 to 2017.

When installed in accordance with Section 2.4 of this Certificate, the KORE Lock boards will have sufficient resistance to wind uplift.

4.4 RESISTANCE TO MOISTURE

KORE Lock Roof Insulation System will not be adversely affected by rain during installation for a limited timescale or by wind driven snow or rain penetrating the tiling in service.

Capillary action – The closed cell structure does not allow water uptake by capillary action.

4.5 WATER VAPOUR PENETRATION AND CONDENSATION RISK

The KORE Lock Roof Insulation System has a water vapour resistance of 145MNs/g. The Certificate holder should be contacted for the purpose of calculating a project specific condensation risk analysis.

The risk of condensation on the underside of the sarking will be minimal under normal conditions of use.

4.6 THERMAL INSULATION

Calculations of the thermal transmittance (U-value) of specific constructions should be carried out in accordance with IS EN ISO 6946:2007 *Building components and building elements – Thermal resistance and thermal transmittance – Calculation method*, using a manufacturer's declared thermal conductivity value as outlined in Table 2 of this Certificate. The U-value of a construction will depend on the materials used and the design. Examples of U-value calculations are given in Table 3 of this Certificate.

A full listing of U-value calculations is available from the Certificate holder on request. End users should seek guidance from the Certificate holder on U-values that can be achieved.

The product can contribute to maintaining continuity of thermal insulation at junctions between elements and around openings. Guidance in this respect, and on limiting heat loss by air infiltration, can be found in the DoHPCLG publication *Limiting Thermal Bridging & Air Infiltration – Acceptable Construction Details*.

4.7 LIMITING THERMAL BRIDGING

The linear thermal transmittance ψ (Psi) describes the heat loss associated with junctions and around openings. The certificate holder has carried out ψ-value calculations for a wide range of thermally bridged junctions for new build. A full listing of ψ-value calculations, along with AutoCAD building details on which calculations are based, are available from the Certificate holder on request.

For window jambs, door reveals and all building junctions, when shown to be equivalent or better than junctions detailed in the DoHPCLG publication *Limiting Thermal Bridging & Air Infiltration – Acceptable Construction Details*, then it is acceptable to use the linear thermal transmittance values outlined in Table D1 of TGD to Part L of the Building Regulations 1997 to 2017. When all bridged junctions comply with the requirements of Table D1, the improved 'y' factor of 0.08 can be entered into the Dwelling Energy Assessment Procedure (DEAP) Building Energy Rating (BER) calculation.

Where either of the above options are shown to be valid, or when the required values cannot be achieved, all relevant details should be recorded on the 'Certificate of Compliance' for that project for use in future BER calculations.

ψ-values for other junctions outside the scope of this Certificate should be assessed in accordance with the BRE IP1/06 *Assessing the effects of thermal bridging at junctions and around openings* and BRE Report BR 497 *Conventions for calculation linear thermal transmittance and temperature factors*, in accordance with Appendix D of TGD to Part L of the Building Regulations 1997 to 2017.

4.8 DURABILITY AND MAINTENANCE

KORE Lock Roof Insulation System boards are rot-proof and durable. As roof insulation, the boards are judged to be stable and will remain effective as an insulation system for the life of the building, once installed in accordance with this Certificate and the manufacturer's instructions.

Damaged boards can be easily replaced prior to the installation of counter battens.

4.9 TESTS AND ASSESSMENTS WERE CARRIED OUT TO DETERMINE THE FOLLOWING:

- Density
- Water vapour transmission
- Long term water absorption by diffusion
- Dimensional accuracy
- Compressive stress
- Bending strength
- Dimensional stability
- Thermal conductivity
- Thermal resistance
- Efficiency of the construction process

4.10 OTHER INVESTIGATIONS

(i) Existing data on product properties in relation to fire, toxicity, environmental impact and the effect on mechanical strength/stability and durability were assessed.

(ii) The manufacturing process was examined including the methods adopted for quality control, and details were obtained of the quality and composition of the materials used.

(iii) Site visits were conducted to assess the practicability of installation and the history of performance in use of the product.

(iv) A condensation risk analysis was performed.

4.11 CE MARKING

The manufacturer has taken responsibility of CE marking the KORE Lock Roof Insulation System in accordance with harmonised European Standard EN 13163:2012+A1:2015. An asterisk (*) appearing in this Certificate indicates that data shown is an essential characteristic of the product and declared in the manufacturers Declaration of Performance (DoP). Reference should be made to the latest version of the manufacturer's DoP for current information on any essential characteristics declared by the manufacturer.

KORE Lock EPS70 White / KORE Thermal Board EPS70 White			
Essential Characteristics	**Performance**	**Test Standard**	**Harmonised Standard**
Thermal Conductivity*	0.037W/mK	EN 12667	EN 13163:2012
Reaction to Fire*	Class E	EN 15715	
Length*	L3	EN 822	
Width*	W3	EN 822	
Thickness*	T2	EN 823	
Compressive Strength*	CS(10)70	EN 826	
Bending Strength*	BS100	EN 12089	
Dimensional Stability*	DS(N)5	EN 1603	
Flatness*	P(5) ≤0.72m^2 P(15) >0.72m^2	EN 825	
Squareness*	S(5)	EN 824	
Long Term Water Absorption by Partial Immersion*	WL(P)I 0.2kg/m^2	EN 12087	
Long Term Water Absorption by Total Immersion*	WL(T)I 5%	EN 12087	
KORE Lock EPS70 Silver / KORE Thermal Board EPS70 Silver			
Essential Characteristics	**Performance**	**Test Standard**	**Harmonised Standard**
Thermal Conductivity*	0.031W/mK	EN 12667	EN 13163:2012
Reaction to Fire*	Class E	EN 15715	
Length*	L3	EN 822	
Width*	W3	EN 822	
Thickness*	T2	EN 823	
Compressive Strength*	CS(10)70	EN 826	
Bending Strength*	BS100	EN 12089	
Dimensional Stability*	DS(N)5	EN 1603	
Flatness*	P(5) ≤0.72m^2 P(15) >0.72m^2	EN 825	
Squareness*	S(5)	EN 824	
Long Term Water Absorption by Partial Immersion*	WL(P)I 0.2kg/m^2	EN 12087	
Long Term Water Absorption by Total Immersion*	WL(T)I 5%	EN 12087	

Table 2: Product Characteristics

Warm Pitched Roof – Insulation Between and Over Rafters (With Sarking Board)		
KORE Lock EPS70 Silver	**KORE Warmsark EPS70 Silver**	**U-Value (W/m²K)**
100mm	50mm	0.22
125mm	50mm	0.19
150mm	50mm	0.17
175mm	50mm	0.15
200mm	50mm	0.14
KORE Lock EPS70 Silver	**KORE Warmsark EPS70 Silver**	**U-Value (W/m²K)**
100mm	100mm	0.16
125mm	100mm	0.14
150mm	100mm	0.13
175mm	100mm	0.12
200mm	100mm	0.11
KORE Lock EPS70 White	**KORE Warmsark EPS70 White**	**U-Value (W/m²K)**
100mm	50mm	0.25
125mm	50mm	0.22
150mm	50mm	0.19
175mm	50mm	0.17
200mm	50mm	0.16
KORE Lock EPS70 White	**KORE Warmsark EPS70 White**	**U-Value (W/m²K)**
100mm	100mm	0.18
125mm	100mm	0.17
150mm	100mm	0.15
175mm	100mm	0.14
200mm	100mm	0.13
Cold Pitched Roof – Insulation Between and Under Rafters (No Sarking Board)		
KORE Lock EPS70 Silver	**KORE Thermal Board EPS70 Silver**	**U-Value (W/m²K)**
100mm	50mm	0.21
125mm	50mm	0.19
150mm	50mm	0.17
175mm	50mm	0.15
200mm	50mm	0.14
KORE Lock EPS70 Silver	**KORE Thermal Board EPS70 Silver**	**U-Value (W/m²K)**
100mm	100mm	0.16
125mm	100mm	0.15
150mm	100mm	0.13
175mm	100mm	0.12
200mm	100mm	0.11
KORE Lock EPS70 White	**KORE Thermal Board EPS70 White**	**U-Value (W/m²K)**
100mm	50mm	0.25
125mm	50mm	0.22
150mm	50mm	0.20
175mm	50mm	0.18
200mm	50mm	0.16
KORE Lock EPS70 White	**KORE Thermal Board EPS70 White**	**U-Value (W/m²K)**
100mm	100mm	0.19
125mm	100mm	0.17
150mm	100mm	0.16
175mm	100mm	0.14
200mm	100mm	0.13

Table 3: Typical U-values (W/m^{2}K)

Part Five / Conditions of Certification

5.1 National Standards Authority of Ireland ("NSAI") following consultation with NSAI Agrément has assessed the performance and method of installation of the product/process and the quality of the materials used in its manufacture and certifies the product/process to be fit for the use for which it is certified provided that it is manufactured, installed, used and maintained in accordance with the descriptions and specifications set out in this Certificate and in accordance with the manufacturer's instructions and usual trade practice. This Certificate shall remain valid for five years from date of issue so long as:

(a) the specification of the product is unchanged.

(b) the Building Regulations 1997 to 2017 and any other regulation or standard applicable to the product/process, its use or installation remains unchanged.

(c) the product continues to be assessed for the quality of its manufacture and marking by NSAI.

(d) no new information becomes available which in the opinion of the NSAI, would preclude the granting of the Certificate.

(e) the product or process continues to be manufactured, installed, used and maintained in accordance with the description, specifications and safety recommendations set out in this certificate.

(f) the registration and/or surveillance fees due to NSAI are paid.

5.2 The NSAI Agrément mark and certification number may only be used on or in relation to product/processes in respect of which a valid Certificate exists. If the Certificate becomes invalid the Certificate holder must not use the NSAI Agrément mark and certification number and must remove them from the products already marked.

5.3 In granting Certification, the NSAI makes no representation as to;

(a) the absence or presence of patent rights subsisting in the product/process; or

(b) the legal right of the Certificate holder to market, install or maintain the product/process; or

(c) whether individual products have been manufactured or installed by the Certificate holder in accordance with the descriptions and specifications set out in this Certificate.

5.4 This Certificate does not comprise installation instructions and does not replace the manufacturer's directions or any professional or trade advice relating to use and installation which may be appropriate.

5.5 Any recommendations contained in this Certificate relating to the safe use of the certified product/process are preconditions to the validity of the Certificate. However the NSAI does not certify that the manufacture or installation of the certified product or process in accordance with the descriptions and specifications set out in this Certificate will satisfy the requirements of the Safety, Health and Welfare at Work Act 2005, or of any other current or future common law duty of care owed by the manufacturer or by the Certificate holder.

5.6 The NSAI is not responsible to any person or body for loss or damage including personal injury arising as a direct or indirect result of the use of this product or process.

5.7 Where reference is made in this Certificate to any Act of the Oireachtas, Regulation made thereunder, Statutory Instrument, Code of Practice, National Standards, manufacturer's instructions, or similar publication, it shall be construed as reference to such publication in the form in which it is in force at the date of this Certification.

NSAI Agrément

This Certificate No. **05/0235** is accordingly granted by the NSAI to **KORE Insulation** on behalf of NSAI Agrément.

Date of Issue: **December 2005**

Signed

Seán Balfe
Director of NSAI Agrément

Readers may check that the status of this Certificate has not changed by contacting NSAI Agrément , NSAI, 1 Swift Square, Northwood, Santry, Dublin 9, Ireland. Telephone: (01) 807 3800. Fax: (01) 807 3842. www.nsai.ie

Revisions
9th January 2018: References to Building Regulations and standards updated, product specifications updated to reflect manufacturer's DoP.

CI/SfB (47) Ln6

Agrément

CERTIFICATE NO. 02/0138

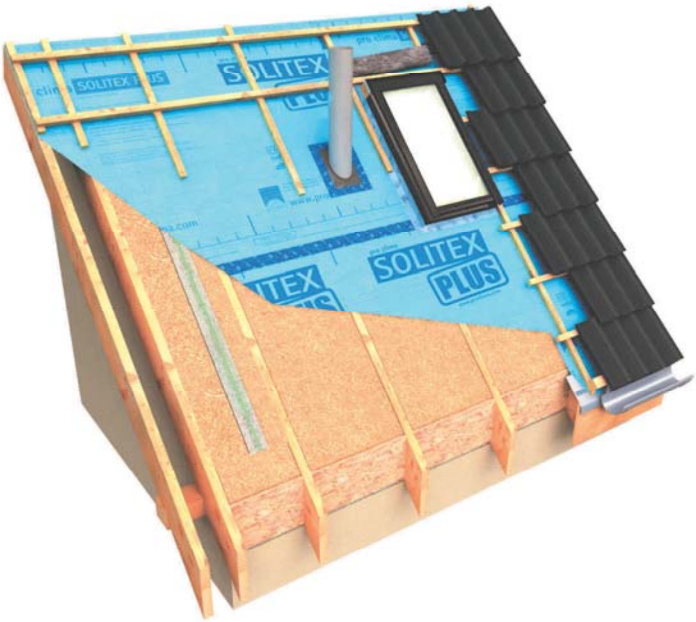
Moll Bauökologische Produkte GmbH,
Pro Clima, Schwetzingen, Germany.
Tel: 00353 (0)46 9432104
Fax: 00353 (0)46 9432435
Email: info@maccannandbyrne.ie
Website: www.ecologicalbuildingsystems.com

Solitex Plus & Solitex Plus Connect Vapour Permeable Roofing Underlays for Pitched Roofs

Revétement D'étanchéité
Dachabdichtungen

NSAI Agrément (Irish Agrément Board) is designated by Government to carry out European Technical Assessments.

NSAI Agrément Certificates establish proof that the certified products are **'proper materials'** suitable for their intended use under Irish site conditions, and in accordance with the **Building Regulations 1997 to 2014**.



PRODUCT DESCRIPTION:
This Certificate relates to Solitex Plus and Solitex Plus Connect (with pre-applied adhesive tape) roof tile underlays made from a spunbonded polypropylene fabric designed for use as unsupported and supported roofing underlays for warm and cold tiled or slated pitched roofs.

This Certificate certifies compliance with the requirements of the Building Regulations 1997 to 2014.

USE:
This Certificate relates to the use of Solitex Plus and Solitex Plus Connect on either fully supported or unsupported ventilated pitched roofs. Solitex Plus and Solitex Plus Connect roof tile underlay prevents the ingress of windblown rain, dust and snow. Solitex Plus and Solitex Plus Connect provides a barrier to minimise the effects of wind load generated under wind gusts acting on slates and tiles when installed in accordance with this Certificate. Solitex Plus and Solitex Plus Connect facilitates the control of surface and interstitial condensation in insulated roofs. Solitex Plus and Solitex Plus Connect roof tile underlay provides resistance to tearing during installation and will give high flexibility at low ambient temperatures.

MANUFACTURE & MARKETING:
These products are manufactured on behalf of:

Moll Bauökologische Produkte GmbH,
Pro Clima, Schwetzingen, Germany

These products are marketed by:

MacCann & Byrne Ltd.,
Importers and Distributors,
Athboy, Co. Meath.
Tel: 00353 (0)46 9432104
Fax: 00353 (0)46 9432435
Email: info@maccannandbyrne.ie
Website: www.ecologicalbuildingsystems.com

Readers are advised to check that this Certificate has not been withdrawn or superseded by a later issue by contacting NSAI Agrément, NSAI, Santry, Dublin 9 or online at www.nsai.ie

1.1 ASSESSMENT

In the opinion of the NSAI (National Standards Authority of Ireland) Agrément Board, Solitex Plus and Solitex Plus Connect roof tile underlays, if used in accordance with this Certificate can meet the requirements of the Building Regulations 1997 to 2014, as indicated in Section 1.2 of this Irish Agrément Certificate.

1.2 BUILDING REGULATIONS 1997 to 2014

REQUIREMENT:

Part D – Materials and Workmanship
D3 – Solitex Plus and Solitex Plus Connect roof tile underlays, as certified in this Certificate, are comprised of ‘proper materials’ fit for their intended use (see Part 4 of this Certificate).

D1 – Solitex Plus and Solitex Plus Connect roof tile underlays, as certified in this Certificate, meet the requirements of the building regulations for workmanship.

Part A - Structure
A1 – Loading
Tests indicate that roofs incorporating Solitex Plus and Solitex Plus Connect roof tile underlays meet the requirements provided the installations comply with the conditions set out in Section 2.4 and Part 3 of this Certificate.

Part B – Fire Safety
B4 – External Fire Spread
Solitex Plus and Solitex Plus Connect roof tile underlays will not prejudice the external fire resistance of the roof, as indicated in Section 4.1 of this Certificate.

Part C – Site Preparation and Resistance to Moisture
C4 – Resistance to Weather and Ground Moisture
Solitex Plus and Solitex Plus Connect roof tile underlays meet the requirements when installed as indicated in Section 2.4 of this Certificate.

Part F – Ventilation
F2 – Condensation in Roofs
Solitex Plus and Solitex Plus Connect roof tile underlays will provide water vapour resistance significantly less than that quoted as a maximum for conventional roof tile underlays in BS 5534:2014 *Slating and tiling for pitched roofs and vertical cladding – Code of practice* hence, movement of moisture vapour can take place through the underlays.

Where Solitex Plus and Solitex Plus Connect roof tile underlays are installed with ventilation, the design guidelines contained in TGD to Part F of the Building Regulations 1997 to 2014 and BS 5250:2016 *Code of practice for control of condensation in buildings* must be met when installing this product.

Solitex Plus and Solitex Plus Connect can be treated as vapour permeable underlays when considering the ventilation requirements of the roof.

Part L – Conservation of Fuel and Energy
L1 – Conservation of Fuel and Energy
Due to the high vapour permeability of the Solitex Plus and Solitex Plus Connect, the zone between rafters can be full filled with insulation to the underside of the roof membrane subject to the provision of adequate ventilation above the Solitex membrane. As a result, roofs incorporating Solitex Plus and Solitex Plus Connect and insulation can meet the requirements of TGD Part L of the Building Regulations 1997 to 2014.

Part Two / Technical Specification and Control Data

2.1 PRODUCT DESCRIPTION

Solitex Plus and Solitex Plus Connect (with pre-applied adhesive tape) roof tile underlays are made from spunbonded polypropylene. Solitex Plus and Solitex Plus Connect are for use under tiles or slates on supported or fully supported ventilated pitched roofs constructed in accordance with ICP 2:2002 *Irish code of practice for slating and tiling*. Solitex Plus and Solitex Plus Connect roof tile underlays prevent the ingress of windblown rain, dust and snow when installed in accordance with this Certificate.

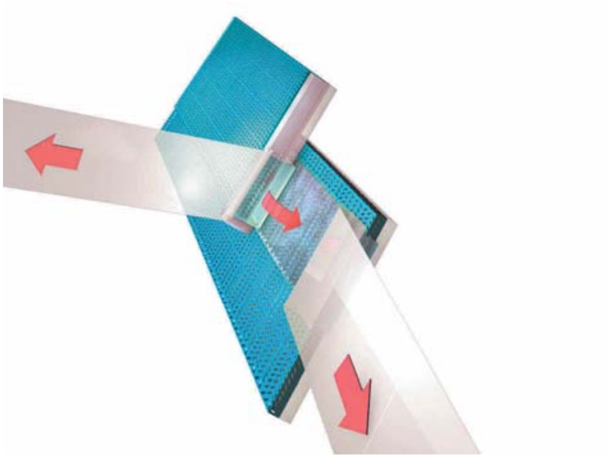


Figure 1 - Solitex Plus Connect with adhesive tape

The Solitex Plus Connect incorporates two rows of pre-applied adhesive tape, one on the top side of the membrane and one underneath. Rolls of Solitex Plus Connect are supplied with a protective film over the adhesive tape with is removed on site during the installation process. The adhesive strip, which is 40mm wide, is set back 30mm from the edge of the role. Each role contains an overlap guidance line to which each subsequent overlapped membrane must line up to in order for the adhesive strips to align.

The dimensions and weights of the underlays are shown in Table 1.

Product	Weight (± 5 g/m^2)	Colour	Length (m)	Width (m)
Solitex Plus/ Plus Connect	170*	Blue/ Grey	50*	1.5*
Other roll widths are available on request *Refer to Clause 3.5 of this certificate				

Table 1 - Dimensions and Weights

2.2 MANUFACTURE

Solitex Plus and Solitex Plus Connect: Roof tile underlay with PP-net reinforcement. This underlay may be used draped from rafter to rafter (unsupported) or fully supported with timber sheathing or rigid insulation board, under roofing tiles/slates or metal panels. The manufacturing process involves the bonding together of two polypropylene spunbonded felts with a reinforcement net and a central layer of monolithic nonporous TEEE membrane through an extrusion-coating process, using a combination of heat and pressure in a continuous process. The Solitex Plus Connect incorporates two rows of pre-applied adhesive tape.

2.2.1 Quality Control

Quality control checks are conducted on the raw materials before and during manufacture and on the finished product. Quality control checks include visual inspection and checks on dimensions (length, width, thickness), tensile strength, tear resistance, roll weight, water vapour permeability and water penetration resistance test.

The product quality manufacturing systems of the company have been assessed and are satisfactory. The company is also registered to ISO 9001:2000.

2.3 DELIVERY, STORAGE AND MARKING

Solitex Plus and Solitex Plus Connect roof tile underlays are supplied in 50m rolls. The rolls are then placed on a pallet and shrink wrapped. Each roll is labelled with a paper wrapper, which shows the manufacturer's name, product description and production batch number identifying date and time of batch. The name of the product is also printed on the exposed surface of the material. Every roll shows the NSAI Agrément identification mark and Certificate number and contains instructions on storage and installation.

Rolls may be stored on end or laid flat and must be kept under cover to protect from UV light. Care must be taken to avoid contact with solvents and with materials containing volatile organic components such as coal tar, and timbers newly treated with creosote.

The rolls must not be exposed to a naked flame or other ignition source.

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2.4 INSTALLATION

2.4.1 General

Solitex Plus and Solitex Plus Connect roof tile underlays must be installed and fixed in accordance with this Certificate, the Certificate holder's instructions, and the relevant recommendations of ICP 2:2002 and BS 5534:2014.

2.4.2 General Installation Criteria

Installation of Solitex Plus and Solitex Plus Connect roof tile underlays can be carried out in all conditions normal to pitched roofing work. In roof construction it is important to remember that Solitex Plus and Solitex Plus Connect roof tile underlays are the second line of defence in excluding water penetrating the roof. For this reason the requirements of BS 5534:2014, ICP 2:2002 and the following list of criteria must be met to comply with the requirements of this Certificate:

2.4.2.1 At the eaves, an eaves carrier felt i.e. 500mm wide strip of type 5U felt, to meet specifications of I.S. EN 13707:2013 Flexible sheets for waterproofing – Reinforced bitumen sheets for roof waterproofing – Definitions and characteristics must be used. This eaves carrier felt should be dressed 50mm into the gutter and the Solitex Plus and Solitex Plus Connect Breathable Membrane must overlap the eaves carrier felt as outlined in Table 2. In an open eaves construction, the use of eaves guards is recommended. The provision of a tilting fillet/continuous ply support or proprietary eaves ventilation tray is also required to avoid water being trapped behind the fascia board (see Figure 5).

Roof Pitch	Horizontal lap		Vertical lap
	Partially Supported	Fully Supported	
	Solitex Plus		
Pitch < 22.5°	225 mm	100 mm	100 mm
22.5° < Pitch <35°	150 mm	100 mm	100 mm
Pitch > 35°	100 mm	75 mm	100 mm
	Solitex Plus Connect		
All Pitches	100 mm		

Table 2 - Minimum Overlaps

2.4.2.2 Installation commences by unrolling the membrane horizontally across the rafters, starting at the eaves and working towards the ridges of the roof. The coloured side should be uppermost.

2.4.2.3 When used unsupported, a nominal 10mm drape must be provided between supports to allow a drainage path for moisture and prevent excessive deflection under wind loads (see Figure 2).

2.4.2.4 When tacking the membrane to the rafters it is recommended that a 3mm diameter x 20mm long extra-large head felt nails of copper, aluminium alloy or galvanised steel be used. The membrane should be tacked at the head of the sheet only, at centres not exceeding 1200mm. It is important that all tacking nails be covered by the overlap of the next membrane course so that the minimal headlap is maintained between the tacks and the lower edge of the overlapping membrane.

2.4.2.5 Overlaps of the membrane should be in accordance with BS 5534:2014 Annex A, Figure A.2, with horizontal laps secured by battens (see Table 2).

2.4.2.6 In an unsupported roof with tiling battens only i.e. no counter battens, when horizontal overlaps do not coincide with a batten, consideration should be given to either including an extra batten at the overlap or increasing the membrane overlap to coincide with the next batten. Alternatively the membrane can by sealed using double-sided TESCON VANA adhesive tape, or similar approved, at the overlap.

2.4.2.7 Batten gauges should not exceed that recommended by the tile/slate manufacturer for the particular tile/slate being used. In areas where the wind speed is greater than 48 m/s ICP 2:2002 should be followed.

