

WUFI®

Guideline for the Calculation of Gravel Roofs

Date: July 2026

Content

Material Data Set „Generic Gravel“..... [Slide 3](#)

Input

- Component Assembly and Grid Settings..... [Slide 4](#)
- Moisture Source in the Gravel Layer..... [Slide 5](#)
- Infiltration Source..... [Slide 7](#)
- Initial Conditions..... [Slide 9](#)
- Boundary Conditions (exterior)..... [Slide 10](#)
- Boundary Conditions (interior)..... [Slide 13](#)
- Control..... [Slide 14](#)

Notes on Evaluation..... [Slide 15](#)

Literature..... [Slide 19](#)

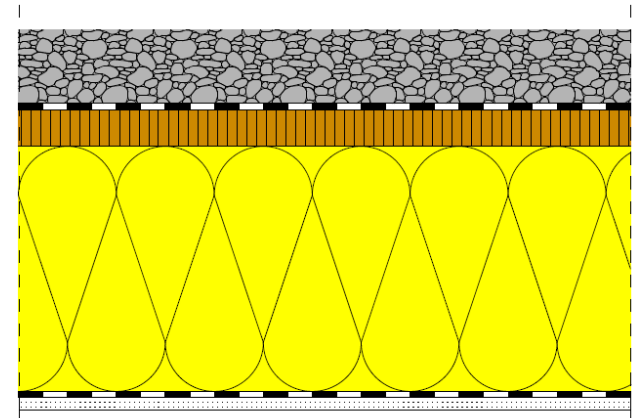
Examples: Gravel roof on lightweight construction..... [Slide 20](#)

- Example A: without additional insulation..... [Slide 21](#)
- Example B: with additional insulation..... [Slide 45](#)

Material Data Set „Generic Gravel“:

The **hygrothermal material properties** of a gravel layer have been **adapted by recalculations of field tests and measurements** which were performed on gravel roofs in Holzkirchen, Gräfelfing (both Southern Germany) and Milan (Italy).

In the gravel layer there is **no capillary transport** – the **rainwater** which runs through the gravel layer **has to be modelled by a moisture source**. The moisture source is spread over the whole layer with the exception of the outermost element – by adding the moisture source in the outermost element numerical problems and differences in the balances may be caused.



Component – Assembly

Generic gravel layer

The generic gravel layer must be specified with the required thickness. The material is available directly in the WUFI® Material Database under *Fraunhofer-IBP → Green and Gravel Roofs*.

Underlying Roof Assembly

The underlying layers must be entered according to the structure in the simulation axis (e.g. insulated cavity).

Grid Setting

Recommended grid setting:

Automatic (II) with 200 elements (corresponds to default setting)

Input: Moisture Source in the Gravel

Component – Assembly

Moisture Source in the Gravel Layer

To account for the water passing through the gravel layer, a moisture source must be applied throughout the whole layer with the exception of the outermost element.

Note: Applying the moisture source to the outermost element may result in numerical problems and balance differences.

Settings:

- Spread Area: Area – right-fixed
Thickness: Gravel layer thickness minus approx. 0.003 m
- Source Type: Fraction of incident Driving Rain
- Source Term Cut-Off: Cut-Off at Free Water Saturation
- Fraction: 40% (Gravel roof model IBP)

Hygrothermal Sources

Rain Source

Name: Rain 1

Spread Area

☐ Grid Element ☒ Area ☐ Whole Layer

Thickness [m]: 0.057

right-fixed

Source Type

☐ Transient from File ☒ Fraction of incident Driving Rain ☐ Air Infiltration model IBP ☐ Constant Monthly Moisture Load

Source Term Cut-Off [kg/m³]

☐ No Cut-Off ☐ Cut-Off at Max. Water Content ☒ Cut-Off at Free Water Saturation ☐ User-Defined

Fraction [%]: 40

Gravel roof model IBP (in gravel)

Delete source OK Cancel Help

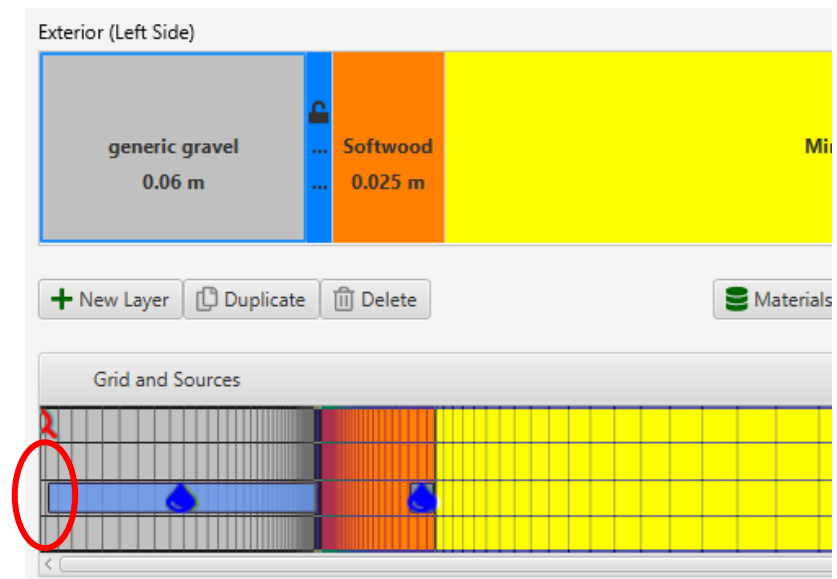
Input: Moisture Source in the Gravel

Component – Assembly

Moisture Source in the Gravel Layer

Note on entering the thickness of the moisture source:

- The distribution of the grid elements varies depending on the component assembly.
- The thickness of the source should be selected so that the moisture source is not located in the outer element of the gravel layer.
- This can be checked visually in the component assembly.



Component – Assembly

Moisture Source – Infiltration (only for wooden structures)

According to DIN 68800 [2], the amount of moisture that convectively enters the construction as a function of the air tightness must always be assessed for wooden structures and can be taken into account in the simulation using the infiltration model of the IBP.

The moisture source must be placed in the component assembly at the position where the condensation water will occur in practice – usually this is in front of the second airtight layer on the cold side of the component.

Recommended settings for roofs:

- with wooden sheathing: moisture source in the interior 5 mm of the wooden sheathing
- without wooden sheathing: moisture source in the exterior 5 mm of the insulation layer

Component – Assembly

Moisture Source – Infiltration (only for wooden structures)

The amount of moisture entered during cold periods is automatically determined in the program from the overpressure due to the thermal buoyancy in the building (temperature difference between outside and inside as well as specified air space height), the indoor air humidity and the specified airtightness of the building envelope [2].

For more information on using the infiltration source in WUFI®, click here:
[Guideline for Using the Air Infiltration Source in WUFI®](#)

Component – Initial Conditions

Initial Temperature and Moisture:

A constant initial relative humidity of 80 % and an initial temperature of 20 °C should be used as a default setting.

If increased construction moisture contents are known, these can be specified separately for each individual layer.

Boundary Conditions (exterior) – Climate

Outdoor Climate:

An outdoor climate appropriate for the building location must be used.

For Germany:

The hygrothermal reference years (HRY), which were created for 11 locations in Germany as part of a research project [4], are useful here. These locations are representative for the respective climate region. For more information, please refer to the

WUFI® Help (F1) → Topic: Hygrothermal Reference Years

The Holzkirchen location, with 20% reduced radiation, is considered critically representative of German locations up to altitudes of 700 m. This can be set in the simulation by reducing the absorption coefficient from a to $a \cdot 0.8$. This climate was also used for the exemption of deemed-to-satisfy constructions in DIN 4108-3 [8].