2.4.2.8 Moisture content of battens at time of fixing should not exceed 22%. Where timbers on roofs have been treated with wood preservative due to high moisture content of timbers, it is essential that manufacturer's guidance be sought in relation to chemical attack from preservative on roofing membrane.

2.4.2.9 Nails for use with battens, counter battens and boarding (sarking boarding) should be zinc-coated in accordance with IS EN 10230-1:2000 Steel wire nails – Loose nails for general applications. Refer to BS 5534:2014 Cl 4.12.1.2 for details, and also ICP 2:2002 Cl 4.11.

2.4.2.10 Solitex Plus and Solitex Plus Connect Breathable Membranes are not designed to withstand the weight of operatives or tiles being loaded out. Battens must therefore be installed as work progresses from eaves to ridge for achieving support for feet and avoiding damage to the underlay surface. No materials or implements should be resting on the underlay. Where pressure on the membrane over a rafter is unavoidable, it should be noted that the membrane does not offer substantial grip, particularly at overlaps or when wet.

Characteristic	Test Standard	Results Solitex Plus/ Solitex Plus Connect		Units
Thickness*	EN 1849-2:2001	0.55 ± 0.05		mm
Surface Weight*	EN 1849-2:2001	170 ± 5		g/m^2
Standard roll weight	BS 2782-6	13		kg
S_d-value*	EN ISO 12572:2001	0.04 ± 0.01		m
g-value* Water vapour resistance	EN ISO 12572 Set C At 23°C/ RH 50/93%	0.20 ± 0.05		MNs/g
Fire Class*	EN 13501-1:2010	E		
Water resistance un-/aged[2]*	EN 1928:2000	Class W1/W1		
		MD	**CD**	
Tensile strength MD/CD[1]*	EN 12311-1:1999, Appendix A	495 ± 40	350 ± 40	N/50mm
Tensile strength MD/CD Aged[1]*	EN 12311-1:1999, Appendix A	495 ± 40	350 ± 40	N/50mm
Elongation MD/CD*	EN 12311-1:1999	15 ± 5	15 ± 5	%
Elongation MD/CD Aged[1]*	EN 12311-1:1999	15 ± 5	15 ± 5	%
Nail tear resistance MD/CD*	EN 12310-1:1999, Appendix B	300±30	270 ± 30	N
Artificial ageing by long term*	EN 1297:2004/EN 1296:2001	passed		
Flexibility at low temperature*	EN 1109:1999	-40		°C

*Refer to Clause 3.5 of this certificate
[1] MD/CD – longitudinal direction/transverse direction
[2] Artificial ageing by long term

Table 3 - Physical Properties of Solitex Plus and Solitex Plus Connect

2.4.2.11 Where Solitex Plus and Solitex Plus Connect roof tile underlays become damaged for whatever reason, it is imperative that they are suitably repaired with a new piece of matching material or a suitable pro clima adhesive tape if the damage is minimal. Alternatively repairs can be carried out by overlaying the damaged area with a layer of additional material ensuring a 150mm overlap all round, ensuring that the up-slope side is overlapped by the next highest horizontal run of membrane, and secured under a batten.

2.4.2.12 Standard methods of workmanship should be used to apply the membrane at penetrations and abutments. It must be ensured that the membrane is turned up at least 50mm at all abutments to be overlapped by the flashings, and that it overlaps the lining tray by at least 100mm at the back face of any abutment.

2.4.2.13 Penetrations by soil and vent pipes etc. must be dealt with as follows. The underlay must be star-cut carefully to prevent tears, closely fitted over the pipe, ensuring that all tabs project upwards along the pipe, and then the tabs taped around the circumference of the pipe using a suitable jointing tape or gasket approved by the Certificate holder. A proprietary collar must be fitted over the pipe to protect the tape.

2.4.2.14 Courses of membrane over a hip should be overlapped by at least 150mm. Each course should overlap the membrane course on the adjacent elevation of the roof.

2.4.2.15 Hips and valleys should be covered with an additional 600mm wide strip of the membrane running continuously from eaves to hip. In valleys, the 600mm wide strip of membrane must be laid over the gutter bed but under the main roof underlay, and held down by valley battens when used. The main roof underlay must be dressed over the valley battens in this case.

2.4.2.16 For duo pitch roofs not requiring ridge ventilation, underlay from each side of the ridge should overlap the other side by at least 225mm. For mono pitch roofs, the underlay should extend over the mono ridge and the top fascia board by at least 100mm. Where proprietary ventilating ridge systems are specified, detailing of the underlay should be in accordance with the Certificate holder's recommendations.

2.4.2.17 When used in warm roof design, when the membrane is in direct contact with the insulation between the rafters, a sealed vapour control layer (pro clima Intello Plus) should be installed on the warm side of the insulation. The roof should be counter-battened to allow a 50mm unobstructed air path between the membrane and the tiles.

2.4.2.18 Reference should be made to BS 5250:2016 Annex H for counter batten and ventilation requirements on titled and slated roofs.

2.4.2.19 Battens and counter battens should be used when the membrane is to be fully supported (e.g. warm roofs or roofs using a sarking board).

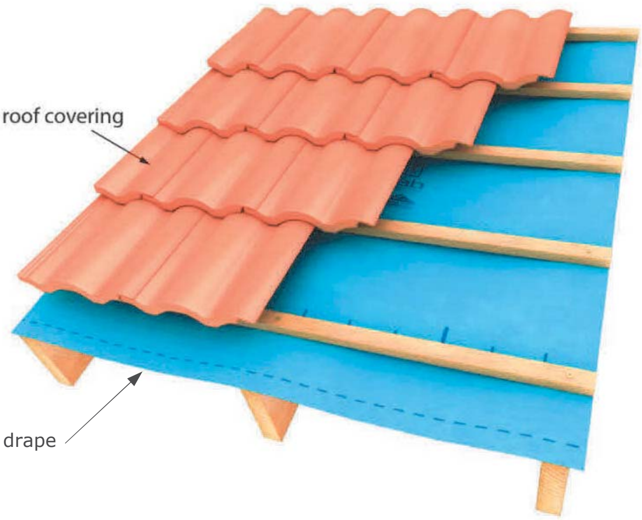


Figure 2 - Cold Roof detail with permeable roof covering

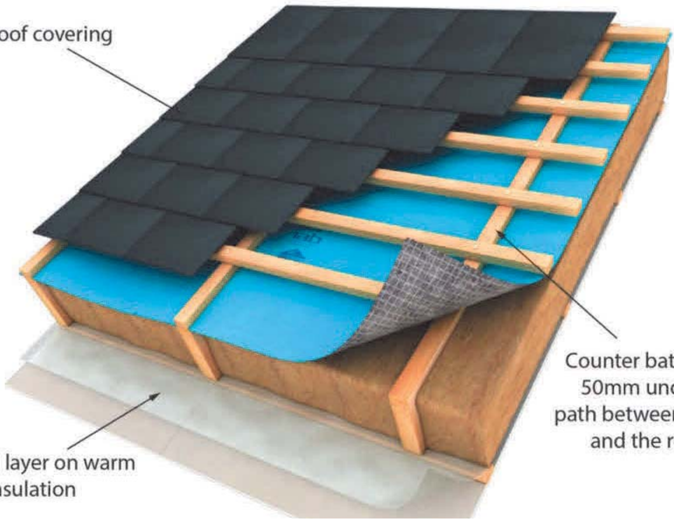


Figure 3 - Warm Roof detail with impermeable roof coverings

This will allow any moisture accessing the main system to drain away unhindered by the battens. In these instances where no drape is provided, for additional security against water leakage through nail holes where underlays are not self-sealing, batten tapes or other sealants approved by the Certificate holder should be used (e.g. pro clima Tescon Naideck nail sealing tape). This risk is particularly important in low pitched roofs.

2.4.2.20 When close fitting man-made slates are to be installed as the roof covering, which constitute an impermeable external covering, counter battens shall be used. In addition, ventilation should be provided above the membrane in the form of ridge tile and eaves ventilation (see Figure 4 and Figure 5). Reference should be made to BS 5250:2016 Section H.5.3. In case of doubt, the advice of the Certificate holder should be sought.

2.4.2.21 Once the Solitex Plus and Solitex Plus Connect Breathable Membrane is installed, it should be covered by the finished roof covering as soon as practicable to minimise the effects of long term exposure to UV light. The manufacture recommends a maximum exposure time of 3 month.

2.4.2.22 Solitex Plus and Solitex Plus Connect Breathable Membranes are not suitable for use in flat roof construction.

When used in a cold roof design and where the insulation is laid on top of the ceiling, it is essential that a sealed vapour control layer (such as pro clima Intello Plus) be used on the warm side of the insulation, and all perforations for pipes, electric cables etc. should be sealed. Continuity of the vapour control layer should be maintained at the perimeter of the ceiling to minimise moisture from the dwelling circumventing the vapour control layer.

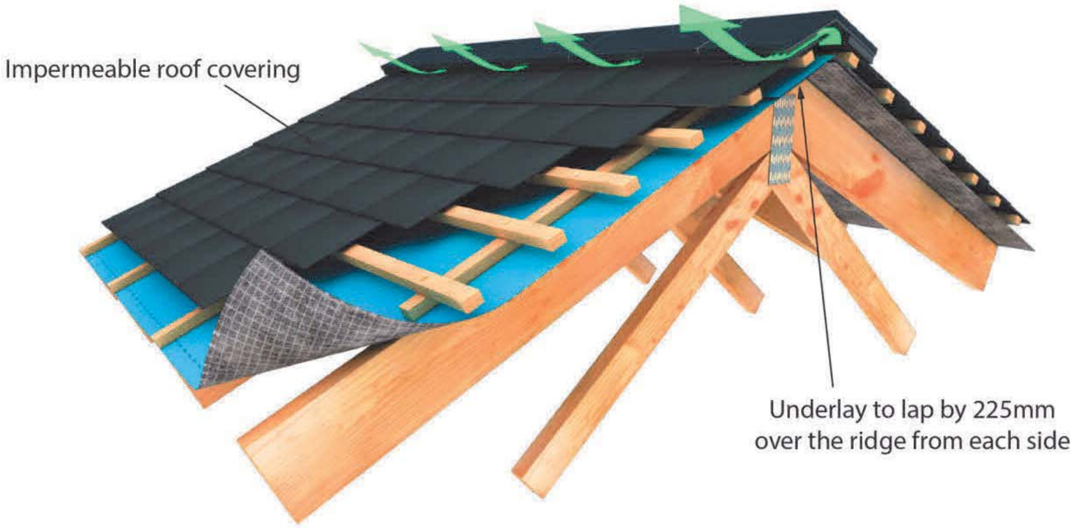


Figure 4 - Cold Roof detail with impermeable roof covering - Ridge Detail

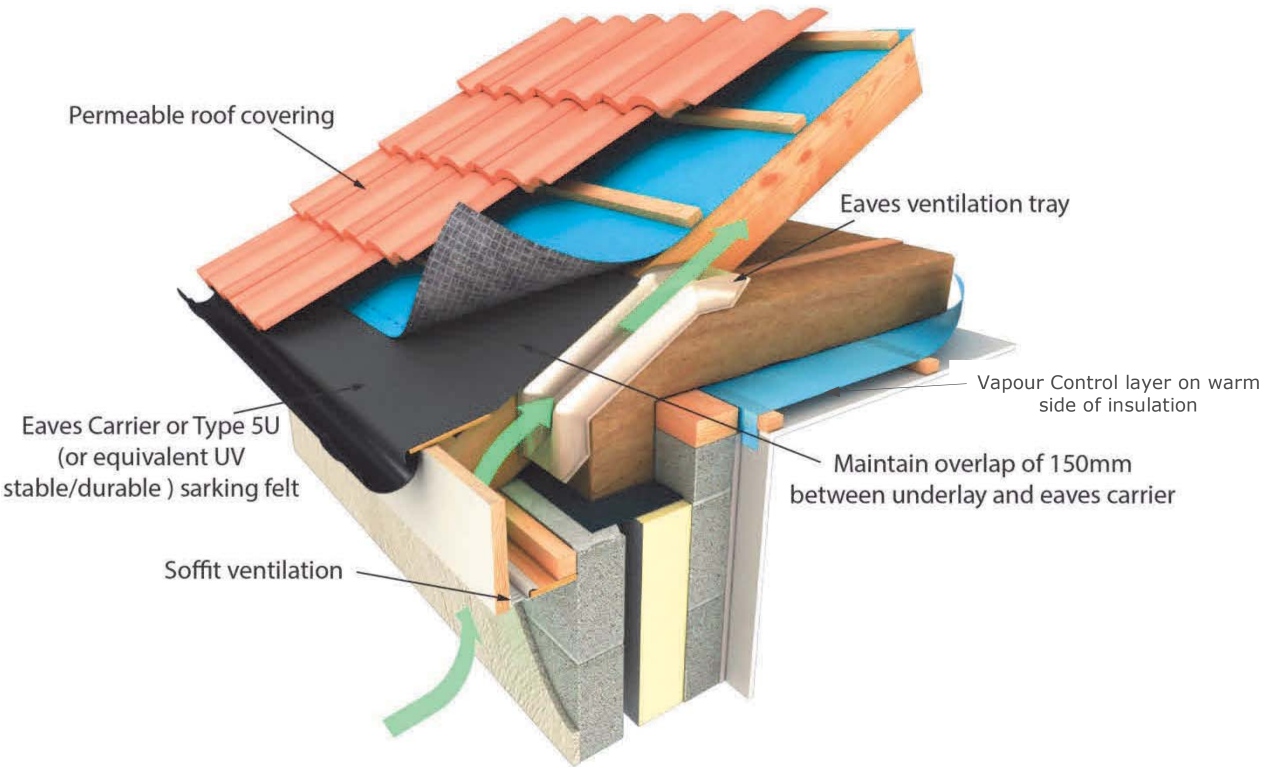


Figure 5 - Cold Roof detail with permeable roof covering - Eaves Details

Ideally the vapour control layer should connect with the vapour control layer or airtight layer in the external walls (see Figure 5).

In additional to a continuous sealed vapour control layer, the following measures should be considered in order to limit the migration of moisture into the attic space:-

- Ventilating the dwelling below for the dispersal and rapid dilution of water vapour, particularly in rooms that may experience high humidity (such as kitchens, utility rooms and bathrooms).

- Covering and insulating all water tanks in the loft space and lagging pipe work.

- Sealing penetrations in the ceiling and making loft hatches convection-tight by using a compressible draught seal.

- Ensuring that there is continuity of joining with walls (and behind wall linings) at sealing perimeters.

- Ensuring that masonry wall cavities do not interconnect with roof cavities.

3.1 GENERAL
Solitex Plus and Solitex Plus Connect breathable membranes provide a satisfactory underlay in pitched roofs constructed in accordance with ICP 2:2002, BS 5534:2014, BS 5250:2016 and BS 8000-6:2013 *Workmanship on building sites – Code of practice for slating and tiling of roofs and walls*.

3.2 WIND LOADING
Solitex Plus and Solitex Plus Connect breathable membranes can resist the loads associated with the installation phase of the roof.

3.2.1 Unsupported
Solitex Plus and Solitex Plus Connect breathable membranes are satisfactory for use in conventional unsupported rafter and batten roof systems as described in Table 4 of this Certificate (see also Figure 6). The classifications show in Table 4 are based on the simplified approach for obtaining design wind pressure and required uplift resistance as defined in BS 5534:2014 Appendix A Cl. A7. These details are valid where a well-sealed ceiling is present and the roof has a ridge height ≤15m, a pitch between 12.5° and 75°, and a site altitude ≤100m where the topography is not significant.

When building and site conditions are outside these limitations, the design wind pressure, p_u should be calculated in accordance with Equation H.13 of BS 5534:2014 in order to determine the required wind uplift resistance. Calculated values can then be compared to the Declared wind uplift resistances in Table 5 of this Certificate in order to select a suitable roof underlay and batten spacing.

The design wind pressure p_u (BS 5524:2014 Eq. H.13), can be calculated from

$$p_u = f_u \times q_p$$

where:
f_u = 0.75 when a well-sealed ceiling is present;
f_u = 0.90 when no ceiling or no well-sealed ceiling is present;
f_u = 1.10 when no ceiling or no well-sealed ceiling is present and a permanent dominant opening is present on an external face of the building;
q_p = peak velocity pressure from I.S. EN 1991-1-4:2005
See BS 5534:2014 for all other considerations.

When battens and counter battens are provided above the roof membrane, the limitations of Table 4 and Table 5 no longer apply.

3.2.2 Supported
Solitex Plus and Solitex Plus Connect, when fully supported, have adequate resistance to withstand typical uplift forces.

The products may be used at any batten gauge in all wind zones when laid over nominally air-tight sheet sarking, for example OSB board, plywood and insulation for warm-roof designs. Counter battens are required to provide a drainage channel for wind driven rain and a ventilation void if required.

Poorly fitted sarking boards such as square-edged butt-joints planks are not considered to be airtight and the underlay should be treated as unsupported.

Product	≤345 mm batten gauge with battened lap[(2)]	≤250 mm batten gauge with battened lap	≤345 mm batten gauge with taped laps [(1)]	≤345 mm batten gauge with integrated taped laps
Solitex Plus	Zones 1 to 3	Zones 1 to 5	Zones 1 to 5	Zones 1 to 5
Solitex Plus Connect	-	-	-	Zones 1 to 5

(1) Using TESCON VANA (details available from the Certificate holder).
(2) When using untapped laps at 345mm batten gauges in Zone 4, the batten gauge must reduce to 250mm adjacent to the lap.

Table 4 - Zones of applicability of Solitex Plus and Solitex Plus Connect according to BS 5534: 2014, clause A.8 with battened laps and taped laps

Product	≤345 mm batten gauge with battened lap	≤250 mm batten gauge with battened lap	≤345 mm batten gauge with taped laps	≤345 mm batten gauge with integrated taped laps
Solitex Plus	1164	2571	2626	-
Solitex Plus Connect	-	-	-	3204

Table 5 - Declared wind uplift resistance (Pa)

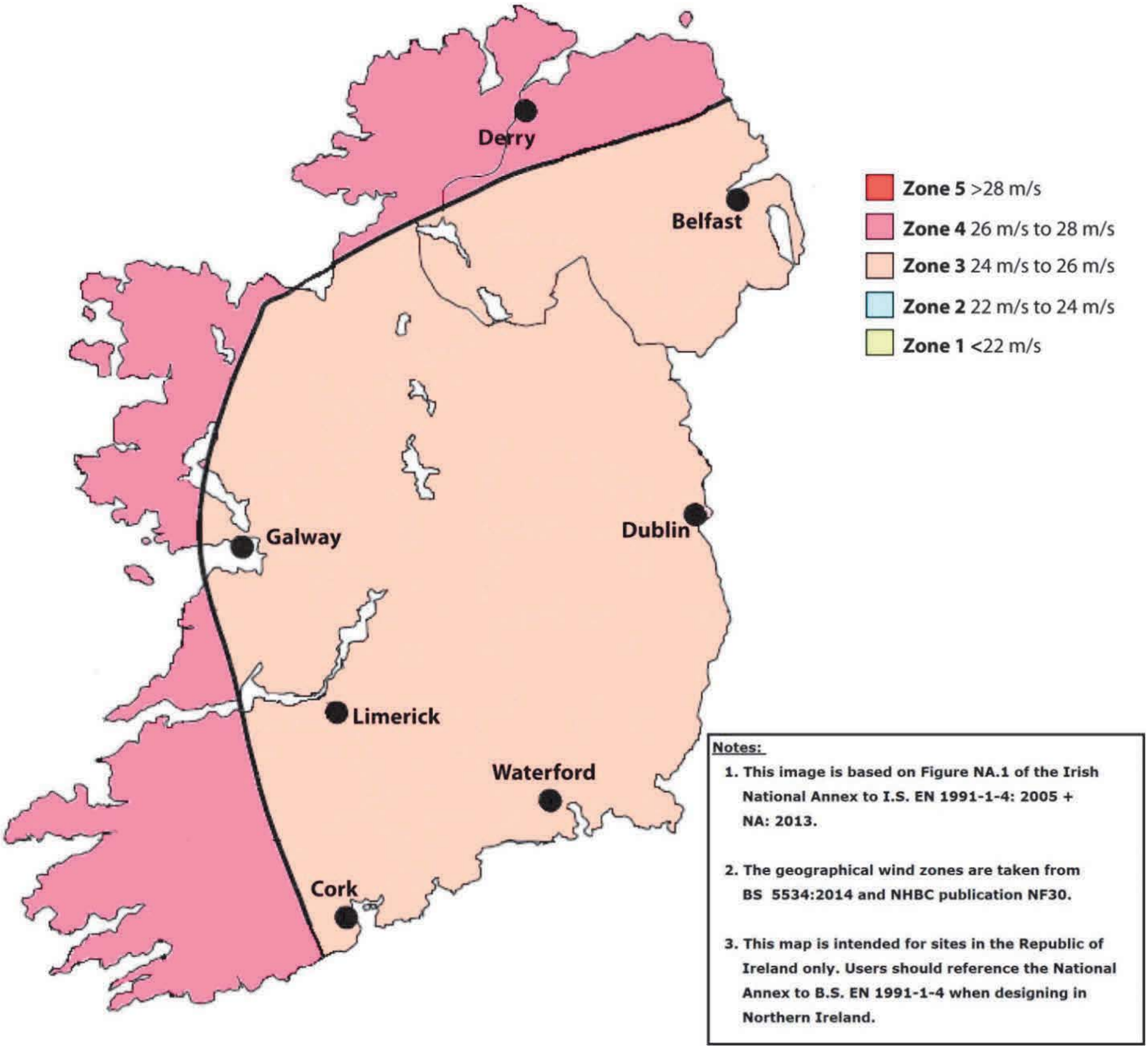


Figure 6 - Design wind speeds for geographical wind zones in Ireland

3.3 WEATHERTIGHTNESS

Tests confirm that Solitex Plus and Solitex Plus Connect will resist the passage of water, wind-blown snow and dust into the interior of a building under all conditions to be found in a roof constructed to ICP 2:2002, BS 5534:2014, BS 8000-6:2013 and I.S. EN 13111:2010 *Flexible sheets for waterproofing – Underlays for discontinuous roofing and walls – Determination of resistance to water penetration.*

For effective water management of a roof subject to severe driving rain conditions all underlay must be installed so that any water leaking through the roof tiles/slates is carried by the draped deflection of the underlay to the gutters.

3.4 VENTILATION

Solitex Plus and Solitex Plus Connect have a low water vapour diffusion-equivalent air layer thickness or S_d value (see Table 3 of this certificate and the manufactures DOP). As a result the vapour resistance of the membranes is very low and the membrane is classified as a LR (low resistance) membrane as defined in BS 5250:2016.

In pitched roofs, when using impermeable roof coverings such as man-made roof slates, where the insulation follows the line of the pitch and an AVCL (air and vapour control layer) exists on the warm side of the insulation, a 50mm ventilation void must be provided either above the insulation or above the membrane (See Figure 3). The 50mm ventilation void requires openings at low level having a free area equivalent to 25mm per meter run, and at higher level, having a free area equivalent to 5mm per meter run along ridges and hips. There is no requirement for a ventilation void when permeable roof covering, such as loosely fitting natural slates or concrete roof tiles, an AVCL and 10mm drape in the underlay are installed.

In pitched roofs where the insulation follows the line of the ceiling, attic ventilation must be provided in accordance with TGD to Part F of the Building Regulations 1997 to 2014. The optimum size and disposition of vents should be determined by the size and shape of the loft; large and/or complex roofs may require vents at both high and low levels. In general, cross ventilation having a free area equivalent to 10mm per meter run of eaves should be provided. Further design guidance can be found in BS 5250:2016.

A vapour control layer, such as pro clima Intello Plus or equivalent, should be installed on the warm side of the insulation unless a hygrothermal analysis to I.S. EN ISO 13788:2012 *Hygrothermal performance of building components and building elements – Internal surface temperature to avoid critical surface humidity and interstitial condensation – Calculation methods (Glazer)*, or I.S. EN 15026:2007 *Hygrothermal performance of building components and building elements – Assessment of moisture transfer by numerical simulation (Wufi)* deems it to be unnecessary.

It is essential that roofs be constructed so as to prevent moisture penetration and the formation of condensation. In accordance with good building construction practice, all openings for services and trap doors should be draught sealed, and trap doors should not be located in bathrooms, shower rooms or kitchens.

The risk of condensation is highest in new-build construction during the first heating period, where there is high moisture loading owing to wet trades such as cast concrete slabs or plaster. Additional ventilation should be provided during this period, including the opening of doors and windows. The risk diminishes as the building dries out naturally.

3.5 CE MARKING

The Certificate holder has taken responsibility of CE marking the product in accordance with harmonised European Standard I.S. EN 13859-1:2014. An asterisk (*) appearing in this Certificate indicates that data shown is given in the manufacturer's Declaration of Performance. (DoP). Designers should refer to the latest version of the manufacturer's DoP for all essential characteristics.