Boundary Conditions (exterior) – Orientation

Orientation

The relevant orientation for the Northern hemisphere is usually North, as here the lowest radiation gains occur. However, the orientation is only of minor importance for very low roof pitches.

Roof Inclination

The inclination of the roof must be specified according to the planned roof inclination.

Input: Surface Transfer Coefficients (exterior)

Boundary Conditions (exterior) – Surface

Heat transfer

The heat transfer coefficient at the exterior surface of gravel roofs is assumed to be $19 \text{ W/m}^2\text{K}$.

Radiation

Selection (drop-down menu): Roof → Gravel roof, generic model

According to the gravel roof model, the short-wave radiation absorption coefficient is 0.5. The long-wave radiation emission is 0.93. For roofs, the radiative overcooling must always be switched on due to the large field of view to the sky in order to take into account overcooling as a result of long-wave radiation.

Rain

Rain must be taken into account when simulating gravel roofs.

Boundary Conditions (interior) – Climate / Surface

Indoor Climate:

For design purposes, an indoor climate with medium moisture load + 5% (according to DIN 4108-3 [3] and EN 15026 [6]) is recommended.

Alternatively, depending on the use of the building, the indoor climate with low moisture load (according to EN 15026 [6]) or with medium or high moisture load (according to DIN 4108-3 [3] and EN 15026 [6]) can be applied. For example, constant or measured conditions can also be applied.

Heat Transfer:

The heat transfer coefficient at the interior surface is assumed to be $8 \text{ W/m}^2\text{K}$ according to DIN 4108-3 [3].

Control

Period of Calculation:

It is recommended to start the calculation on October 1, because the component usually moistens up further in the following winter months before drying out possibly starts in spring. This start date is therefore usually an extra stressing of the component.

The calculation time depends the time the construction needs to reach steady state conditions. Gravel roofs usually require a calculation time of about 10-15 years.

Calculation Quality

- The differences in the balances should remain as small as possible.
- The number of convergence failures is not a decisive factor, but a high number indicates difficult convergence.

However, in the case of gravel roofs, the large amounts of moisture in the gravel roof structure (driving rain source) can lead to a higher number of convergence failures. These usually occur in the gravel layer and often have no or only a marginal effect on the underlay construction.

- If the water content curves in the layers of the underlay construction do not show any abnormalities (e.g. abrupt jumps, peaks, etc.), the result is usually acceptable.

Status of Calculation

Calculation: Time and Date	Mar 19, 2026, 4:04 PM
Start / end of the computed time period	Oct 1, 2025 / Oct 1, 2035
Calculation Period	0:03:06.913
Currently simulated time step	Oct 1, 2035, 12:00 AM

Check for numerical quality

No. of Convergence Failures		135	
Sum of diffusive fluxes (left/right)	[kg/m ²]	-1109.836	0.469
Sum of capillary fluxes (left/right)	[kg/m ²]	0.000	0.000
Balance (mass vs. sum of surface-fluxes)	[kg/m ²]	2.787	2.776

Gravelled lightweight constructions

The evaluation procedure and the evaluation criteria are almost identical to those for normal flat roofs and can be found in the [Guideline for the calculation of flat roofs](#)

The evaluation of the moisture conditions in a possibly existing additional insulation of the outer sheathing is explained on the following slides.

Additional evaluation in the case of an additional insulation

A slow accumulation of moisture is often observed in the additional insulation of the exterior sheathing, therefore moisture-insensitive materials should preferably be used in this area.

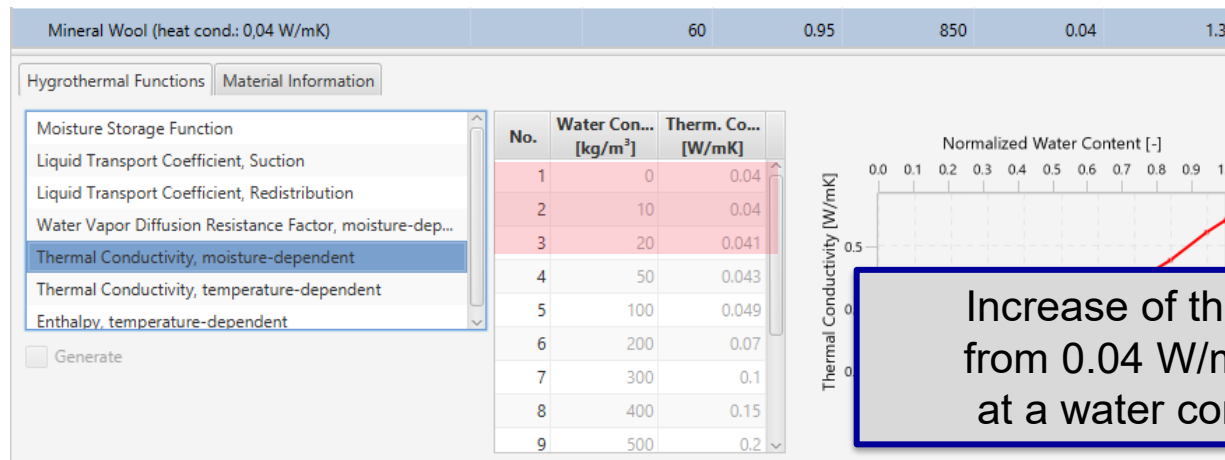
- Moisture leads to an increase in thermal conductivity - but this increase usually remains so small (see next slide) that it appears negligible even for typical service lives of 25 years.
- In rigid-foam insulation, moisture remains in the pore structure of the material - i.e. usually without any further consequences for the material or construction.
- In fibre insulation, dew water can possibly run off into other component layers and damage them - this effect must be considered separately!

Notes on the Evaluation of Gravel Roofs

Additional evaluation in the case of an additional insulation

The example shows the water content of a mineral wool insulation, which increases to about 20 kg/m³ over the service life of the roof (converted to a thickness of 6 cm, this corresponds to about 1.2 kg/m²).

The effect on the thermal conductivity can be taken from the material data. In this case, it increases by about 2.5 % from 0.04 to 0.041 W/mK. If the additional insulation is relevant for the U-value of the component, the effect could be compensated by using insulation that is about 1.5 mm thicker.



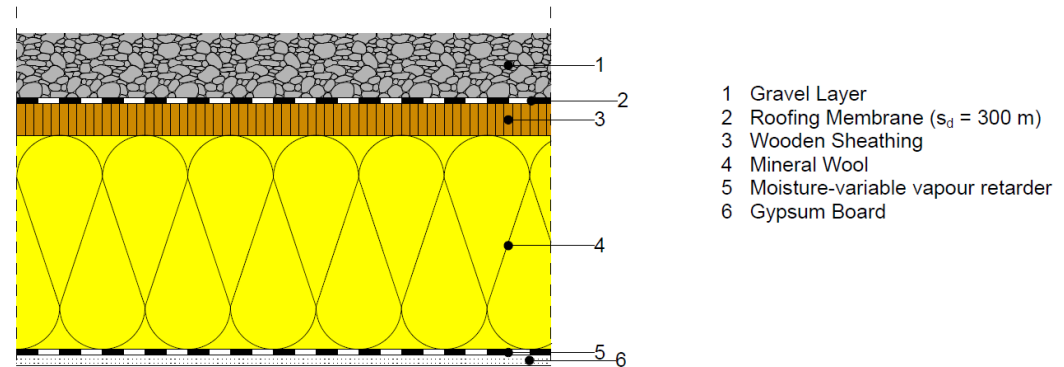
Increase of thermal conductivity from 0.04 W/mK to 0.041 W/mK at a water content of 20 kg/m³.