4.1 BEHAVIOUR IN FIRE

Solitex Plus and Solitex Plus Connect roof tile underlays have similar properties in relation to fire as those which are acceptable under BS 5534:2014, and so will present no additional fire hazard to a roof structure in which they are incorporated.

Solitex Plus and Solitex Plus Connect roof tile underlays have the risk of fire spread when used unsupported if the material is accidentally ignited during maintenance works etc. (e.g. roofer or plumbers torch). As with all types of sarking material, care must be taken during building and maintenance to avoid the material becoming ignited.

When the product is used in a fully supported situation, the reaction to fire will be determined by the supporting board.

The toxicity risks in relation to the product in the event of fire are negligible when used in a roof.

Solitex Plus and Solitex Plus Connect roof tile underlays being combustible material must be separated from chimneys and flues as indicated in cl. 2.15, 2.16 and 2.17 of TGD to Part J of the Building Regulations 1997 to 2014.

4.2 WATER PENETRATION

Solitex Plus and Solitex Plus Connect roof tile underlays, when used in accordance with this Certificate, present no significant risk of water penetration.

4.3 WATER VAPOUR PENETRATION AND CONDENSATION RISK

Solitex Plus and Solitex Plus Connect roof tile underlays will provide water vapour resistance less than that quoted as a maximum for conventional roof tile underlays in BS 5534:2014, and hence movement of moisture vapour can take place through the underlay. This standard also describes the factors to be considered in reducing condensation to a satisfactory minimum. The general design guidelines contained in TGD to Part F of the Building Regulations 1997 to 2014 and BS 5250:2016, Sections 8.4.2.2 to 8.4.2.6 must be met with installing this product. Typical values of water vapour resistance are given in Table 3.

Solitex Plus and Solitex Plus Connect roof tile underlays when being installed should be treated as vapour permeable underlays when considering the ventilation requirements.

The risk of condensation is highest in new-build construction during the first heating period, where there is high moisture loading due to wet trades, such as in-situ cast concrete slabs or plaster. The risk of condensation diminishes as the building naturally dries out.

4.4 DURABILITY AND MAINTENANCE

Solitex Plus and Solitex Plus Connect roof tile underlays, when installed in accordance with this Certificate, Certificate holder's instructions and relevant codes of practice, is virtually unaffected by conditions normally found in a roof space and will have a design life comparable with that of the roof and in accordance with BS 7543:1992 *Guide to the durability of building elements, products and components*. The durability of the roof underlay will be dependent on the performance of the roof covering (slates/tiles) and this could be compromised if the roof is not routinely maintained or is subjected to inappropriate traffic. Such maintenance would involve building owners having their roofs inspected annually, preferably in late autumn. Inspection should include checking for missing, damaged or loose slates/tiles and their accessories or flashings. Clogged gutters or downpipes should be unblocked and cleaned.

4.5 TESTS AND ASSESSMENTS WERE CARRIED OUT TO DETERMINE THE FOLLOWING:

- Density
- Water vapour permeability
- Dimensional accuracy
- Nail tear resistance
- Tear strength
- Elongation at break
- Dimensional stability
- UV stability
- Efficiency of the construction and installation process

4.6 OTHER INVESTIGATIONS

(i) Existing data on product properties in relation to fire, toxicity, environmental impact and the effect on mechanical strength/stability and durability were assessed.

(ii) The manufacturing process was examined including the methods adopted for quality control, and details were obtained of the quality and composition of the materials used.

(iii) Site visits were conducted to assess the practicability of installation and the history of performance in use of the product.

(iv) Driving rain resistance was assessed.

(v) A condensation risk analysis was performed.

Part Five / Conditions of Certification 5

5.1 National Standards Authority of Ireland ("NSAI") following consultation with the Irish Agrément Board ("IAB") has assessed the performance and method of installation of the product/process and the quality of the materials used in its manufacture and certifies the product/process to be fit for the use for which it is certified provided that it is manufactured, installed, used and maintained in accordance with the descriptions and specifications set out in this Certificate and in accordance with the manufacturer's instructions and usual trade practice. This Certificate shall remain valid for five years from date of revision so long as:

(a) the specification of the product is unchanged.

(b) the Building Regulations 1997 to 2006 and any other regulation or standard applicable to the product/process, its use or installation remains unchanged.

(c) the product continues to be assessed for the quality of its manufacture and marking by NSAI.

(d) no new information becomes available which in the opinion of the NSAI, would preclude the granting of the Certificate.

(e) the product or process continues to be manufactured, installed, used and maintained in accordance with the description, specifications and safety recommendations set out in this certificate.

(f) the registration and/or surveillance fees due to IAB are paid.

5.2 The IAB mark and certification number may only be used on or in relation to product/processes in respect of which a valid Certificate exists. If the Certificate becomes invalid the Certificate holder must not use the IAB mark and certification number and must remove them from the products already marked.

5.3 In granting Certification, the NSAI makes no representation as to;

(a) the absence or presence of patent rights subsisting in the product/process; or

(b) the legal right of the Certificate holder to market, install or maintain the product/process; or

(c) whether individual products have been manufactured or installed by the Certificate holder in accordance with the descriptions and specifications set out in this Certificate.

5.4 This Certificate does not comprise installation instructions and does not replace the manufacturer's directions or any professional or trade advice relating to use and installation which may be appropriate.

5.5 Any recommendations contained in this Certificate relating to the safe use of the certified product/process are preconditions to the validity of the Certificate. However the NSAI does not certify that the manufacture or installation of the certified product or process in accordance with the descriptions and specifications set out in this Certificate will satisfy the requirements of the Safety, Health and Welfare at Work Act. 1989, or of any other current or future common law duty of care owed by the manufacturer or by the Certificate holder.

5.6 The NSAI is not responsible to any person or body for loss or damage including personal injury arising as a direct or indirect result of the use of this product or process.

5.7 Where reference is made in this Certificate to any Act of the Oireachtas, Regulation made thereunder, Statutory Instrument, Code of Practice, National Standards, manufacturer's instructions, or similar publication, it shall be construed as reference to such publication in the form in which it is in force at the date of this Certification.

NSAI Agrément

NSAI Agrément

This Certificate No. **02/0138** is accordingly granted by the NSAI to **MacCann & Byrne** on behalf of The Irish Agrément Board.

Date of Issue: **February 2002**

Signed

Seán Balfe
Director of the Irish Agrément Board

Readers may check that the status of this Certificate has not changed by contacting the Irish Agrément
Board, NSAI, Glasnevin, Dublin 9, Ireland. Telephone: (01) 807 3800. Fax: (01) 807 3842.
www.nsai.ie

Revisions: May 2007
- Classification of Solitex UD and Solitex Plus as vapour permeable underlays

Revisions: April 2017
- Product specification updated to reflect manufactures Declaration of Performance.

Appendix B – U-Value Calculations

DT 9771 Postgraduate Certificate in Building Performance (EED)

U Value Calculator - [redacted]

A Description of the Layers Making Up the Construction

Layer	Path	Material	Thickness [mm]	Thickness [m]	Area Fraction F	Thermal Conductivity λ [W/mK]	Source of Data	Thermal Resistance R [m²K/W]
		External Surface Resistance	-				BR443	0.1
1		Slate Tiles	19	0.019		2.2	TGD Part L Table A1	-
2		Softwood Timber Battens	25	0.025		0.13	TGD Part L Table A1	-
3		Softwood Timber Counter Battens	25	0.025		0.13	TGD Part L Table A1	-
4		Sarking Felt (Solitex Plus Vapour Permeably Roofing Underlay)	1	0.001		0.17	Manufacturers Data	0.006
5		KORE Warmsark EPS 100 White Insulation	50	0.05		0.036	Manufacturers Data	1.389
6		OSB Board (Racking Board and Airtight Layer)	18	0.018		0.13	BS EN 12524 : 2000	0.138
7	a	KORE Lock EPS 70 Silver Insulation (Between Rafters)	165	0.165	0.91	0.031	Manufacturers Data	5.323
	b	Rafters	165	0.165	0.09	0.13	TGD Part L Table A1	1.269
8		PlasterBoard	12.5	0.0125		0.25	TGD Part L Table A1	0.050
		Internal Surface Resistance	-				BR443	0.13

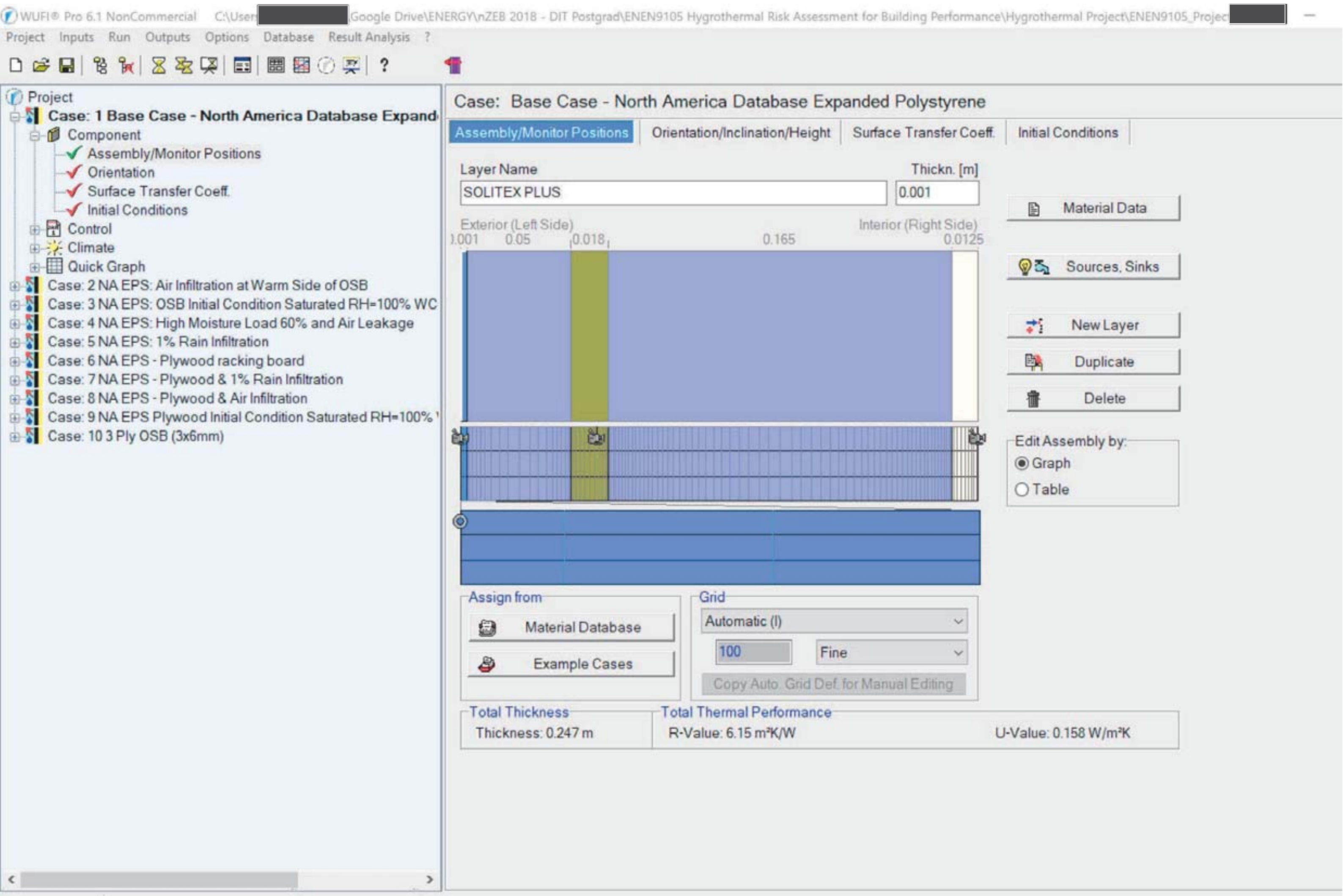
Calculation of the Upper Limit of Thermal Resistance

Layer		Material	Heat Flow Path a [m²K/W]	Heat Flow Path b [m²K/W]	Units
		Fraction of Area (Fa, Fb)	0.910	0.090	m²K/W
		External Surface Resistance	0.10	0.10	m²K/W
1		Slate Tiles	-	-	m²K/W
2		Softwood Timber Battens	-	-	m²K/W
3		Softwood Timber Counter Battens	-	-	m²K/W
4		Sarking Felt (Solitex Plus)	0.006	0.006	m²K/W
5		EPS White 100 Insulation	1.389	1.389	m²K/W
6		OSB Board (AT Layer)	0.138	0.138	m²K/W
7		EPS Silver 70 Insulation and Rafters	5.323	1.269	m²K/W
8		PlasterBoard	0.050	0.050	m²K/W
		Internal Surface Resistance	0.13	0.13	m²K/W
		Total Thermal Resistance (Ra, Rb)	8.046	3.082	m²K/W
		Fraction of Area / Resistance	0.113	0.029	W/m²K
		Upper Limit of Resistance, Rmax			
	=	1/((Fa/Ra) + (Fb/Rb))		**7.027**	**m²K/W**

Calculation of the Lower Limit of Thermal Resistance

Layer		Material	Fraction of Area / Resistance of Path a	Fraction of Area / Resistance of Path b	Conductance of Layer	Resistance of Layer [m²K/W]	Units
		Fraction of Area (Fa, Fb)	0.91	0.09			
		External Surface Resistance				0.10	m²K/W
1		Slate Tiles				-	m²K/W
2		Softwood Timber Battens				-	m²K/W
3		Softwood Timber Counter Battens				-	m²K/W
4		Sarking Felt (Solitex Plus)				0.006	m²K/W
5		EPS White 100 Insulation				1.389	m²K/W
6		OSB Board (AT Layer)				0.138	m²K/W
7		EPS Silver 70 Insulation and Rafters	0.171	0.071	0.242	4.134	m²K/W
8		PlasterBoard				0.050	m²K/W
		Internal Surface Resistance				0.13	m²K/W
		Lower Limit of Resistance, Rmin				**5.948**	**m²K/W**
		Total Thermal Resistance, Rt					
	=	0.5 (Rmax + Rmin)				**6.487**	**m²K/W**
		Assume no adjustment for fixings					
		U Value					
	=	1/Rt				**0.154**	**W/m²K**

Appendix C – WUFI Data Output Report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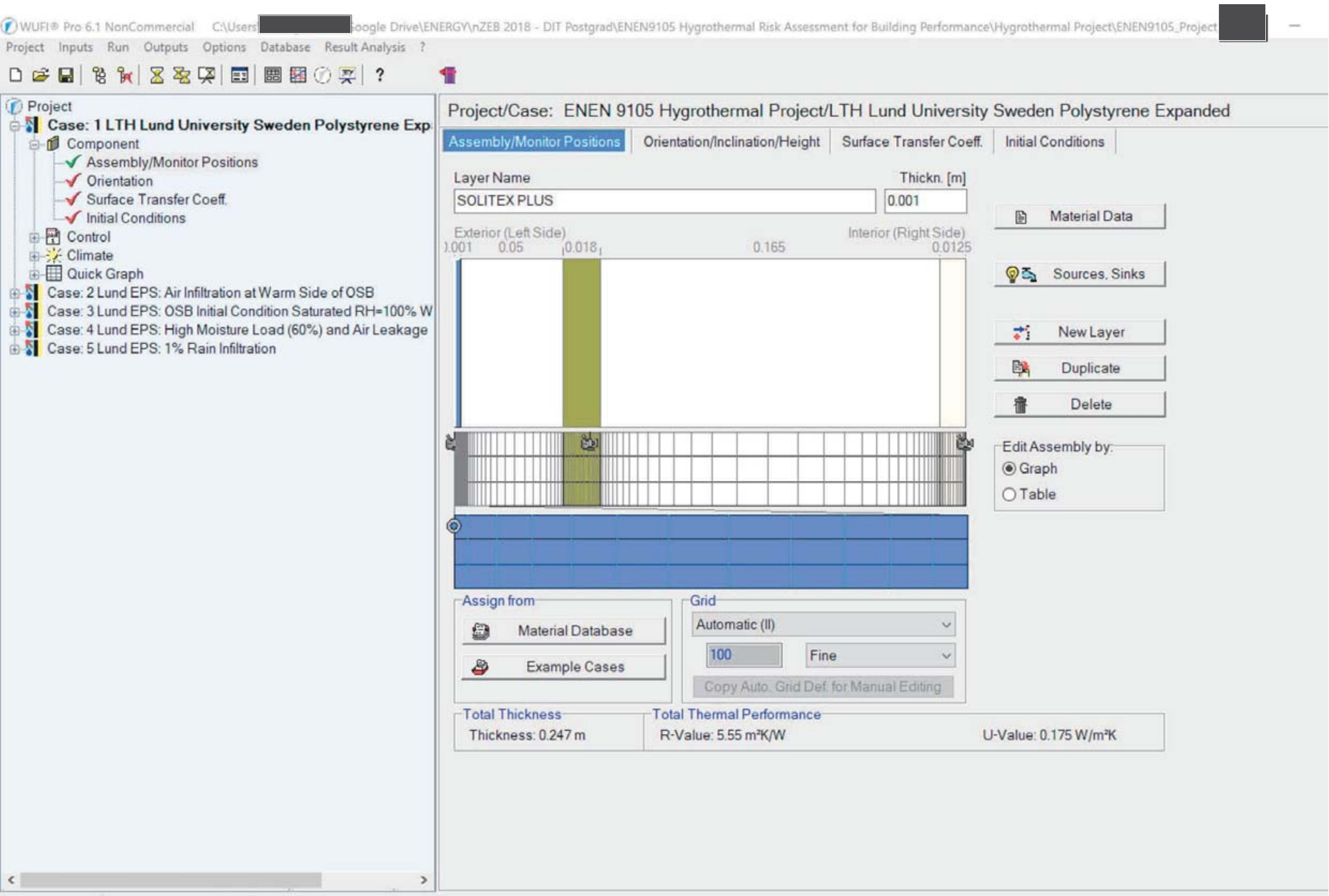
Project Inputs Run Outputs Options Database Result Analysis ?
Project
Case: 1 Base Case - North America Database Expand
Component
Assembly/Monitor Positions
Orientation
Surface Transfer Coeff.
Initial Conditions
Control
Climate
Quick Graph
Case: 2 NA EPS: Air Infiltration at Warm Side of OSB
Case: 3 NA EPS: OSB Initial Condition Saturated RH=100% WC
Case: 4 NA EPS: High Moisture Load 60% and Air Leakage
Case: 5 NA EPS: 1% Rain Infiltration
Case: 6 NA EPS - Plywood racking board
Case: 7 NA EPS - Plywood & 1% Rain Infiltration
Case: 8 NA EPS - Plywood & Air Infiltration
Case: 9 NA EPS Plywood Initial Condition Saturated RH=100%
Case: 10 3 Ply OSB (3x6mm)
Case: Base Case - North America Database Expanded Polystyrene
Assembly/Monitor Positions
Orientation/Inclination/Height
Surface Transfer Coeff.
Initial Conditions
Layer Name
SOLITEX PLUS
Thickn. [m]
0.001
Exterior (Left Side)
Interior (Right Side)
0.05
0.018
0.165
0.0125
Material Data
Sources, Sinks
New Layer
Duplicate
Delete
Edit Assembly by:
Graph
Table
Assign from
Material Database
Example Cases
Grid
Automatic (I)
100
Fine
Copy Auto. Grid Def. for Manual Editing
Total Thickness
Thickness: 0.247 m
Total Thermal Performance
R-Value: 6.15 m²K/W
U-Value: 0.158 W/m²K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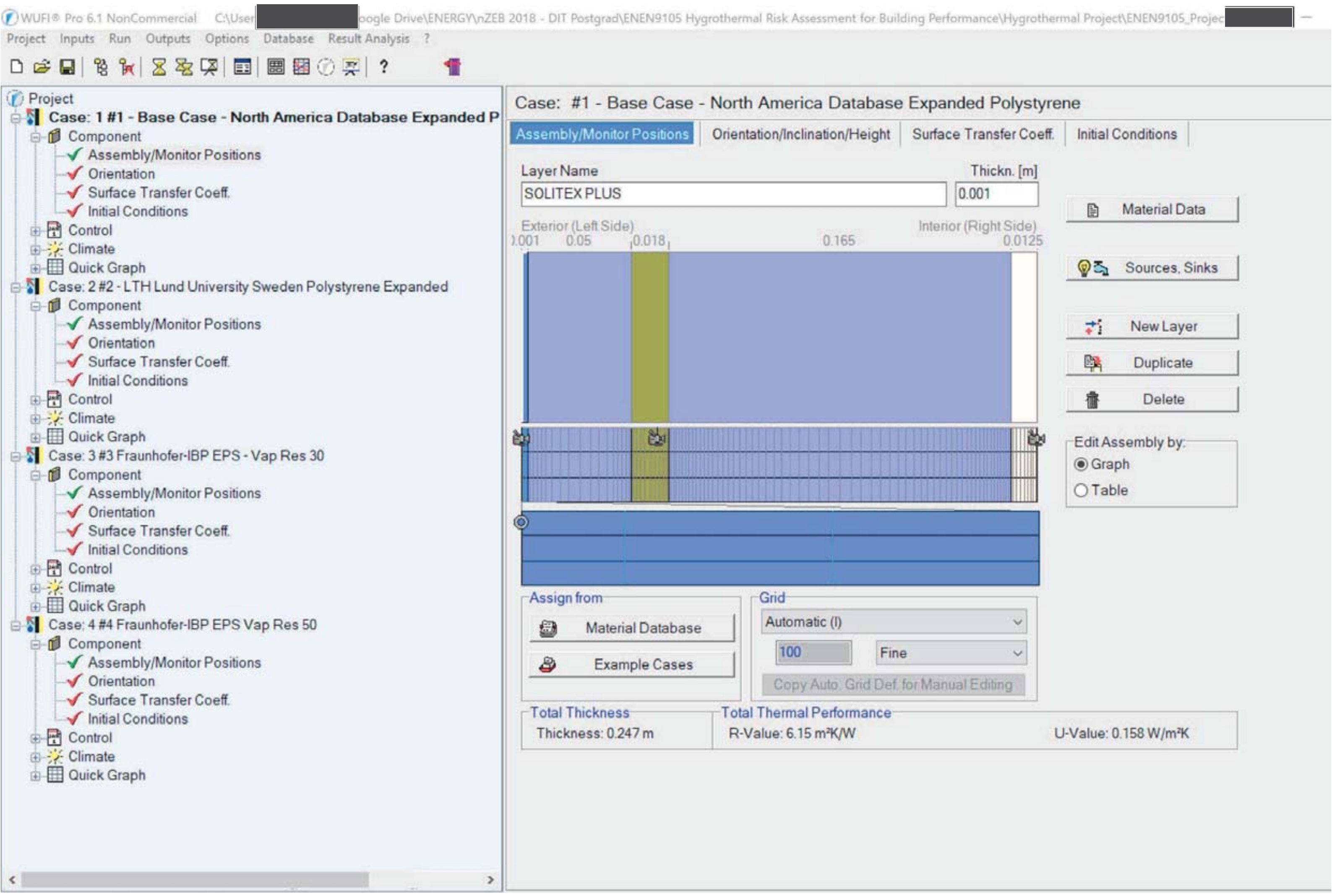
Project Inputs Run Outputs Options Database Result Analysis ?
Project
Case: 1 LTH Lund University Sweden Polystyrene Exp
Component
Assembly/Monitor Positions
Orientation
Surface Transfer Coeff.
Initial Conditions
Control
Climate
Quick Graph
Case: 2 Lund EPS: Air Infiltration at Warm Side of OSB
Case: 3 Lund EPS: OSB Initial Condition Saturated RH=100% W
Case: 4 Lund EPS: High Moisture Load (60%) and Air Leakage
Case: 5 Lund EPS: 1% Rain Infiltration
Project/Case: ENEN 9105 Hygrothermal Project/LTH Lund University Sweden Polystyrene Expanded
Assembly/Monitor Positions
Orientation/Inclination/Height
Surface Transfer Coeff.
Initial Conditions
Layer Name
Thickn. [m]
SOLITEX PLUS
0.001
Exterior (Left Side)
Interior (Right Side)
0.001 0.05 0.018 0.165 0.0125
Material Data
Sources, Sinks
New Layer
Duplicate
Delete
Edit Assembly by:
Graph
Table
Assign from
Material Database
Example Cases
Grid
Automatic (II)
100
Fine
Copy Auto. Grid Def. for Manual Editing
Total Thickness
Thickness: 0.247 m
Total Thermal Performance
R-Value: 5.55 m²K/W
U-Value: 0.175 W/m²K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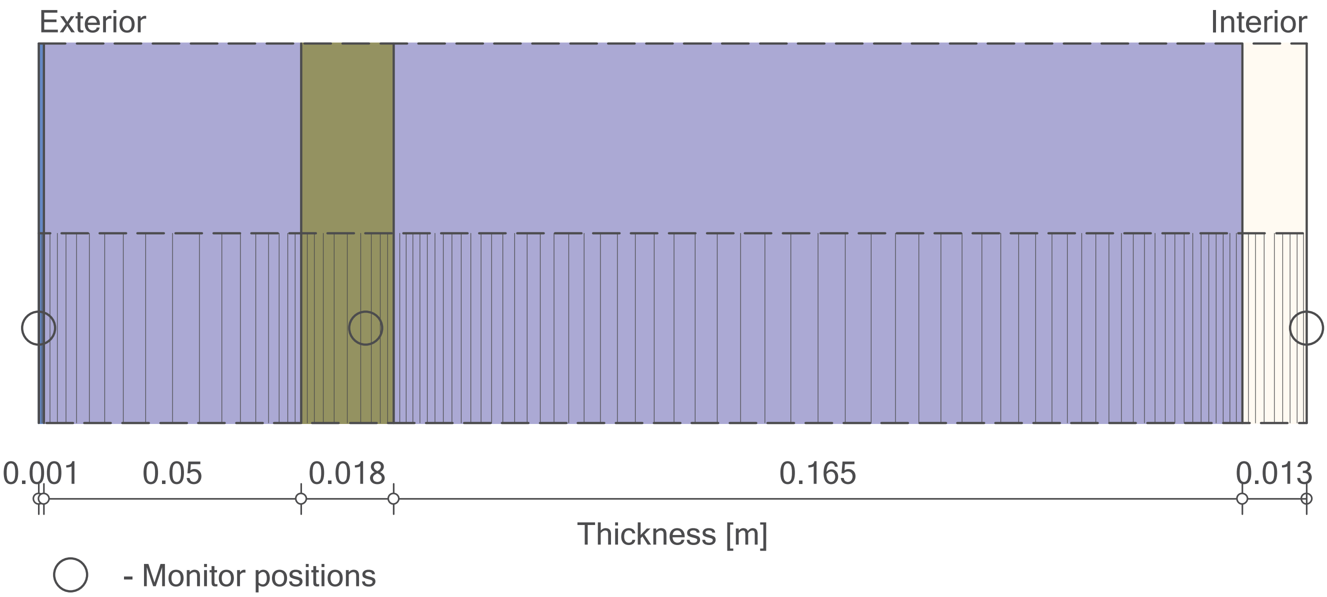
Project Inputs Run Outputs Options Database Result Analysis ?
Project
Case: 1 #1 - Base Case - North America Database Expanded P
Component
Assembly/Monitor Positions
Orientation
Surface Transfer Coeff.
Initial Conditions
Control
Climate
Quick Graph
Case: 2 #2 - LTH Lund University Sweden Polystyrene Expanded
Component
Assembly/Monitor Positions
Orientation
Surface Transfer Coeff.
Initial Conditions
Control
Climate
Quick Graph
Case: 3 #3 Fraunhofer-IBP EPS - Vap Res 30
Component
Assembly/Monitor Positions
Orientation
Surface Transfer Coeff.
Initial Conditions
Control
Climate
Quick Graph
Case: 4 #4 Fraunhofer-IBP EPS Vap Res 50
Component
Assembly/Monitor Positions
Orientation
Surface Transfer Coeff.
Initial Conditions
Control
Climate
Quick Graph
Case: #1 - Base Case - North America Database Expanded Polystyrene
Assembly/Monitor Positions
Orientation/Inclination/Height
Surface Transfer Coeff.
Initial Conditions
Layer Name
Thickn. [m]
SOLITEX PLUS
0.001
Material Data
Exterior (Left Side)
Interior (Right Side)
0.001 0.05 0.018 0.165 0.0125
Sources, Sinks
New Layer
Duplicate
Delete
Edit Assembly by:
Graph
Table
Assign from
Material Database
Example Cases
Grid
Automatic (I)
100
Fine
Copy Auto. Grid Def. for Manual Editing
Total Thickness
Thickness: 0.247 m
Total Thermal Performance
R-Value: 6.15 m²K/W
U-Value: 0.158 W/m²K