- [1] DIN 68800-2: Holzschutz – Teil 2: Vorbeugende bauliche Maßnahmen im Hochbau. Beuth Verlag, February 2022.
- [2] Zirkelbach, D.; Künzel, H.M.; Schafaczek, B. und Borsch-Laaks, R.: Dampfkonnektion wird berechenbar – Instationäres Modell zur Berücksichtigung von konvektivem Feuchteeintrag bei der Simulation von Leichtbaukonstruktionen. Proceedings 30. AIVC Conference, Berlin 2009.
- [3] DIN 4108-3: Wärmeschutz und Energie-Einsparung in Gebäuden - Teil 3: Klimabedingter Feuchteschutz - Anforderungen, Berechnungsverfahren und Hinweise für Planung und Ausführung. Beuth Verlag, March 2024.
- [4] Research Report: Energieoptimiertes Bauen: Klima- und Oberflächenübergangsbedingungen für die hygrothermische Bauteilsimulation. IBP-Bericht HTB-021/2016. Carried out on behalf of Project Management Jülich (PTJ UMW). July 2016.
- [5] WTA Guideline 6-2: Simulation of heat and moisture transfer. October 2025.
- [6] EN 15026: Hygrothermal performance of building components and building elements – Assessment of moisture transfer by numerical simulation. Beuth Verlag, December 2023.

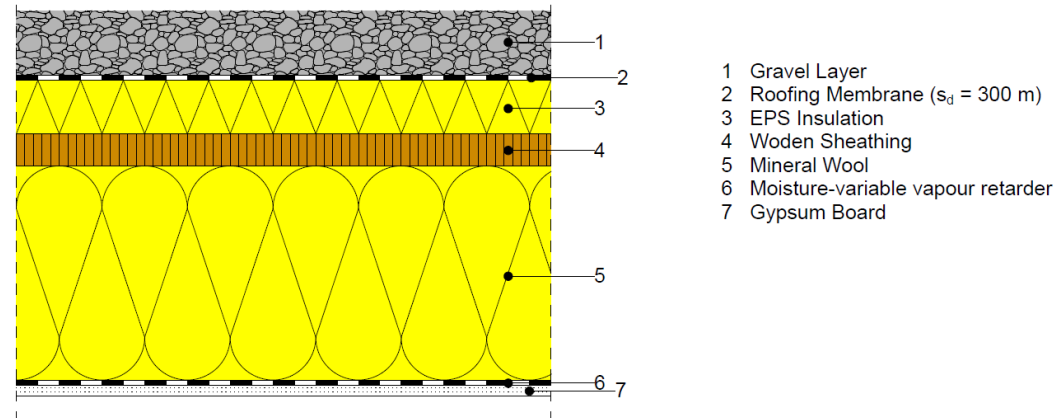
Examples: Gravel roof on lightweight construction

The following section describes the evaluation procedure for gravel roofs on lightweight constructions using two example cases. It presents the required material data, moisture sources, boundary conditions, and the evaluation procedure for the roof assembly.

Example A:
Gravel roof on a
lightweight construction
without additional insulation



Example B:
Gravel roof on a
lightweight construction
with additional insulation



Example A: Assembly

Assembly (from outside to inside):

- Generic Gravel 0.06 m
- Roofing Membrane ($s_d = 300\text{m}$) 0.001 m
- Wooden Sheathing (Softwood) 0.025 m
- Mineral Wool (heat cond.: 0.04 W/mK) 0.24 m
- Moisture-variable vapour retarder (Vario KM Duplex) 0.001 m
- Gypsum Board 0.0125 m