Project Data

Project Name	ENEN 9105 Hygrothermal Project
Project Number	
Client	Mr. & Mrs. Smith
Contact Person	Author: [redacted]
City/Zip	
Street	BlaBla Townload, Askeaton, Co. Limerick
Phone	
Fax	
e-mail	
Responsible	
Remarks	
Date	07/05/2018 08:20:27

Component Assembly

Case: North America Database Expanded Polystyrene



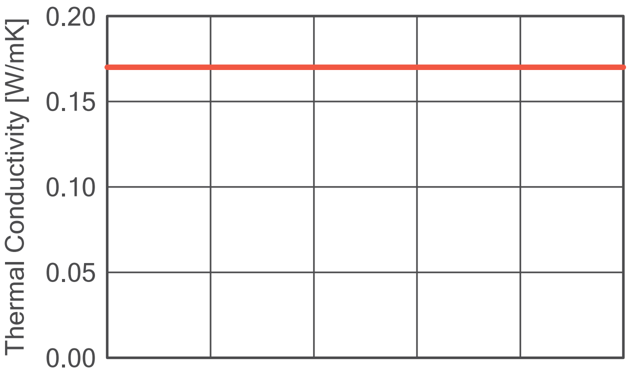
Materials:

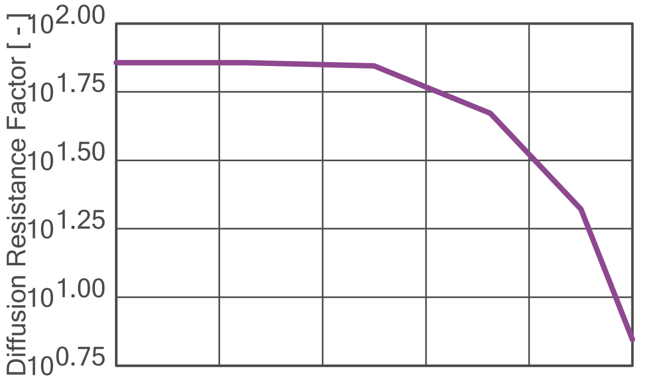
	- *SOLITEX PLUS	0.001 m
	- Expanded Polystyrene Insulation	0.05 m
	- Oriented Strand Board (density 615 kg/m³)	0.018 m
	- Expanded Polystyrene Insulation	0.165 m
	- Gypsum Board	0.013 m

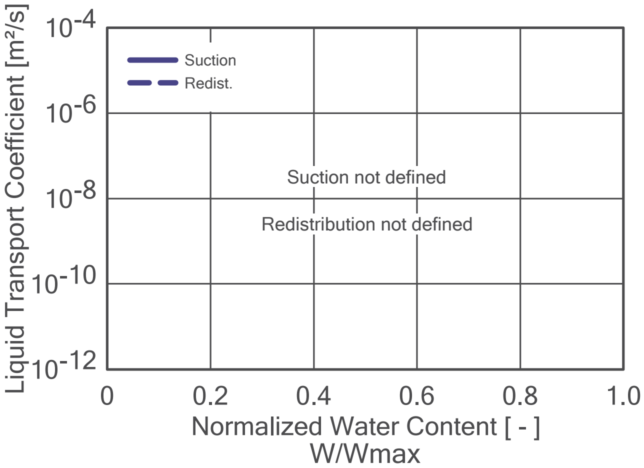
Total Thickness: 0.247 m
R-Value: 6.15 m²K/W
U-Value: 0.158 W/m²K

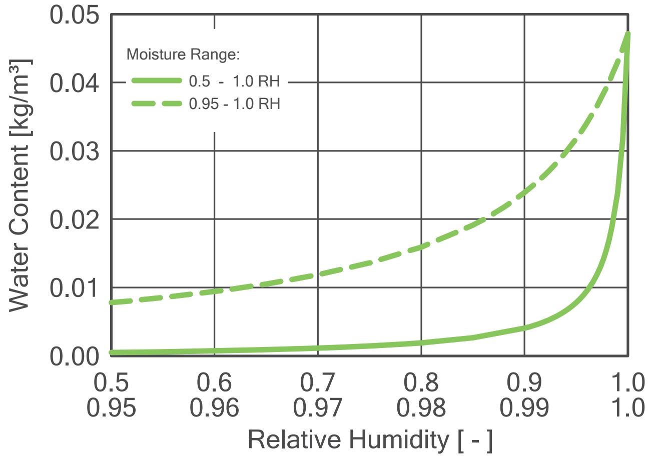
Material: *SOLITEX PLUS

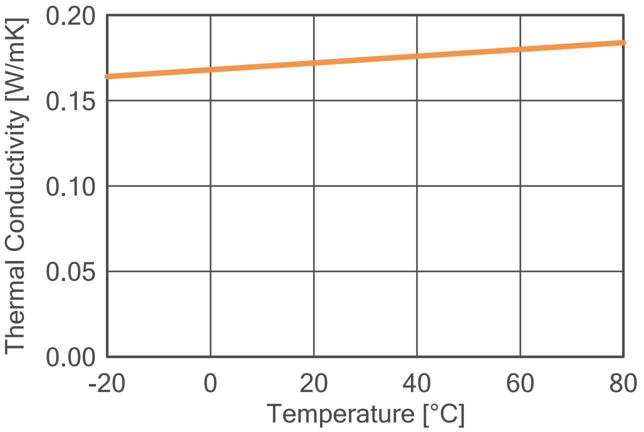
Property	Unit	Value
Bulk density	[kg/m³]	275.0
Porosity	[m³/m³]	0.001
Specific Heat Capacity, Dry	[J/kgK]	1000.0
Thermal Conductivity, Dry, 10°C	[W/mK]	0.17
Water Vapour Diffusion Resistance Factor	[-]	72.0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0.0002





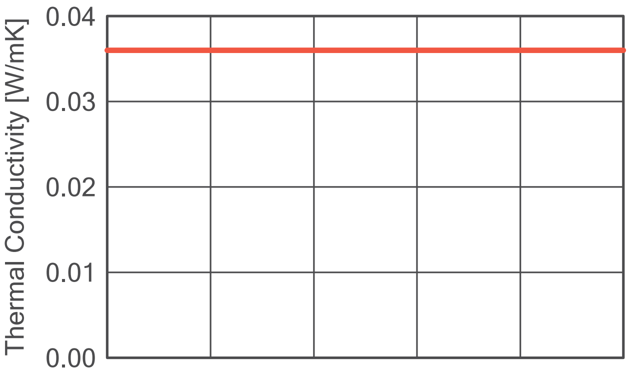


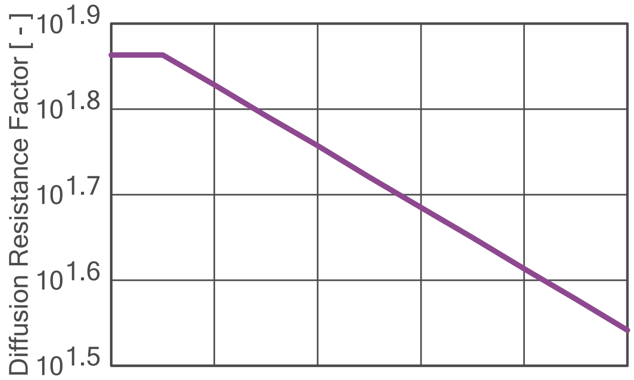


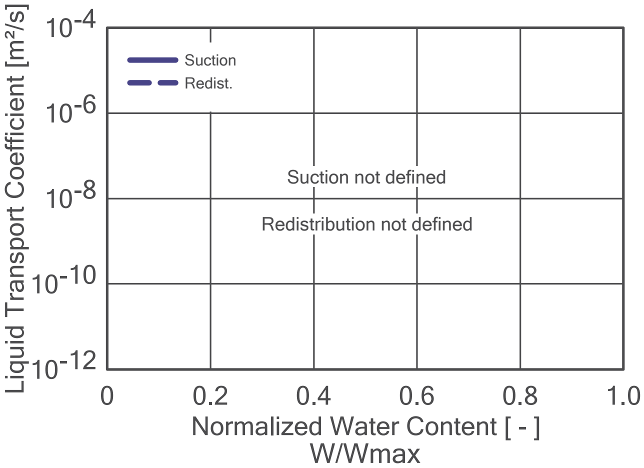


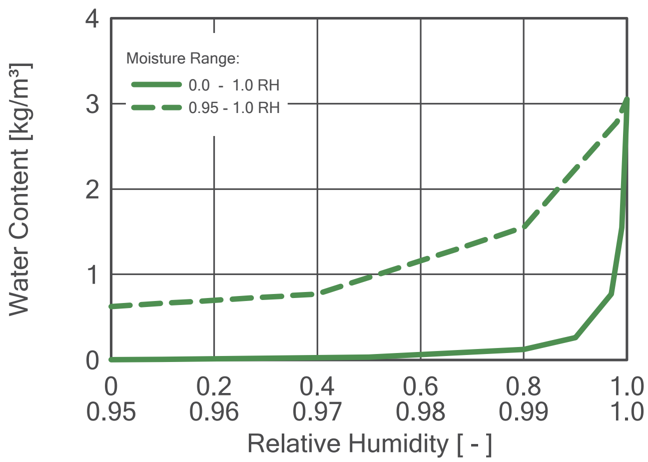
Material: Expanded Polystyrene Insulation

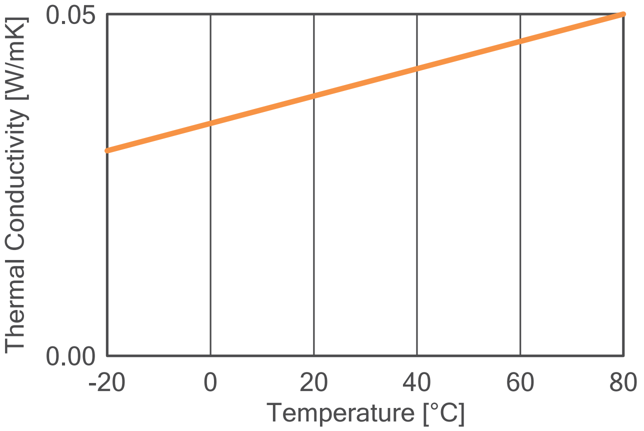
Property	Unit	Value
Bulk density	[kg/m³]	14.8
Porosity	[m³/m³]	0.99
Specific Heat Capacity, Dry	[J/kgK]	1470.0
Thermal Conductivity, Dry, 10°C	[W/mK]	0.036
Water Vapour Diffusion Resistance Factor	[-]	73.01
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0.0002





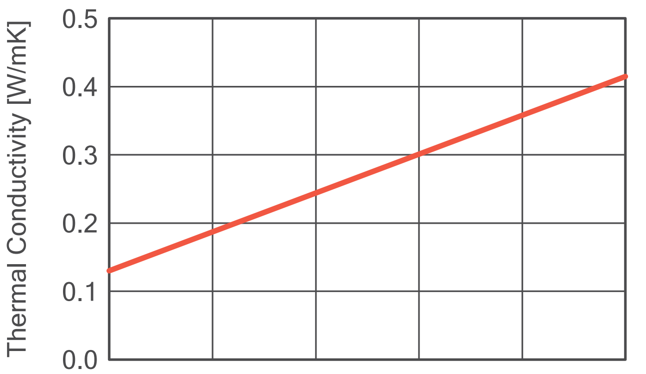


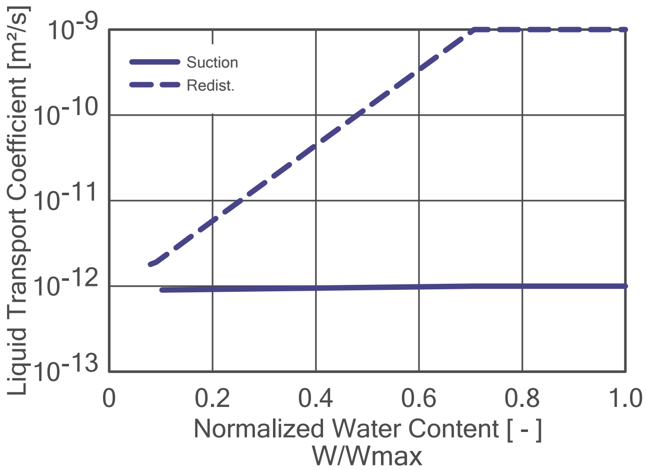


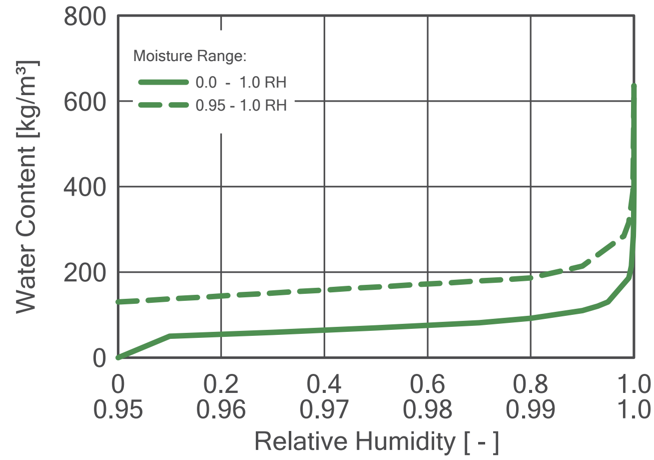


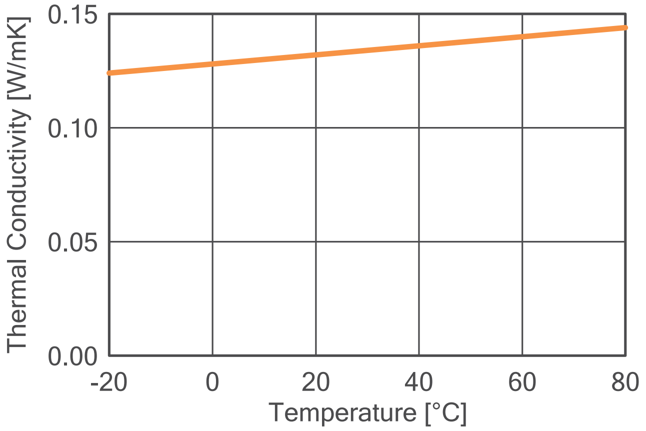
Material: Oriented Strand Board (density 615 kg/m³)

Property	Unit	Value
Bulk density	[kg/m³]	615.0
Porosity	[m³/m³]	0.9
Specific Heat Capacity, Dry	[J/kgK]	1400.0
Thermal Conductivity, Dry, 10°C	[W/mK]	0.13
Water Vapour Diffusion Resistance Factor	[-]	175.0
Moisture-dep. Thermal Cond. Supplement	[%/M.-%]	1.5
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0.0002









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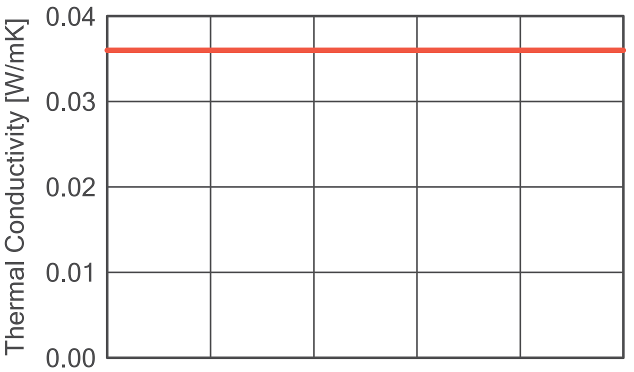
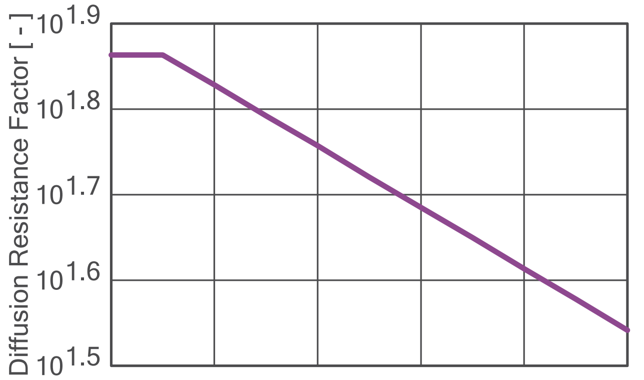
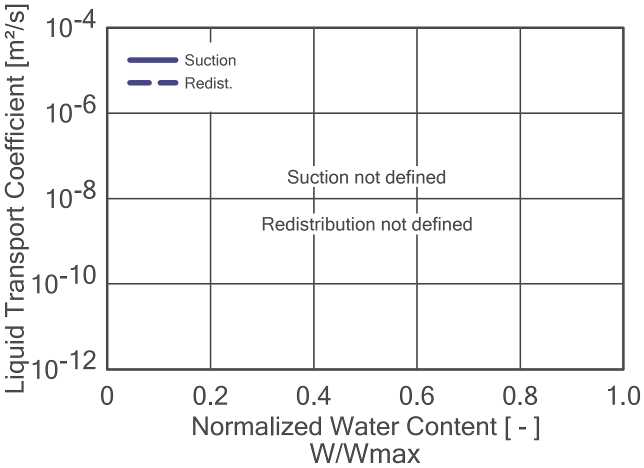
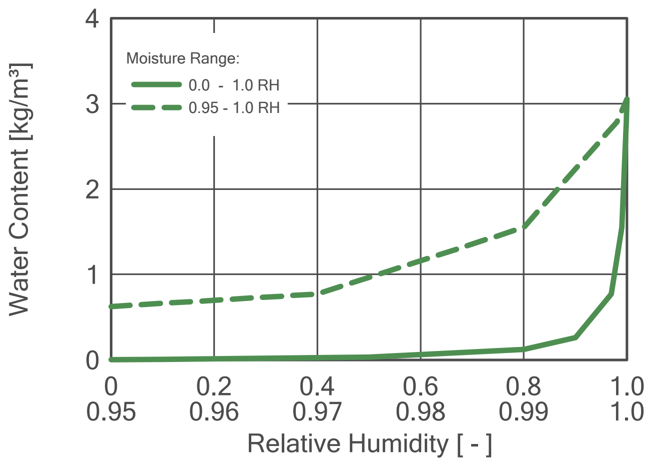
Material: Expanded Polystyrene Insulation

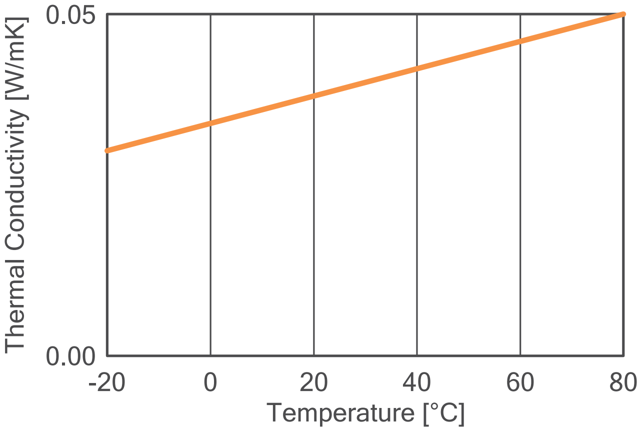
Property	Unit	Value
Bulk density	[kg/m³]	14.8
Porosity	[m³/m³]	0.99
Specific Heat Capacity, Dry	[J/kgK]	1470.0
Thermal Conductivity, Dry, 10°C	[W/mK]	0.036
Water Vapour Diffusion Resistance Factor	[-]	73.01
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0.0002