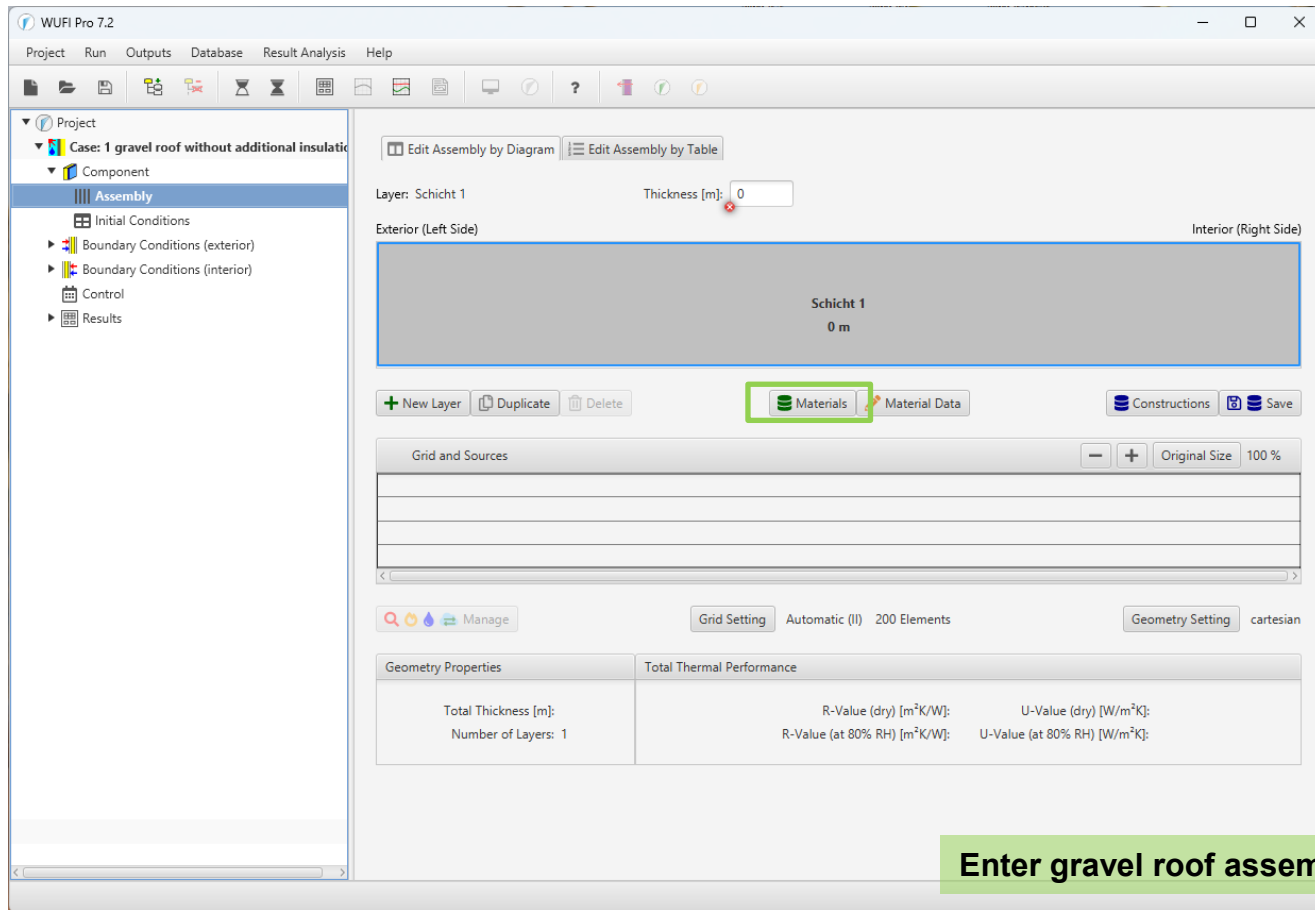
Example A: Boundary conditions

Boundary Conditions:

- Flat roof (3° to the North)
- Short-Wave Radiation Absorptivity / Long-Wave Radiation Emissivity: according to the generic gravel roof model
- Outdoor Climate: Holzkirchen
- Indoor Climate: Medium Moisture Load + 5 %
according to DIN 4108-3
- Air Tightness of the Envelope: $q_{50} = 3 \text{ m}^3/\text{m}^2\text{h}$
- Stack Height: 5 m

Example A: Component Assembly

Input: Component – Assembly



Example A: Component Assembly

Input: Component – Assembly

WUFI materials

Search materials

WUFI → Fraunhofer-IBP → Green and Gravel Roofs

Material Name	Bulk density [kg/m³]	Porosity [m³/m³]	Heat Cap. [J/kgK]	Therm. Cond. [W/mK]	Vap.Res. [s]
generic gravel	1400	0.3	1000	0.7	1
generic substrate	1500	0.5	1500	0.9	5
Optigreen Economy Roof 1					
Optigreen Economy Roof 2					
Optigreen Light-weight Roof Solution 1					
Optigreen Nature Roof Solution 1					
Optigreen Pitched Roof 5° - 45°					

Hygrothermal Functions | Material Information

Moisture Storage Function

- Liquid Transport Coefficient, Suction
- Liquid Transport Coefficient, Redistribution
- Water Vapor Diffusion Resistance Factor, moisture-depen...
- Thermal Conductivity, moisture-dependent
- Thermal Conductivity, temperature-dependent
- Enthalpy, temperature-dependent

☒ Approximate

Approximation Parameters:

Reference Water Content [kg/m³]:

Free Water Saturation [kg/m³]:

No.	RH [-]	Water Con... [kg/m³]
1	0	0
2	0.1	0.154
3	0.2	0.345
4	0.3	0.588
5	0.4	0.909
6	0.5	1.35
7	0.55	1.64
8	0.6	2
9	0.65	2.45
10	0.7	3.04
11	0.75	3.85

Water Content [kg/m³]

Relative Humidity [-]

Thickness [m]: 0.05

Assign Cancel Help

Green and gravel roofs → Generic gravel

Example A: Component Assembly

Input: Component – Assembly

The screenshot displays the WUFI Pro 7.2 software interface. The left sidebar shows a project tree with 'Case: 1 gravel roof without additional insulation' selected, and 'Assembly' is the active component. The main workspace shows a cross-section of a roof assembly with three layers: 'generic gravel' (0.06 m), 'Softwood' (0.025 m), and 'Mineral Wool (heat cond.: 0,04 W/mK)' (0.24 m). A 'Gypsum Board' layer is being edited, with its thickness set to 0.0125 m. Below the assembly diagram, there are buttons for 'New Layer', 'Duplicate', 'Delete', 'Materials', 'Material Data', 'Constructions', and 'Save'. A 'Grid and Sources' section shows a grid of the assembly. At the bottom, a table displays 'Geometry Properties' and 'Total Thermal Performance'.