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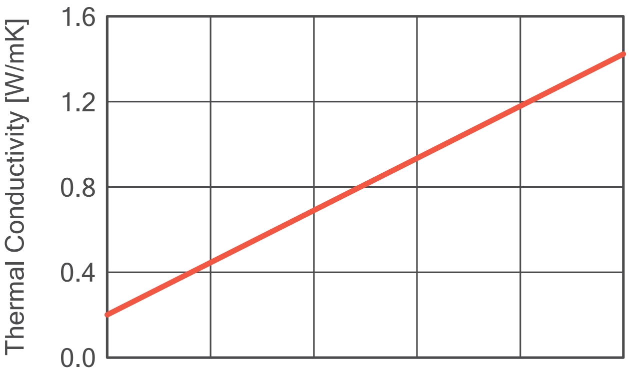
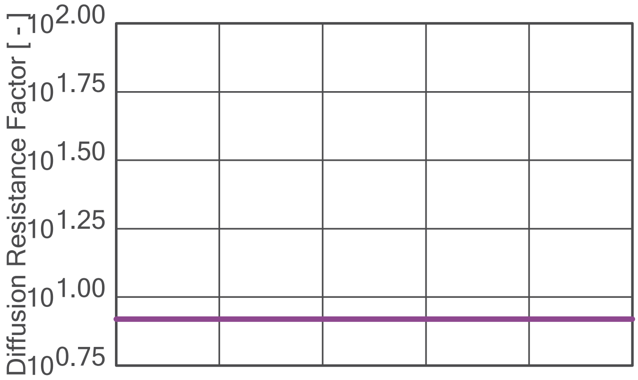
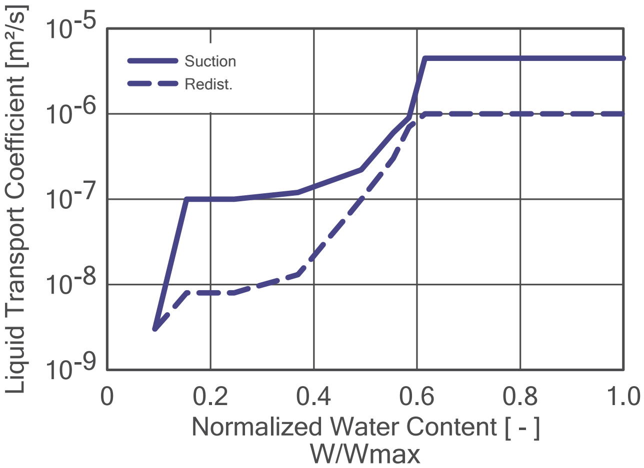
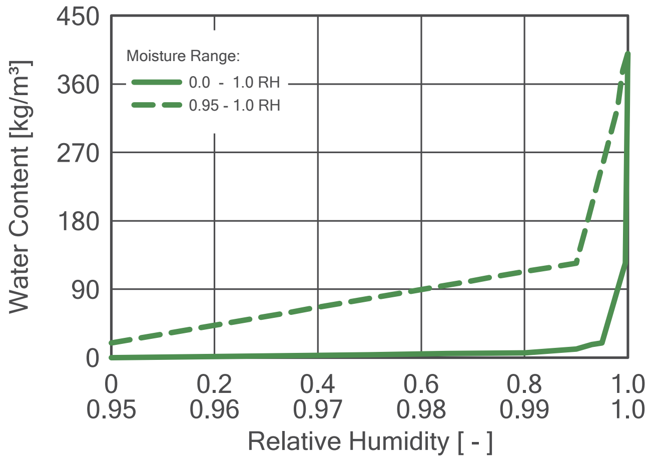
Material: Gypsum Board

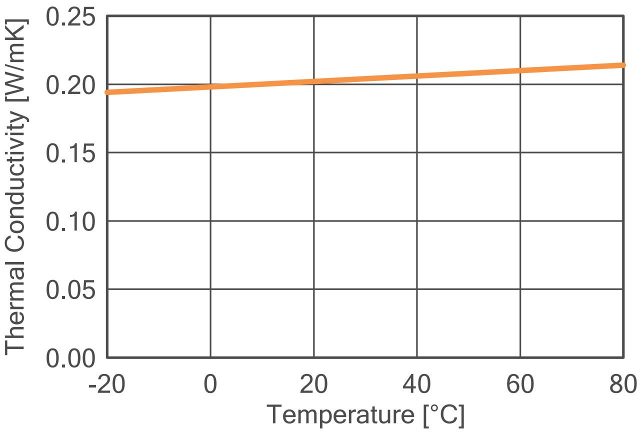
Property	Unit	Value
Bulk density	[kg/m³]	850.0
Porosity	[m³/m³]	0.65
Specific Heat Capacity, Dry	[J/kgK]	850.0
Thermal Conductivity, Dry, 10°C	[W/mK]	0.2
Water Vapour Diffusion Resistance Factor	[-]	8.3
Moisture-dep. Thermal Cond. Supplement	[%/M.-%]	8.0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0.0002











Boundary Conditions

Exterior (Left Side)

Location:	ShannonAirport_extreme.wac
Temperature Shift:	0 °C
Orientation / Inclination:	North / 90 °
Nighttime radiation cooling:	Explicit Radiation Balance

Interior (Right Side)

Indoor Climate:	EN 15026 Medium Moisture Load

Surface Transfer Coefficients

Exterior (Left Side)

Name	Description	Unit	Value
Heat Resistance - includes long-wave radiation	Roof (DIN 68800-2:2012-02)	[m²K/W]	0.0526 yes
Sd-Value	No coating	[m]	----
Short-Wave Radiation Absorptivity	Dark	[-]	0.8
Long-Wave Radiation Emissivity	Dark	[-]	0.9
Adhering Fraction of Rain	No absorption	[-]	----
Explicit Radiation Balance			yes
Terrestrial Short-Wave Reflectivity		[-]	0.2
Terrestrial Long-Wave Emissivity		[-]	0.9
Terrestrial Long-Wave Reflectivity		[-]	0.1
Cloud Index		[-]	0.66

Interior (Right Side)

Name	Description	Unit	Value
Heat Resistance	Roof (DIN 68800-2:2012-02)	[m²K/W]	0.125
Sd-Value	No coating	[m]	----

Results from Last Calculation

Status of Calculation

Calculation: Time and Date	23/04/2018 09:19:21
Computing Time	1 min,47 sec.
Begin / End of calculation	01/10/2018 / 01/10/2023
No. of Convergence Failures	0

Check for numerical quality

Integral of fluxes, left side (kl,dl)	[kg/m²]	0.0 -0.58
Integral of fluxes, right side (kr,dr)	[kg/m²]	7.8E-8 -0.32
Balance 1	[kg/m²]	-0.23
Balance 2	[kg/m²]	-0.27

Water Content [kg/m²]

	Start	End	Min.	Max.
Total Water Content	1.75	1.52	1.49	1.75

Water Content [kg/m³]

Layer/Material	Start	End	Min.	Max.
*SOLITEX PLUS	0.00	0.00	0.00	0.37
Expanded Polystyrene Insulation	0.06	0.12	0.04	0.37
Oriented Strand Board (density 615 k	92.00	80.68	79.06	92.00
Expanded Polystyrene Insulation	0.06	0.07	0.05	0.08
Gypsum Board	6.30	3.97	2.85	6.30

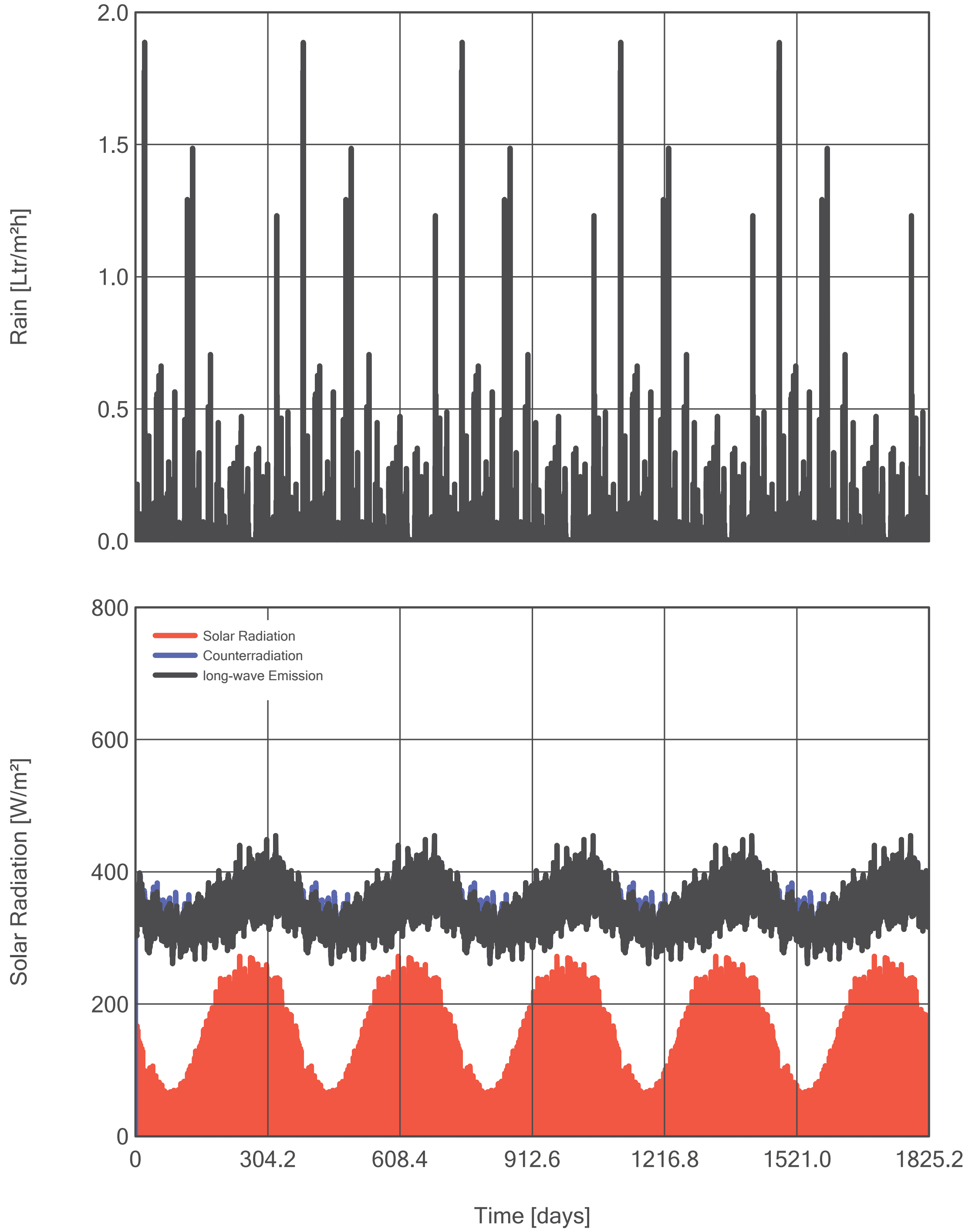
Time Integral of fluxes

Heat Flux, left side	[MJ/m²]	-1620.78
Heat Flux, right side	[MJ/m²]	-242.46
Moisture Fluxes, left side	[kg/m²]	14.57
Moisture Fluxes, right side	[kg/m²]	-0.32

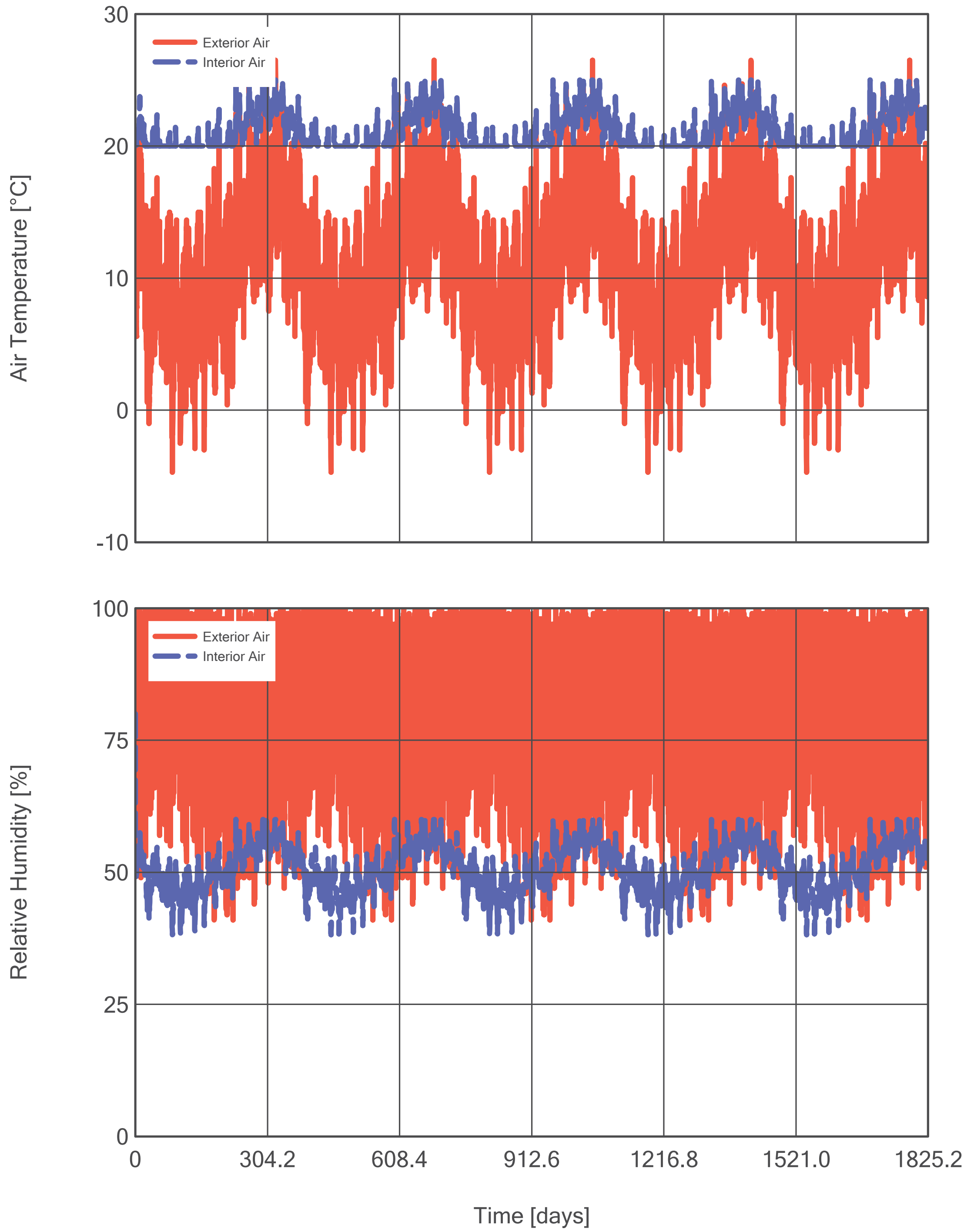
Hygrothermal Sources

Heat Sources	[MJ/m²]	0.0
Moisture Sources	[kg/m²]	0.0
Unreleased Moisture Sources (due to cut-off)	[kg/m²]	0.0

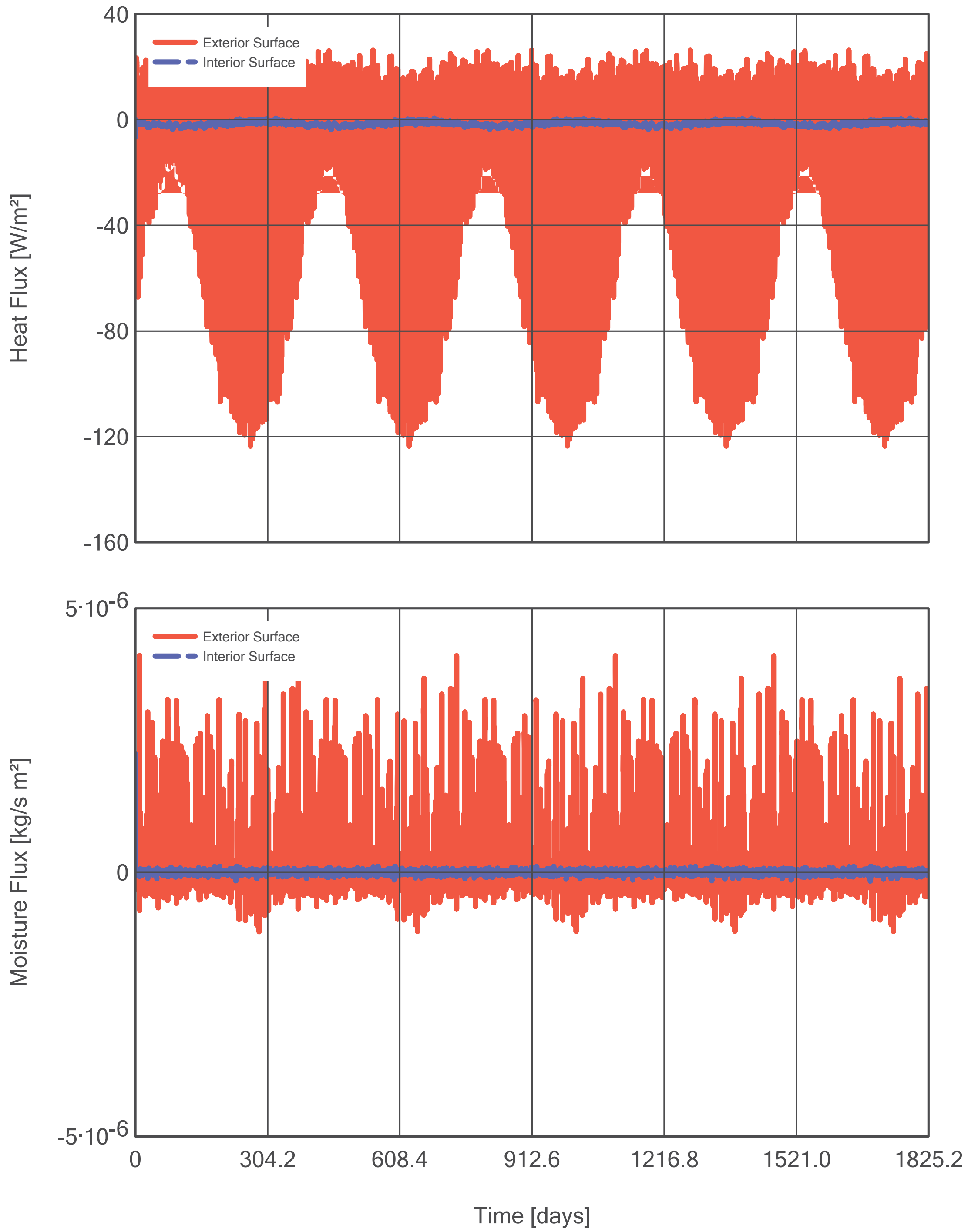
Rain, Radiation (Exterior Climate)



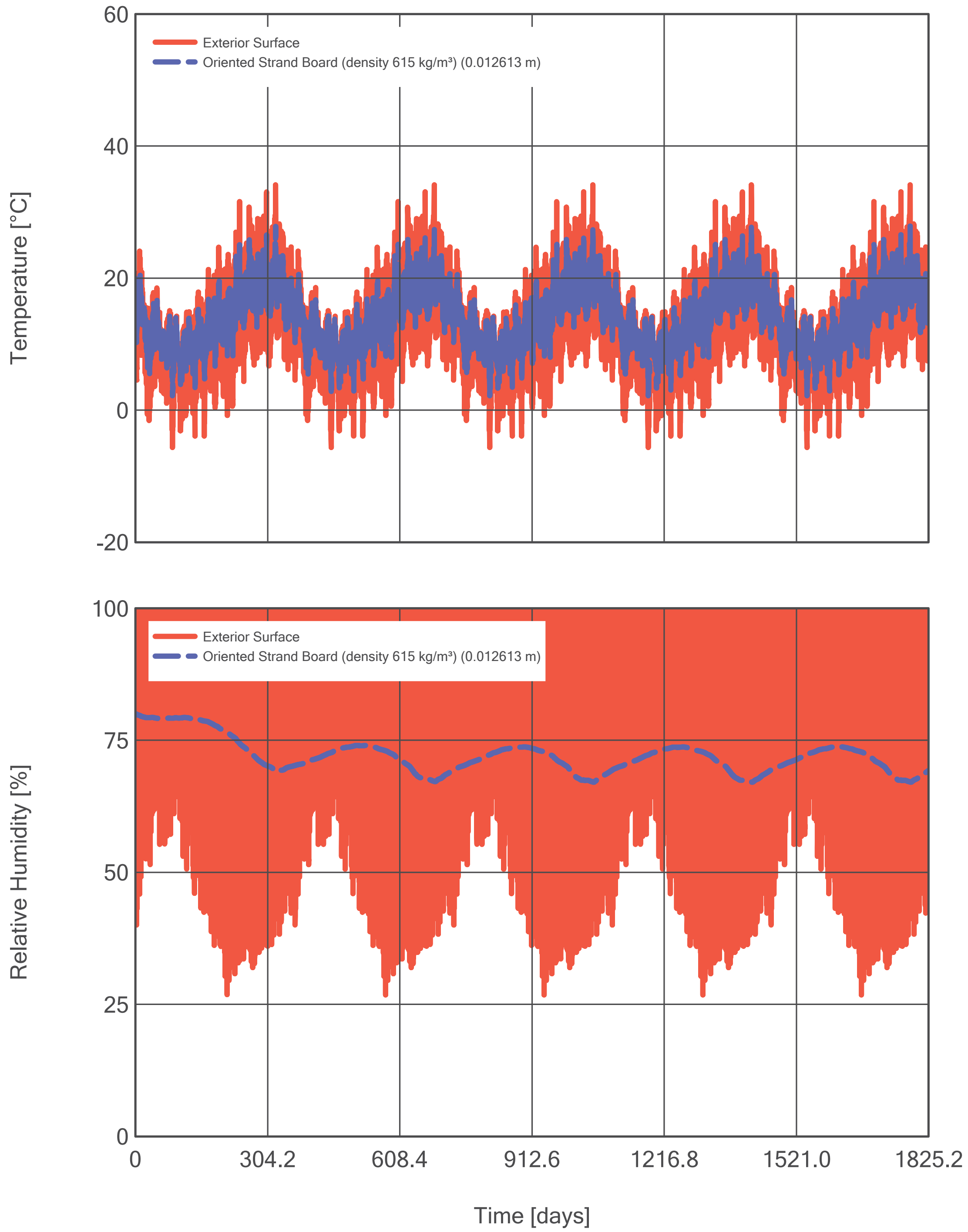
Air Temperature, RH (Exterior, Interior)



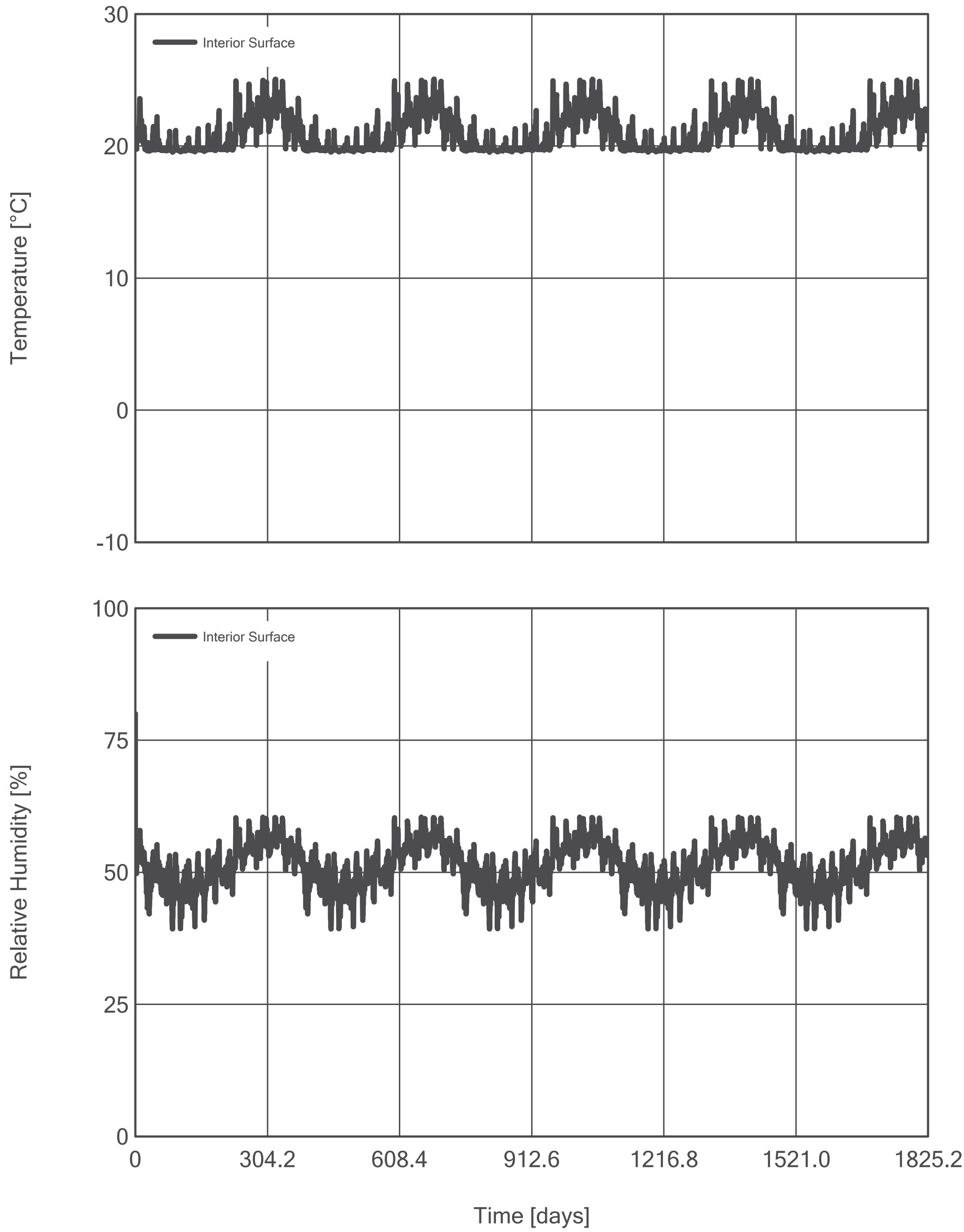
Heat, Moisture Fluxes



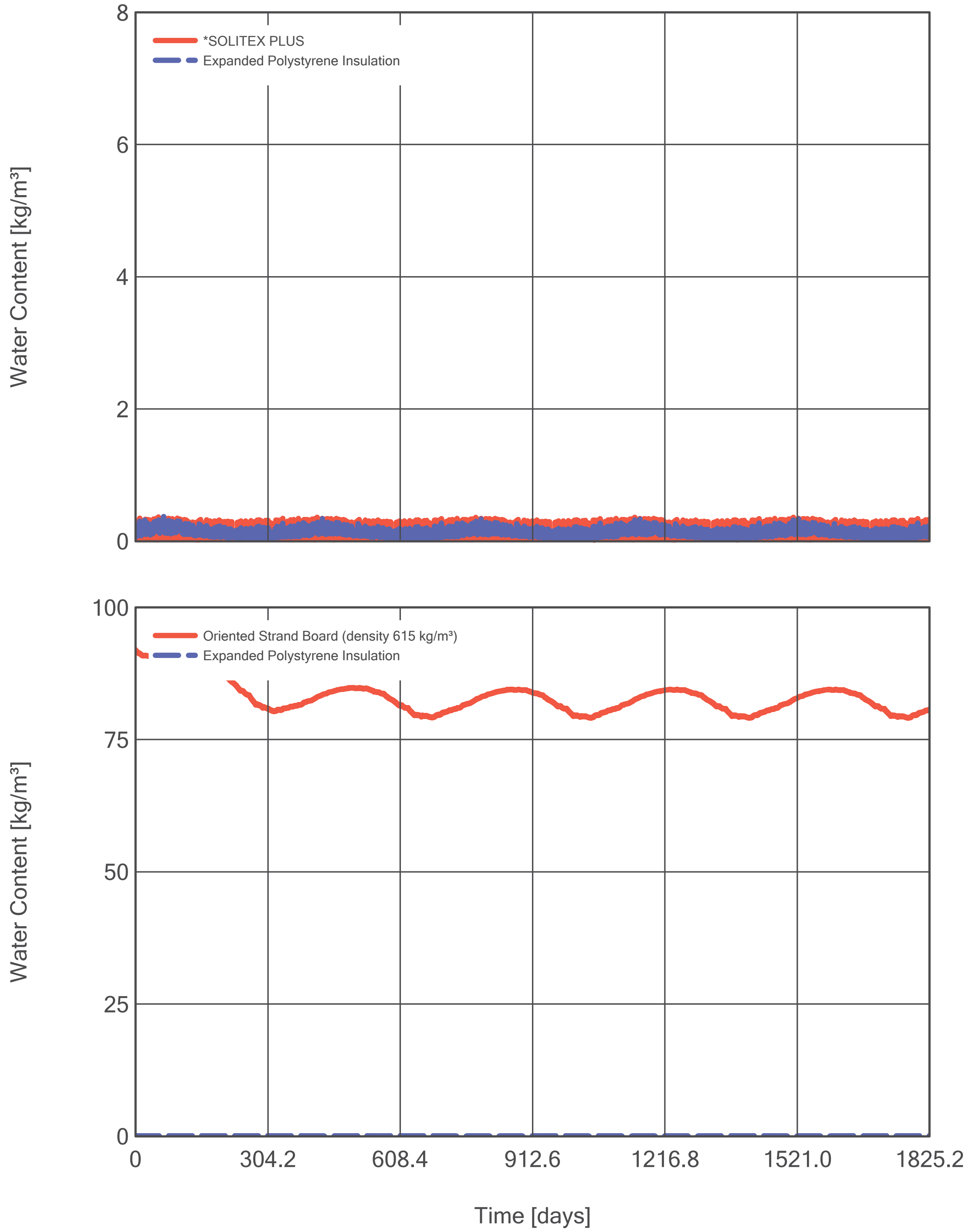
Temperature, RH (Monitor Position 1, 2)



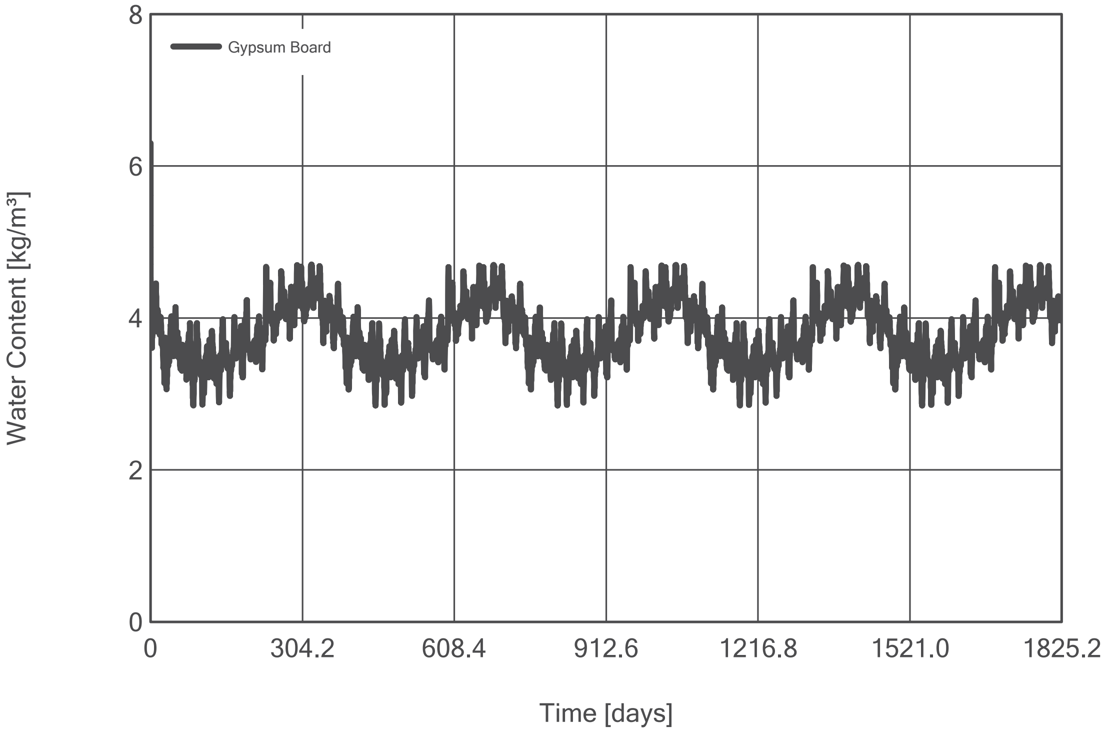
Temperature, RH (Monitor Position 3)



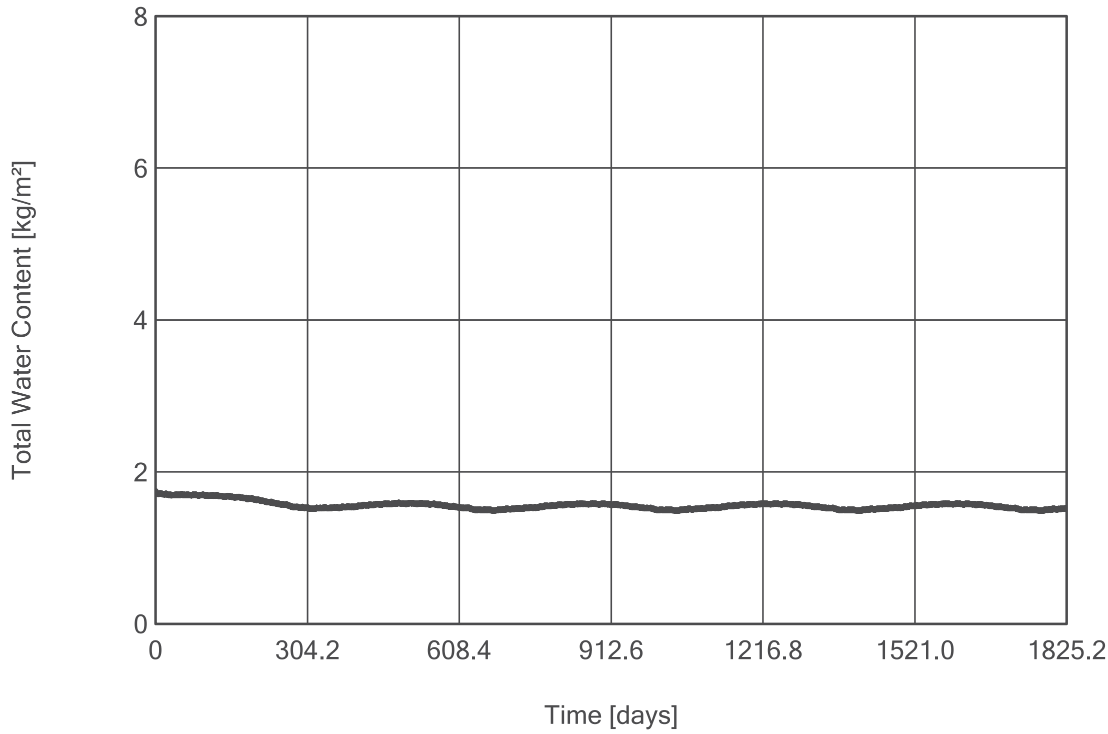
Water Content of Individual Materials



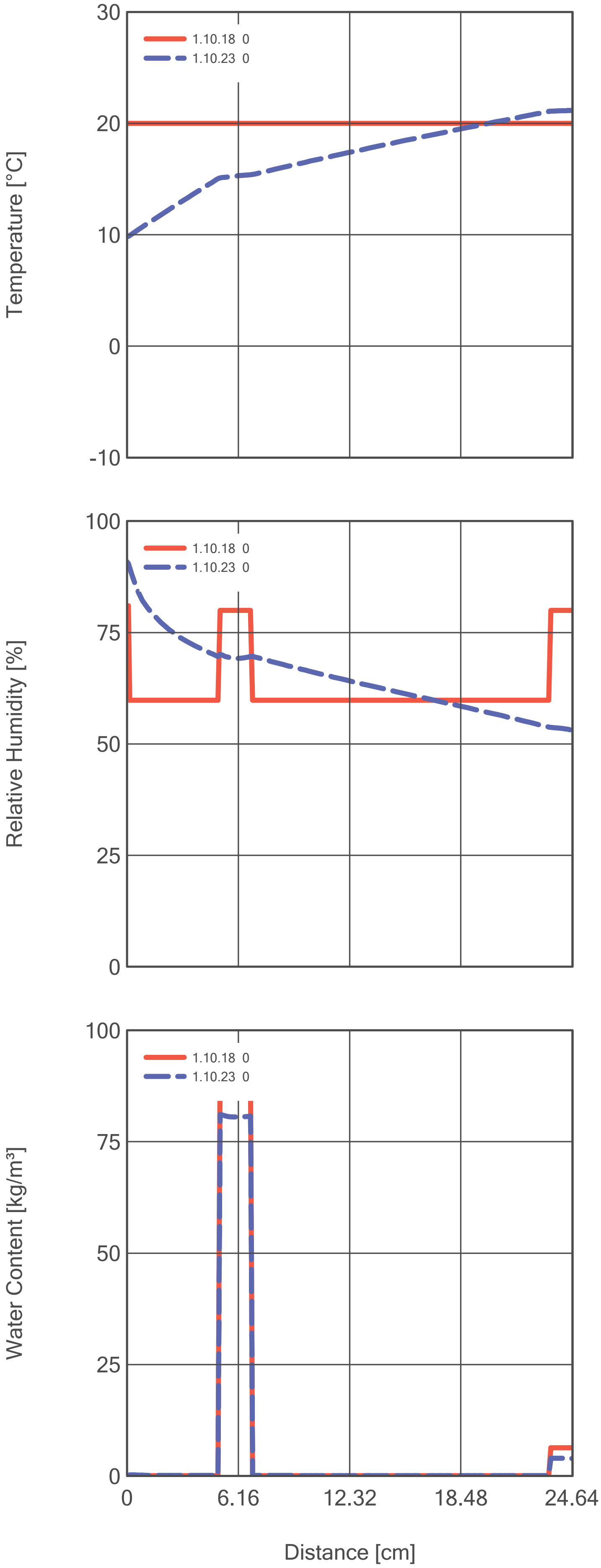
Water Content of Individual Materials



Total Water Content in Construction



Profiles


Temperature [°C]
30
20
10
0
-10
1.10.18 0
1.10.23 0
Relative Humidity [%]
100
75
50
25
0
1.10.18 0
1.10.23 0
Water Content [kg/m³]
100
75
50
25
0
1.10.18 0
1.10.23 0
0
6.16
12.32
18.48
24.64
Distance [cm]

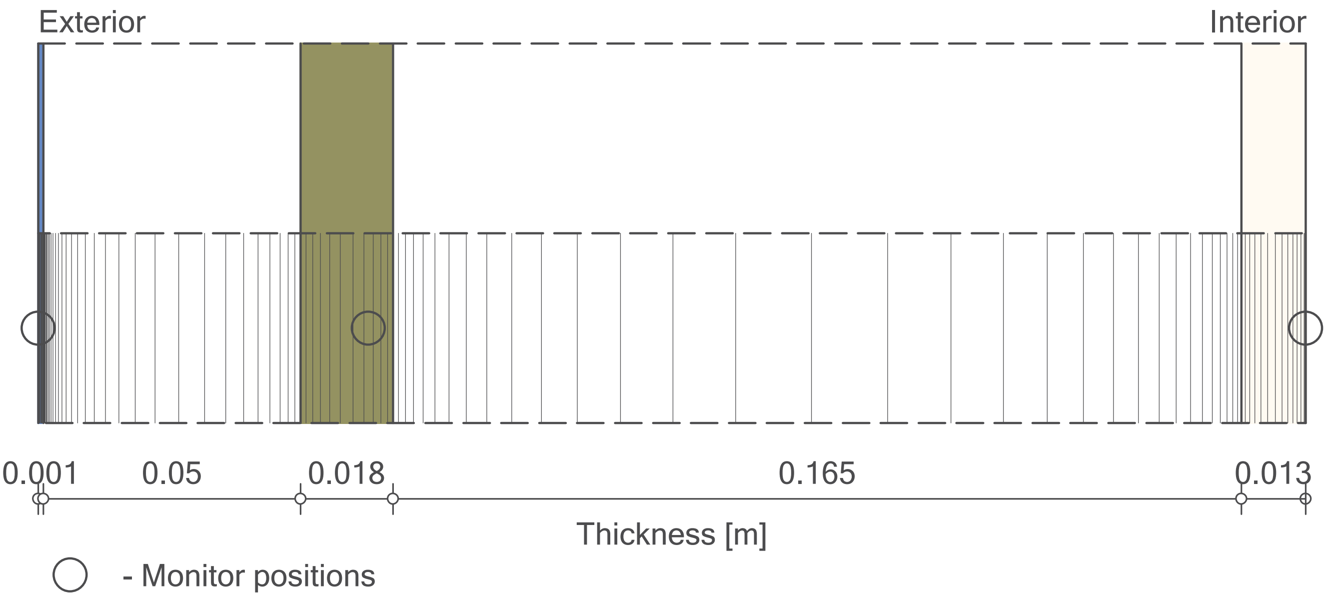
WUFI® Pro 6.1 NonCommercial

Project Data

Project Name	ENEN 9105 Hygrothermal Project
Project Number	
Client	Mr. & Mrs. Smith
Contact Person	Author: [redacted]
City/Zip	
Street	BlaBla Townload, Askeaton, Co. Limerick
Phone	
Fax	
e-mail	
Responsible	
Remarks	
Date	07/05/2018 08:20:27

Component Assembly

Case: LTH Lund University Sweden Polystyrene Expanded



Materials:

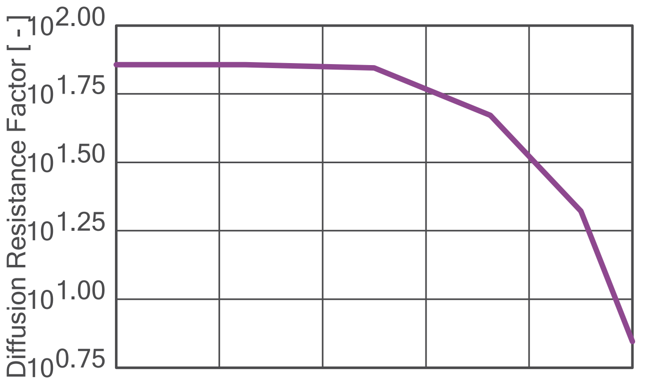
	- *SOLITEX PLUS	0.001 m
	- Polystyrene, expanded	0.05 m
	- Oriented Strand Board (density 615 kg/m³)	0.018 m
	- Polystyrene, expanded	0.165 m
	- Gypsum Board	0.013 m

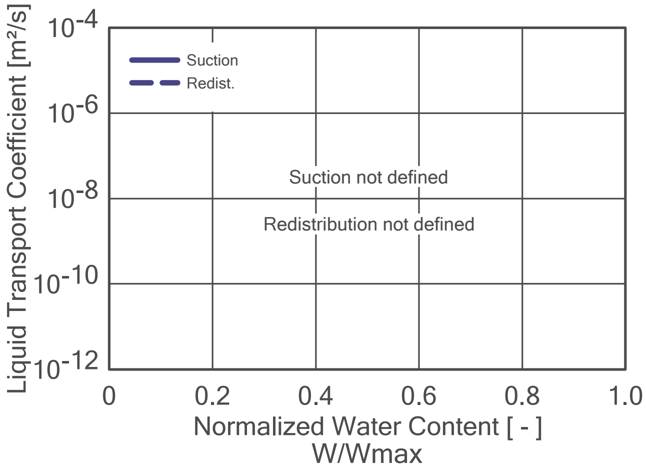
Total Thickness: 0.247 m
R-Value: 5.55 m²K/W
U-Value: 0.175 W/m²K

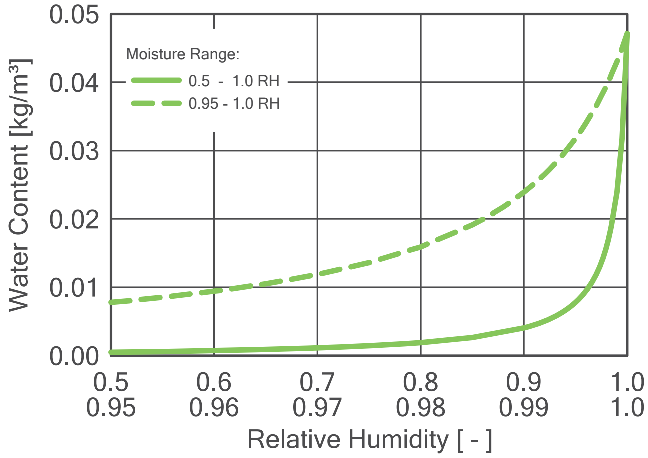
WUFI® Pro 6.1 NonCommercial

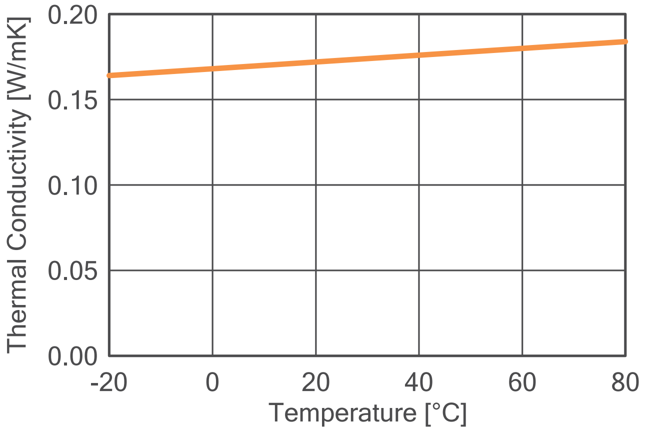
Material: *SOLITEX PLUS

Property	Unit	Value
Bulk density	[kg/m³]	275.0
Porosity	[m³/m³]	0.001
Specific Heat Capacity, Dry	[J/kgK]	1000.0
Thermal Conductivity, Dry, 10°C	[W/mK]	0.17
Water Vapour Diffusion Resistance Factor	[-]	72.0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0.0002





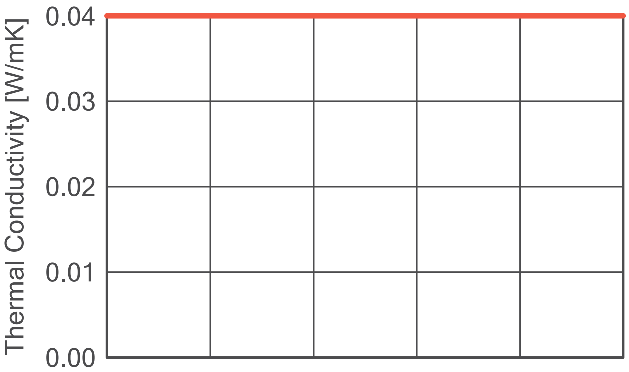


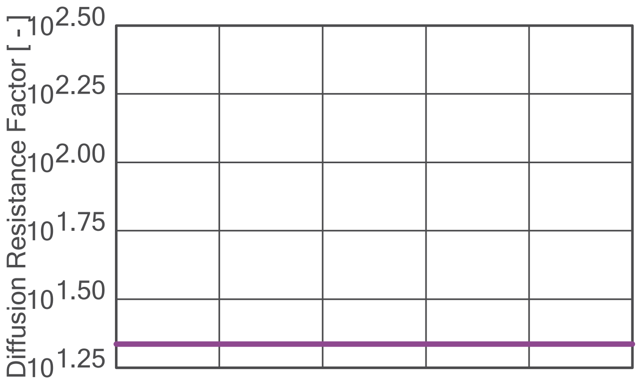


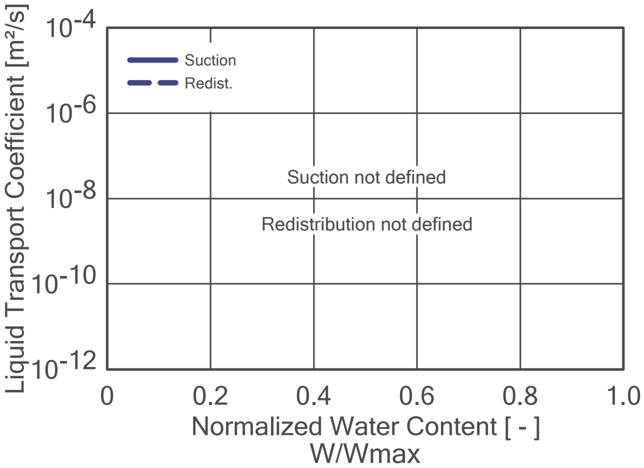
WUFI® Pro 6.1 NonCommercial

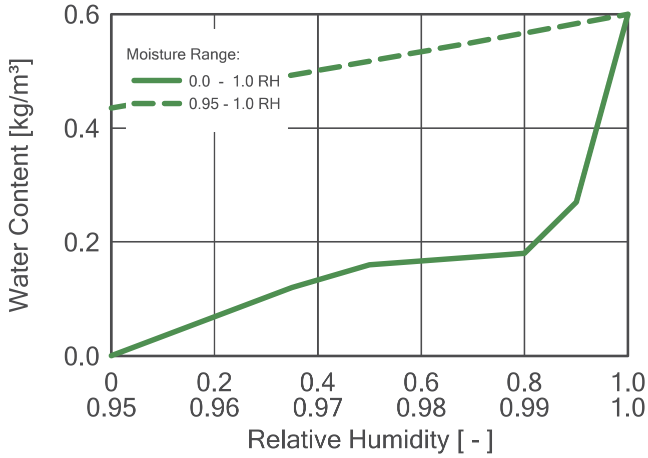
Material: Polystyrene, expanded

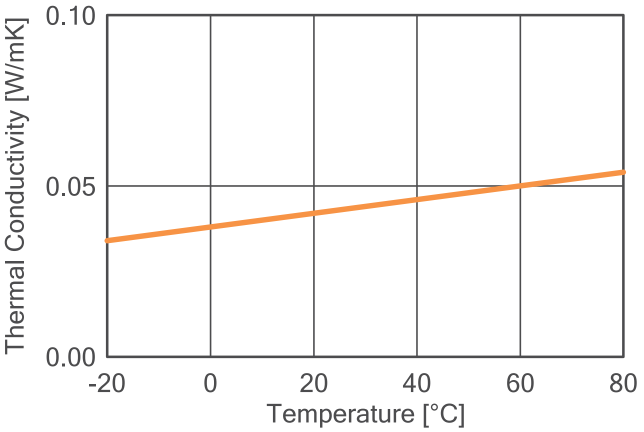
Property	Unit	Value
Bulk density	[kg/m³]	20.0
Porosity	[m³/m³]	0.98
Specific Heat Capacity, Dry	[J/kgK]	1500.0
Thermal Conductivity, Dry, 10°C	[W/mK]	0.04
Water Vapour Diffusion Resistance Factor	[-]	21.7
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0.0002





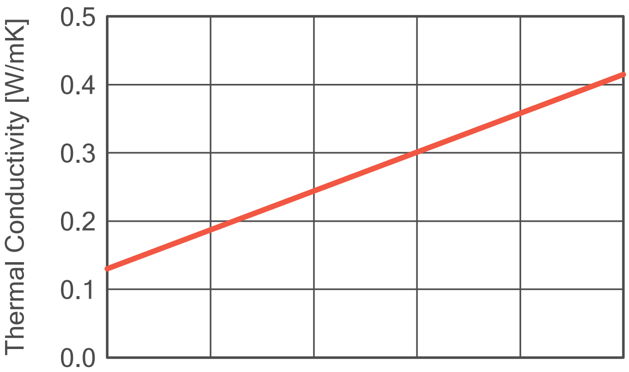


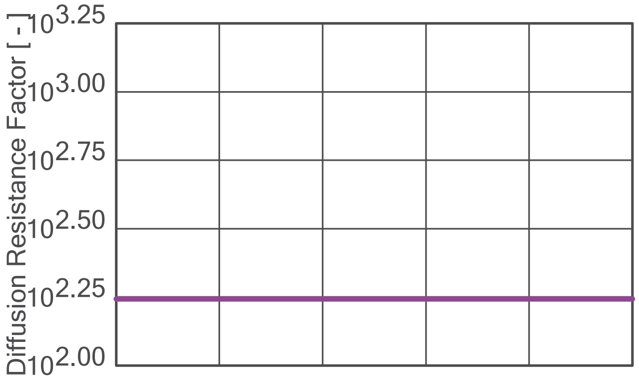


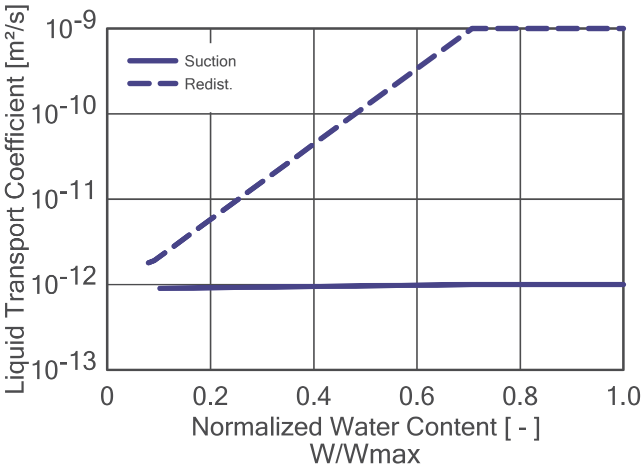


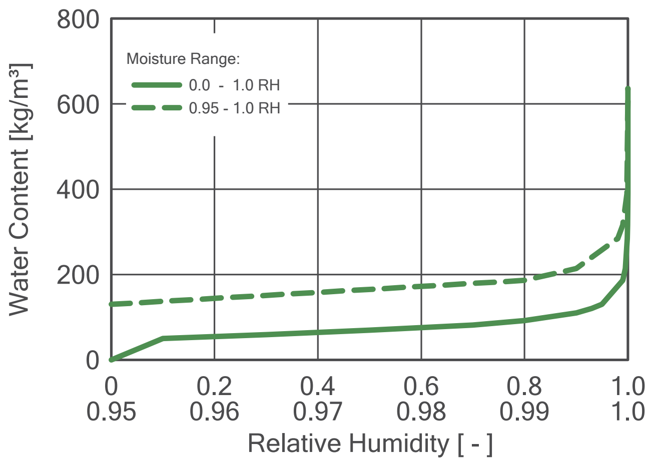
Material: Oriented Strand Board (density 615 kg/m³)

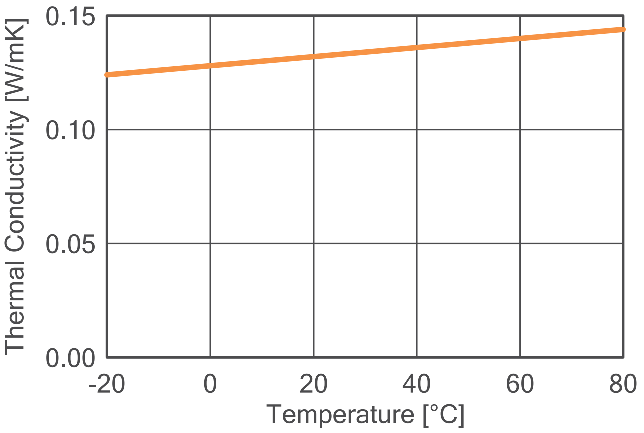
Property	Unit	Value
Bulk density	[kg/m³]	615.0
Porosity	[m³/m³]	0.9
Specific Heat Capacity, Dry	[J/kgK]	1400.0
Thermal Conductivity, Dry, 10°C	[W/mK]	0.13
Water Vapour Diffusion Resistance Factor	[-]	175.0
Moisture-dep. Thermal Cond. Supplement	[%/M.-%]	1.5
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0.0002





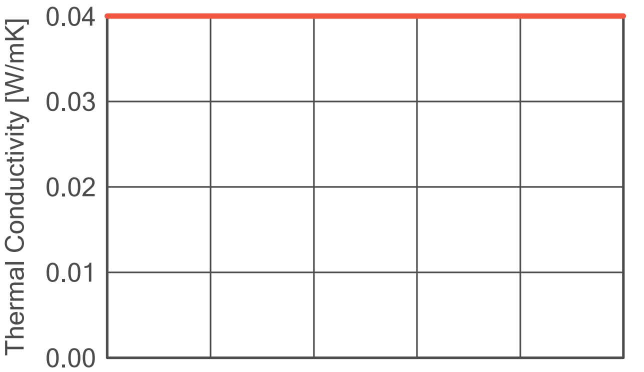


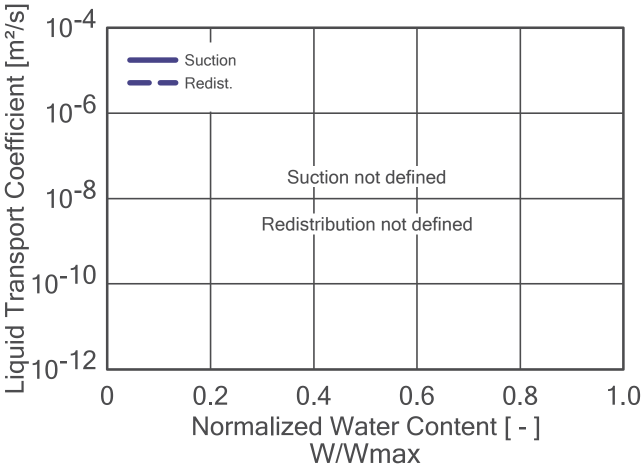


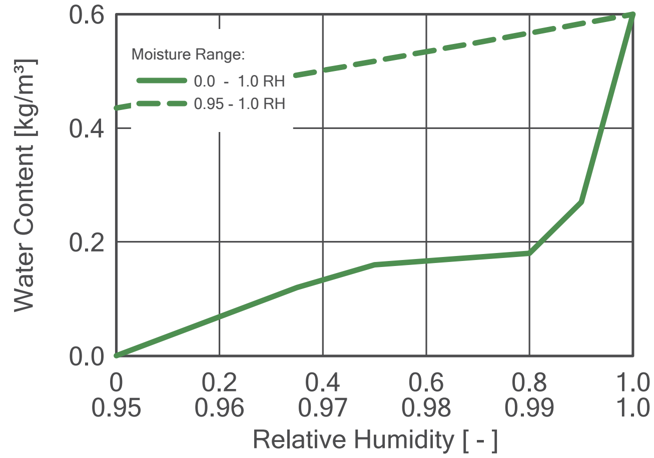


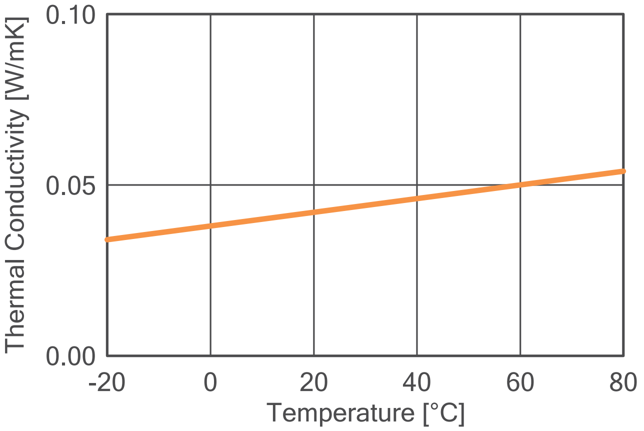
Material: Polystyrene, expanded

Property	Unit	Value
Bulk density	[kg/m³]	20.0
Porosity	[m³/m³]	0.98
Specific Heat Capacity, Dry	[J/kgK]	1500.0
Thermal Conductivity, Dry, 10°C	[W/mK]	0.04
Water Vapour Diffusion Resistance Factor	[-]	21.7
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0.0002





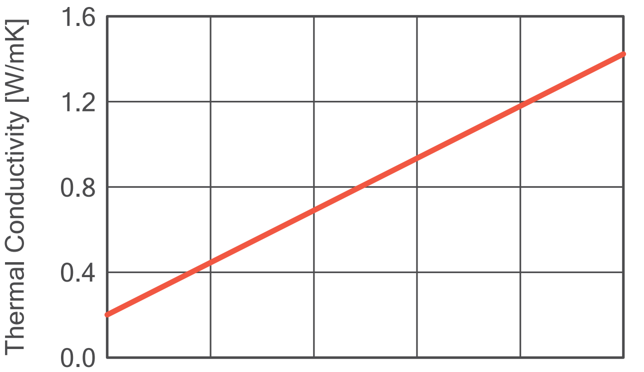


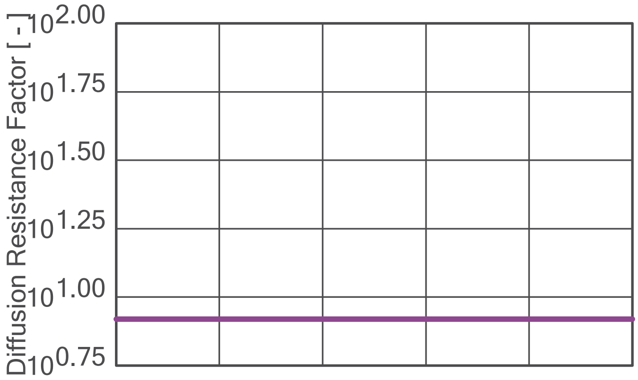


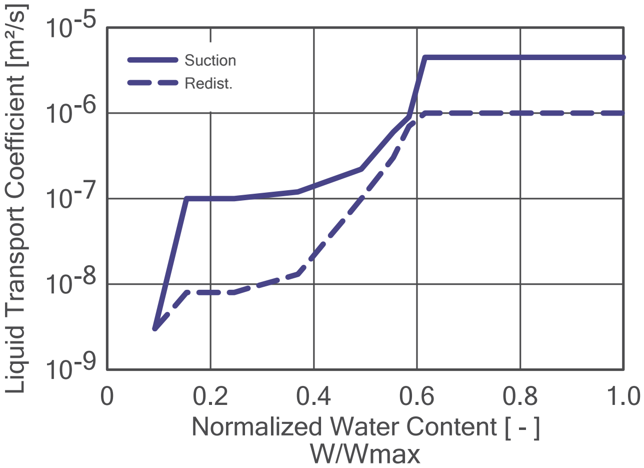
WUFI® Pro 6.1 NonCommercial

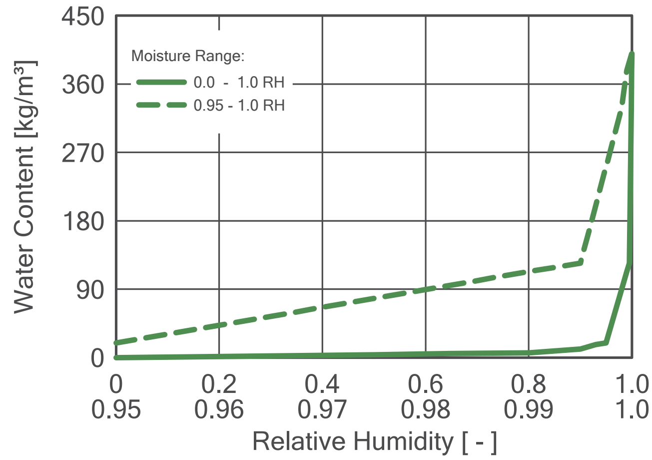
Material: Gypsum Board

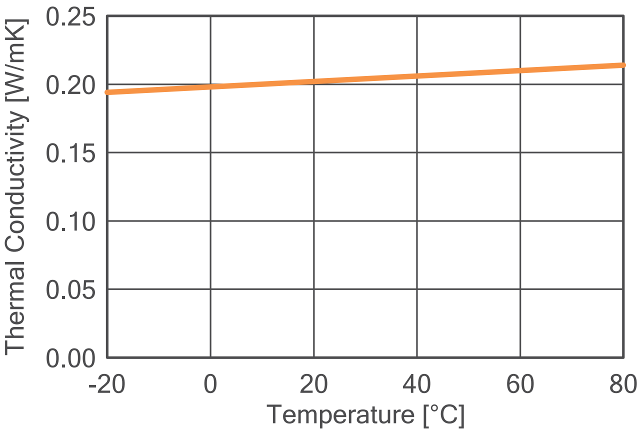
Property	Unit	Value
Bulk density	[kg/m³]	850.0
Porosity	[m³/m³]	0.65
Specific Heat Capacity, Dry	[J/kgK]	850.0
Thermal Conductivity, Dry, 10°C	[W/mK]	0.2
Water Vapour Diffusion Resistance Factor	[-]	8.3
Moisture-dep. Thermal Cond. Supplement	[%/M.-%]	8.0
Temp-dep. Thermal Cond. Supplement	[W/mK²]	0.0002











Boundary Conditions

Exterior (Left Side)

Location:	ShannonAirport_extreme.wac
Temperature Shift:	0 °C
Orientation / Inclination:	North / 90 °
Nighttime radiation cooling:	Explicit Radiation Balance

Interior (Right Side)

Indoor Climate:	EN 15026 Medium Moisture Load

Surface Transfer Coefficients

Exterior (Left Side)

Name	Description	Unit	Value
Heat Resistance - includes long-wave radiation	Roof (DIN 68800-2:2012-02)	[m²K/W]	0.0526 yes
Sd-Value	No coating	[m]	----
Short-Wave Radiation Absorptivity	Dark	[-]	0.8
Long-Wave Radiation Emissivity	Dark	[-]	0.9
Adhering Fraction of Rain	No absorption	[-]	----
Explicit Radiation Balance			yes
Terrestrial Short-Wave Reflectivity		[-]	0.2
Terrestrial Long-Wave Emissivity		[-]	0.9
Terrestrial Long-Wave Reflectivity		[-]	0.1
Cloud Index		[-]	0.66

Interior (Right Side)

Name	Description	Unit	Value
Heat Resistance	Roof (DIN 68800-2:2012-02)	[m²K/W]	0.125
Sd-Value	No coating	[m]	----

Results from Last Calculation

Status of Calculation

Calculation: Time and Date	22/04/2018 18:03:33
Computing Time	4 min,45 sec.
Begin / End of calculation	01/10/2018 / 01/10/2023
No. of Convergence Failures	0

Check for numerical quality

Integral of fluxes, left side (kl,dl)	[kg/m²]	0.0 -2.46
Integral of fluxes, right side (kr,dr)	[kg/m²]	7.3E-8 -0.65
Balance 1	[kg/m²]	-0.23
Balance 2	[kg/m²]	-1.8

Water Content [kg/m²]

	Start	End	Min.	Max.
Total Water Content	1.77	1.54	1.49	1.77

Water Content [kg/m³]

Layer/Material	Start	End	Min.	Max.
*SOLITEX PLUS	0.00	0.00	0.00	0.17
Polystyrene, expanded	0.18	0.19	0.14	0.45
Oriented Strand Board (density 615 k	92.00	80.91	77.83	92.00
Polystyrene, expanded	0.18	0.17	0.16	0.18
Gypsum Board	6.30	3.97	2.85	6.30

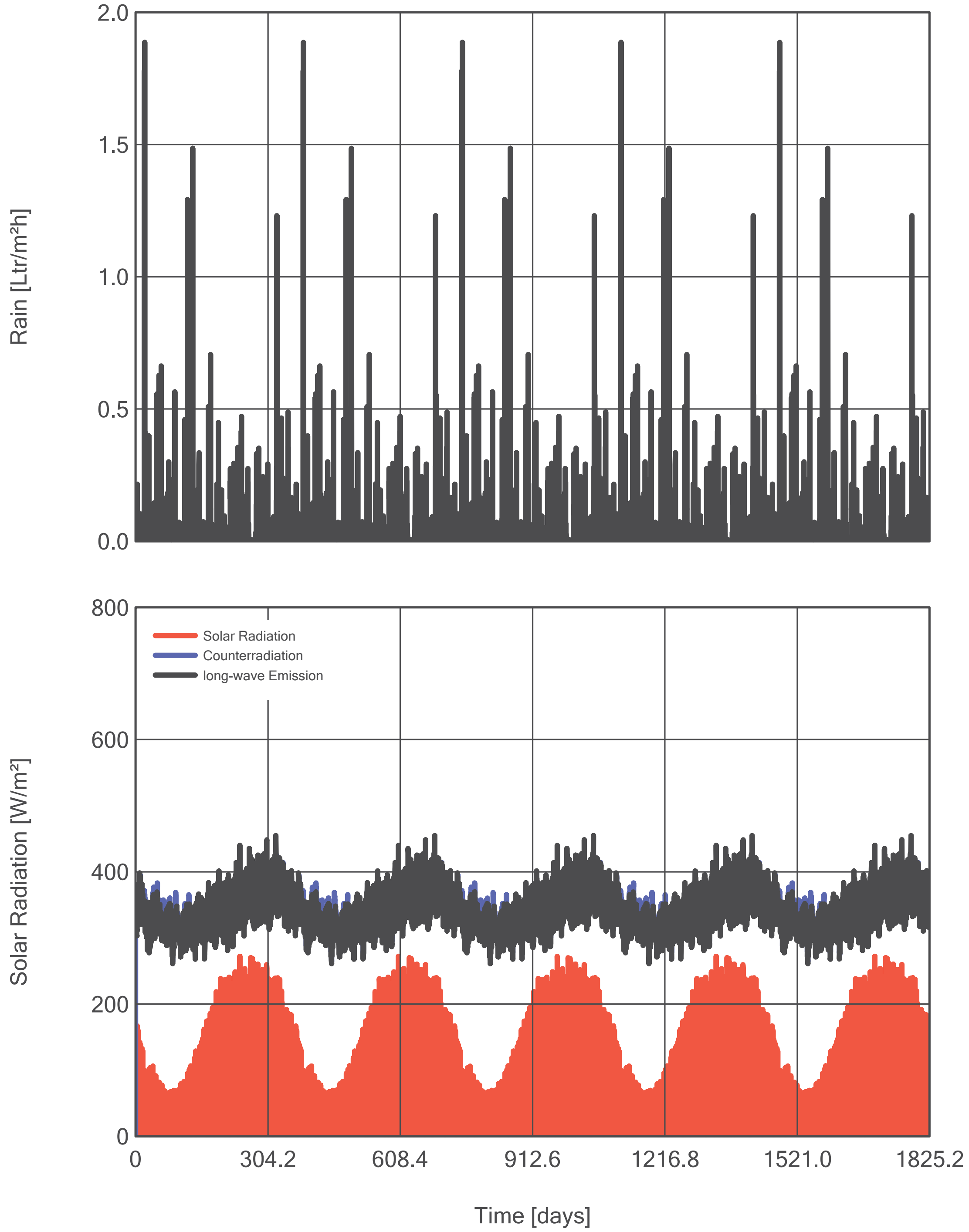
Time Integral of fluxes

Heat Flux, left side	[MJ/m²]	-1634.14
Heat Flux, right side	[MJ/m²]	-267.19
Moisture Fluxes, left side	[kg/m²]	11.68
Moisture Fluxes, right side	[kg/m²]	-0.65

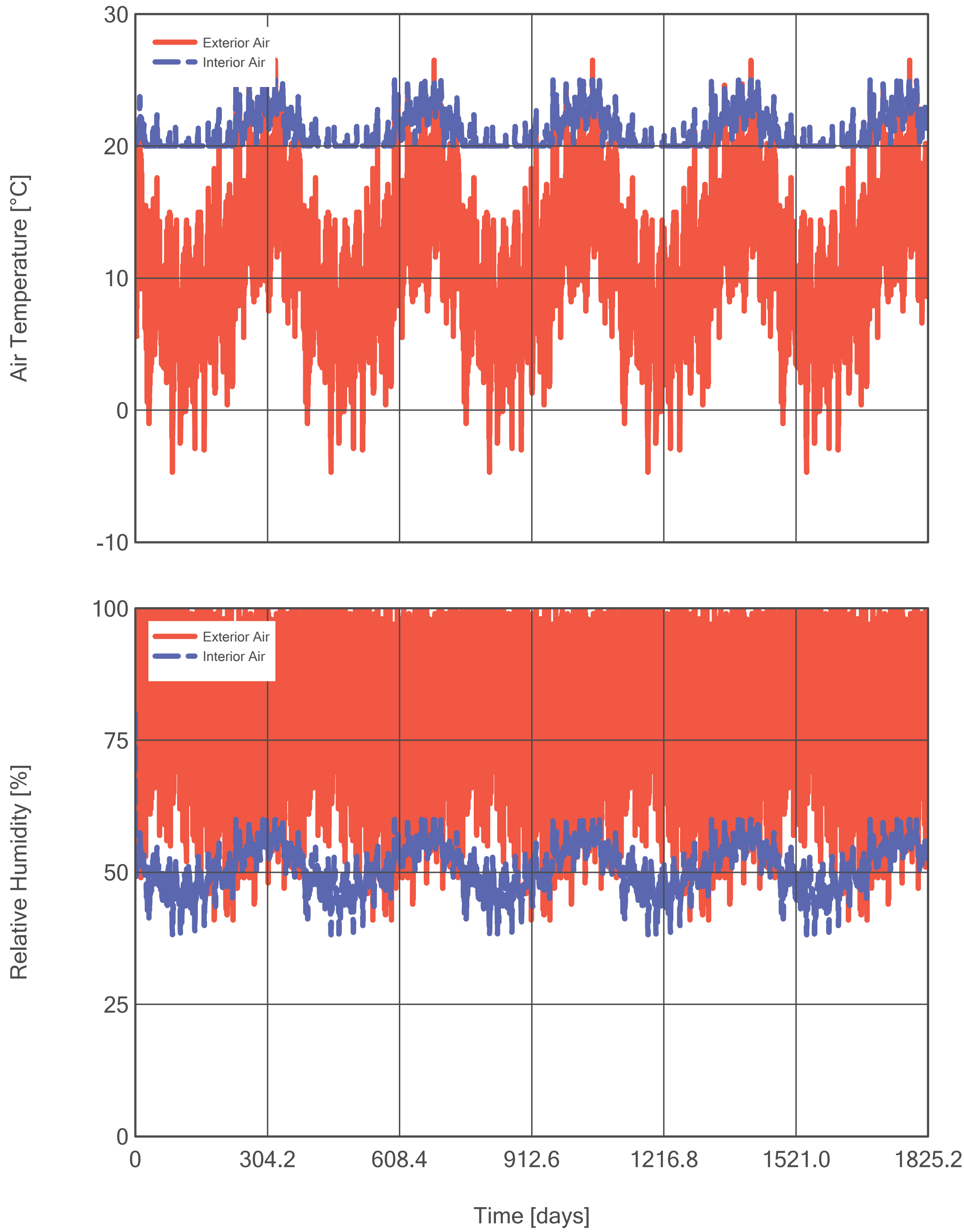
Hygrothermal Sources

Heat Sources	[MJ/m²]	0.0
Moisture Sources	[kg/m²]	0.0
Unreleased Moisture Sources (due to cut-off)	[kg/m²]	0.0

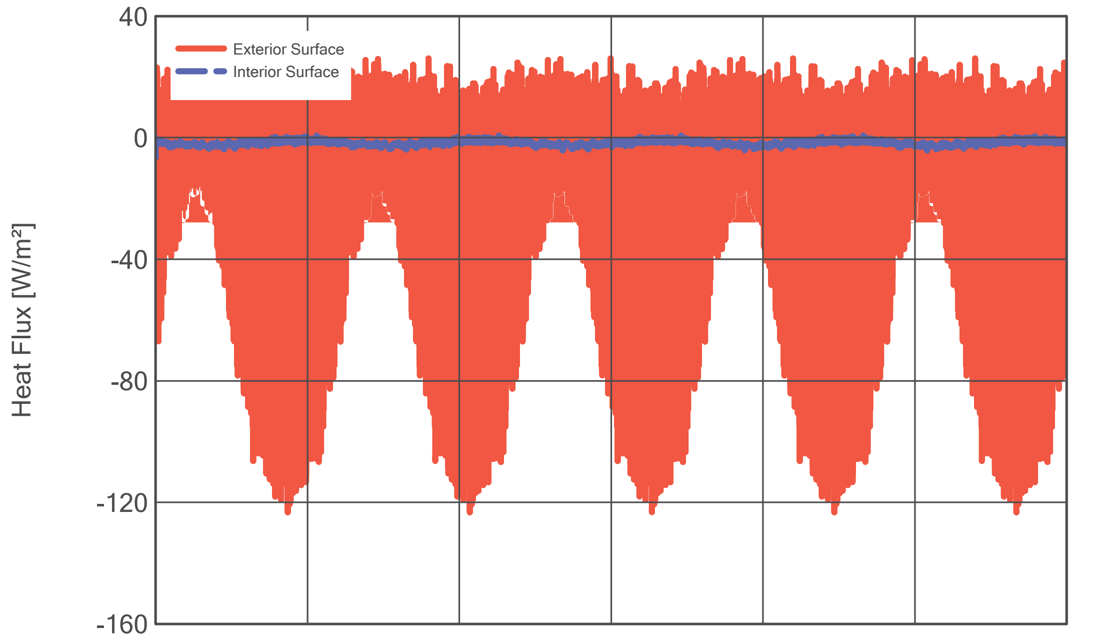
Rain, Radiation (Exterior Climate)

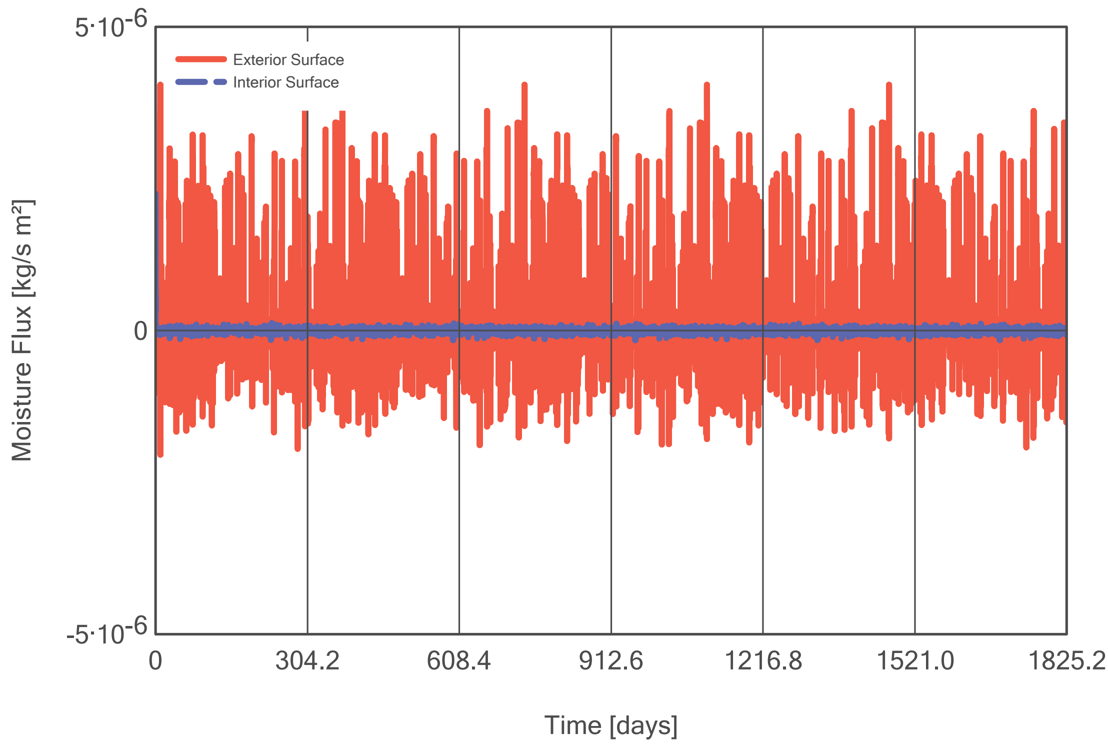


Air Temperature, RH (Exterior, Interior)

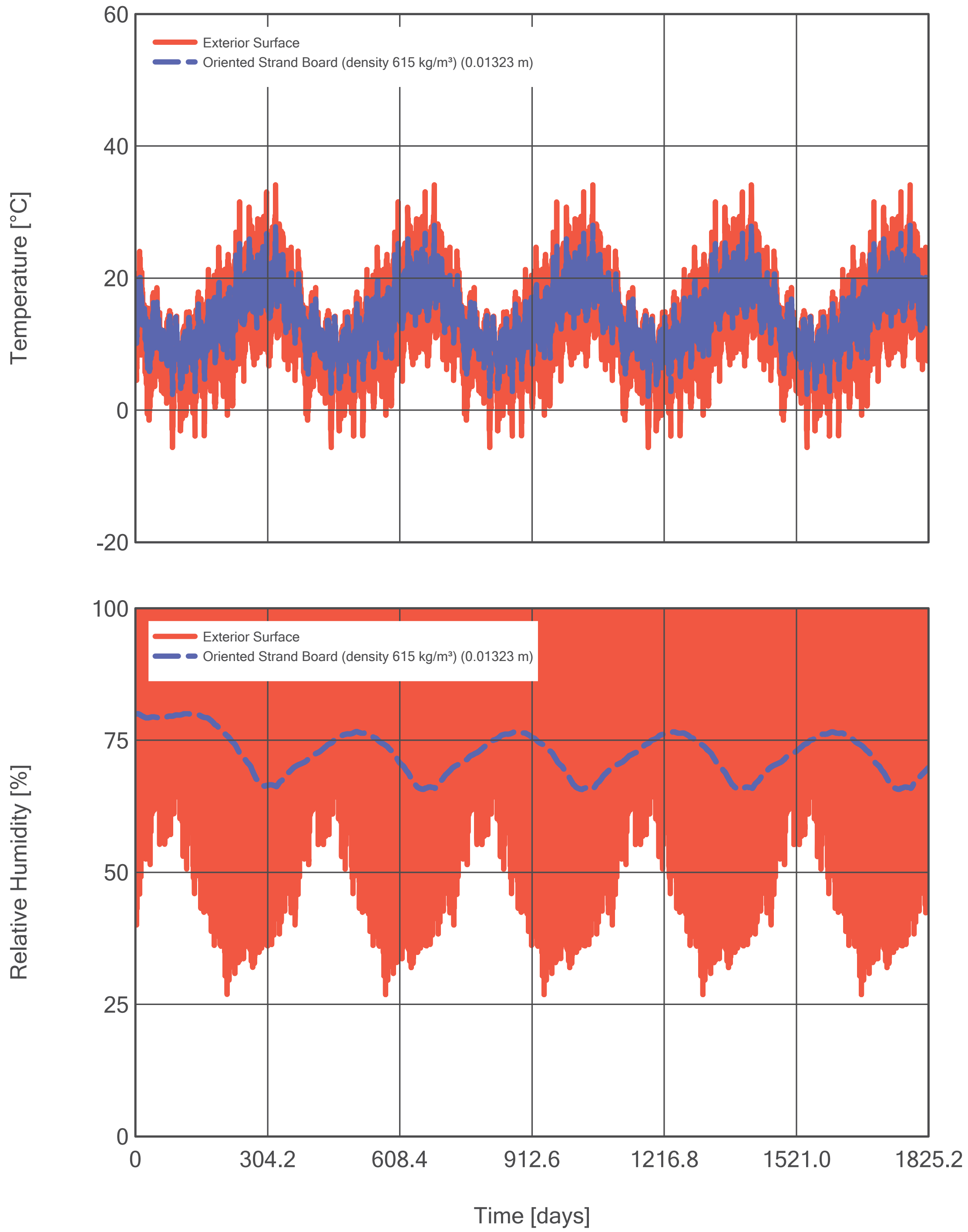


Heat, Moisture Fluxes

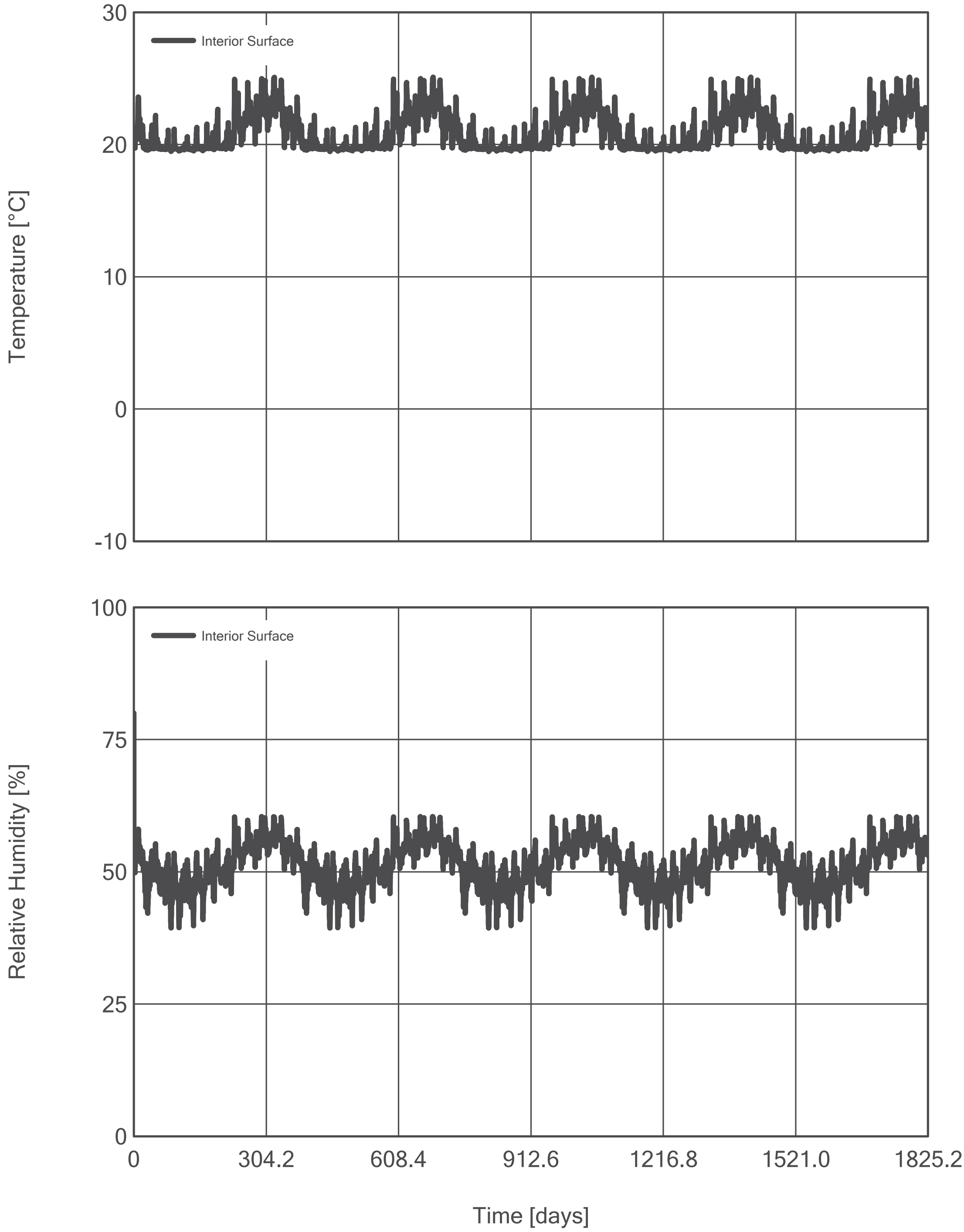




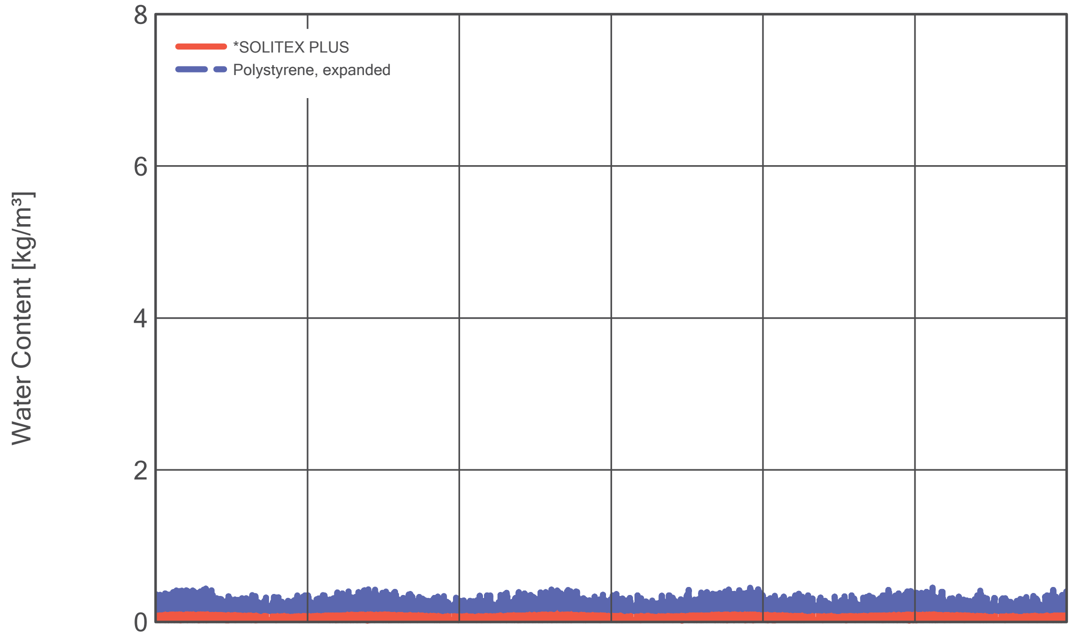
Temperature, RH (Monitor Position 1, 2)

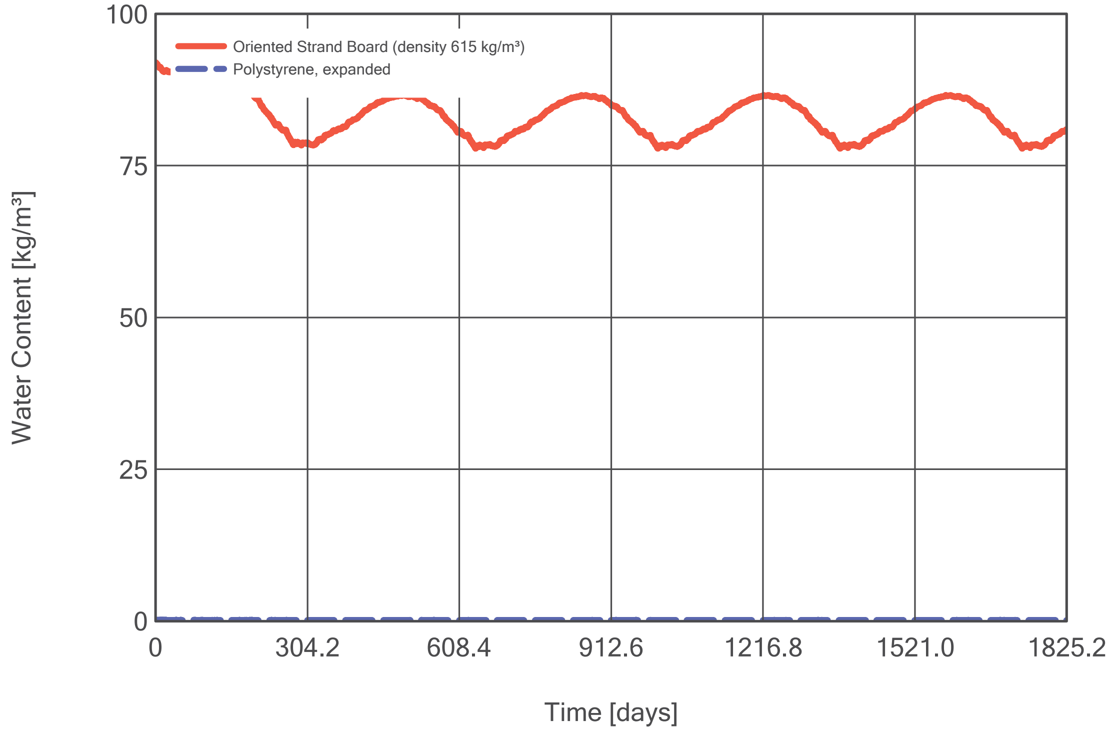


Temperature, RH (Monitor Position 3)

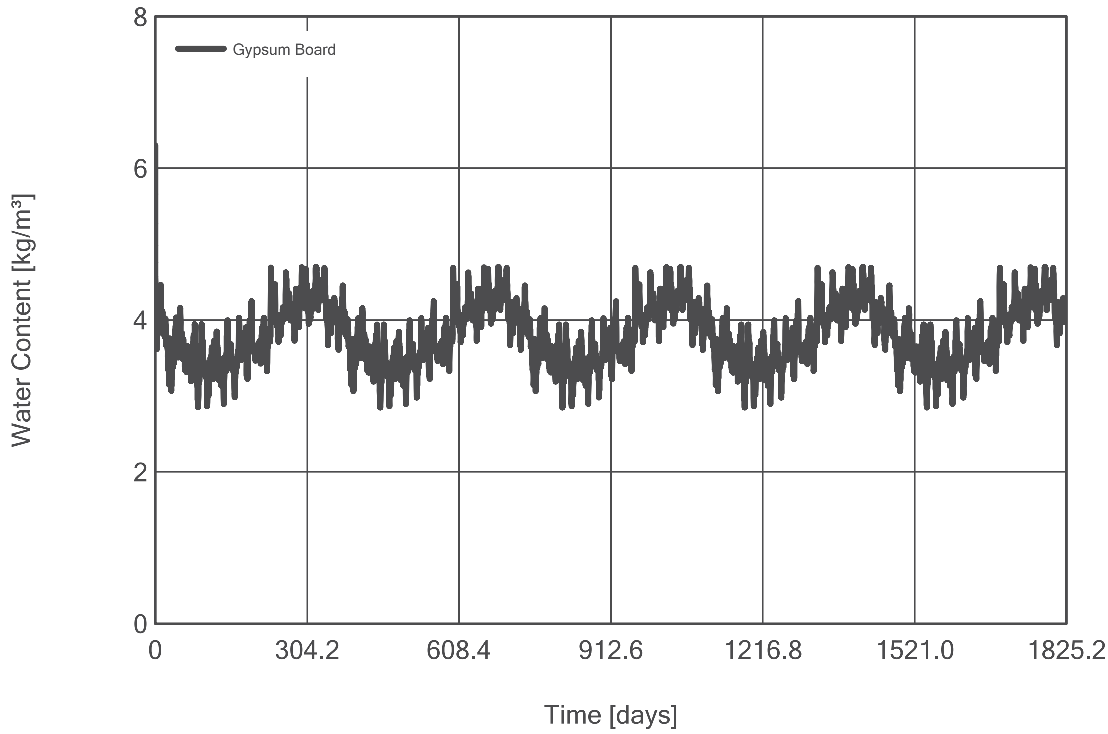


Water Content of Individual Materials

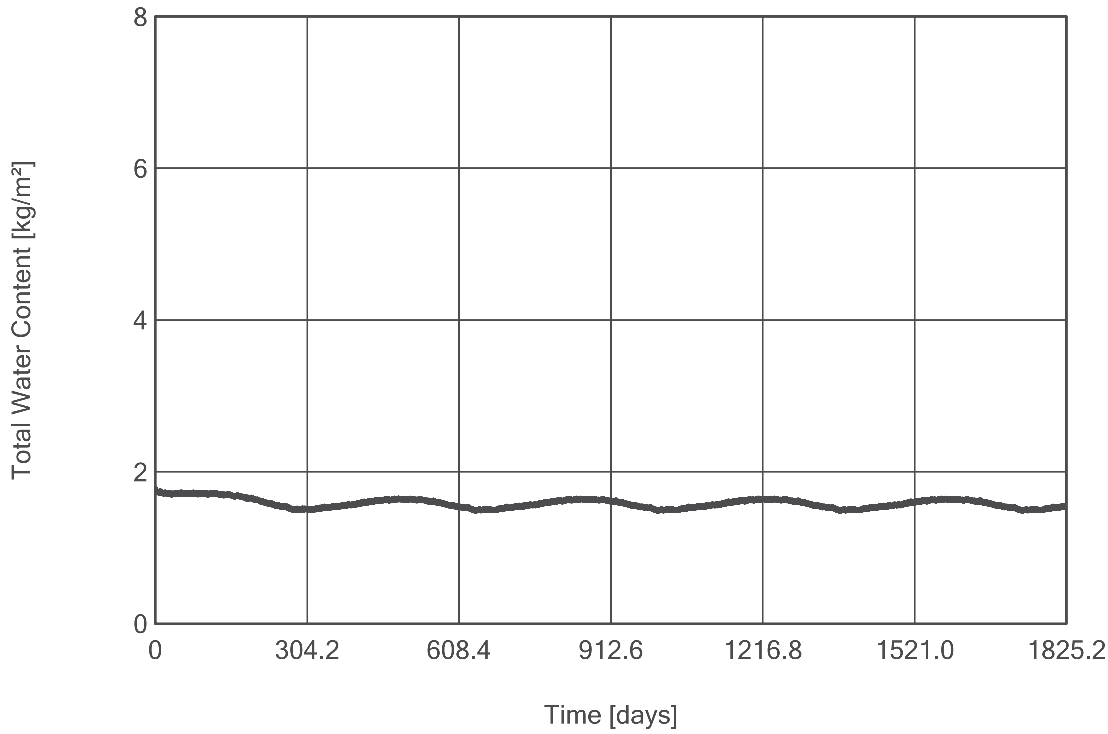




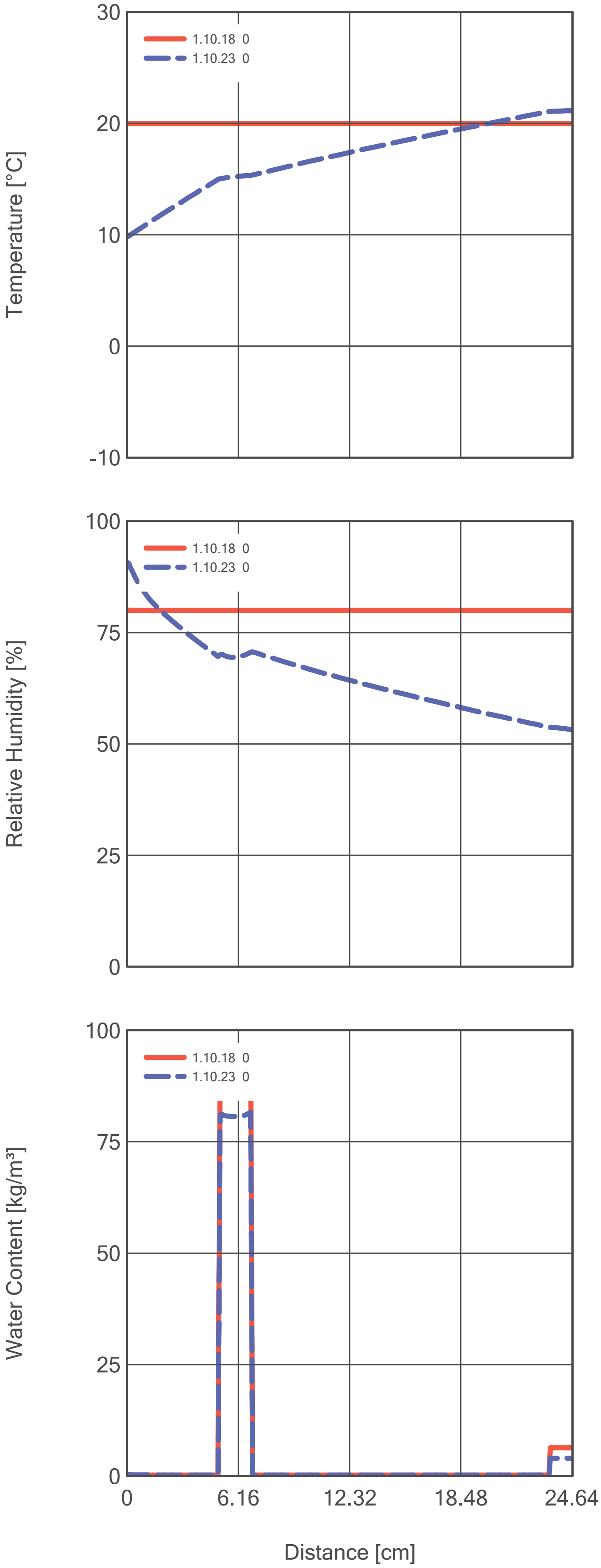
Water Content of Individual Materials



Total Water Content in Construction



Profiles



Temperature [°C]
30
20
10
0
-10
1.10.18 0
1.10.23 0
Relative Humidity [%]
100
75
50
25
0
1.10.18 0
1.10.23 0
Water Content [kg/m³]
100
75
50
25
0
1.10.18 0
1.10.23 0
0
6.16
12.32
18.48
24.64
Distance [cm]