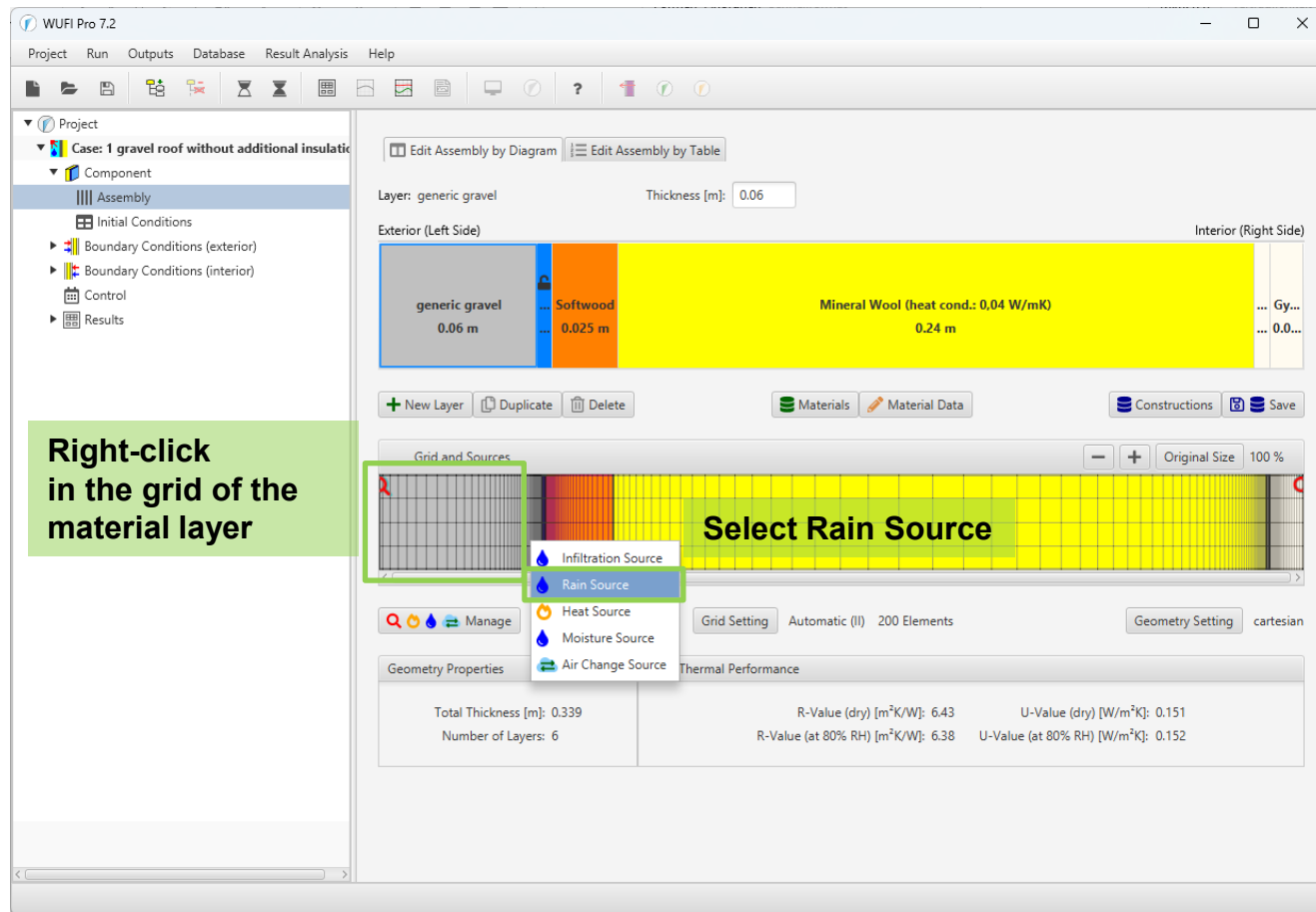
Geometry Properties		Total Thermal Performance	
Total Thickness [m]: 0.339		R-Value (dry) [m²K/W]: 6.43	U-Value (dry) [W/m²K]: 0.151
Number of Layers: 6		R-Value (at 80% RH) [m²K/W]: 6.38	U-Value (at 80% RH) [W/m²K]: 0.152

Enter underlying roof construction;
adjust layer thicknesses if necessary

Example A: Moisture Source in the Gravel Layer

Input: Component – Assembly

Insert moisture source in the layer "Generic Gravel"



Example A: Moisture Source in the Gravel Layer

Input: Component – Assembly

Moisture source in the whole gravel layer with the exception of the outermost element.

Note:

By adding the moisture source in the outermost element numerical problems and differences in the balances may be caused.

Hygrothermal Sources

Rain Source

Name: Rain 1

Spread Area

☐ Grid Element

☒ Area right-fixed

☐ Whole Layer

Thickness [m]: 0.057

Source Type

☐ Transient from File

☒ Fraction of incident Driving Rain

☐ Air Infiltration model IBP

☐ Constant Monthly Moisture Load

Source Term Cut-Off [kg/m³]

☐ No Cut-Off

☐ Cut-Off at Max. Water Content

☒ Cut-Off at Free Water Saturation

☐ User-Defined

Fraction [%]: 40

Fraction: 40% (Gravel roof model IBP)

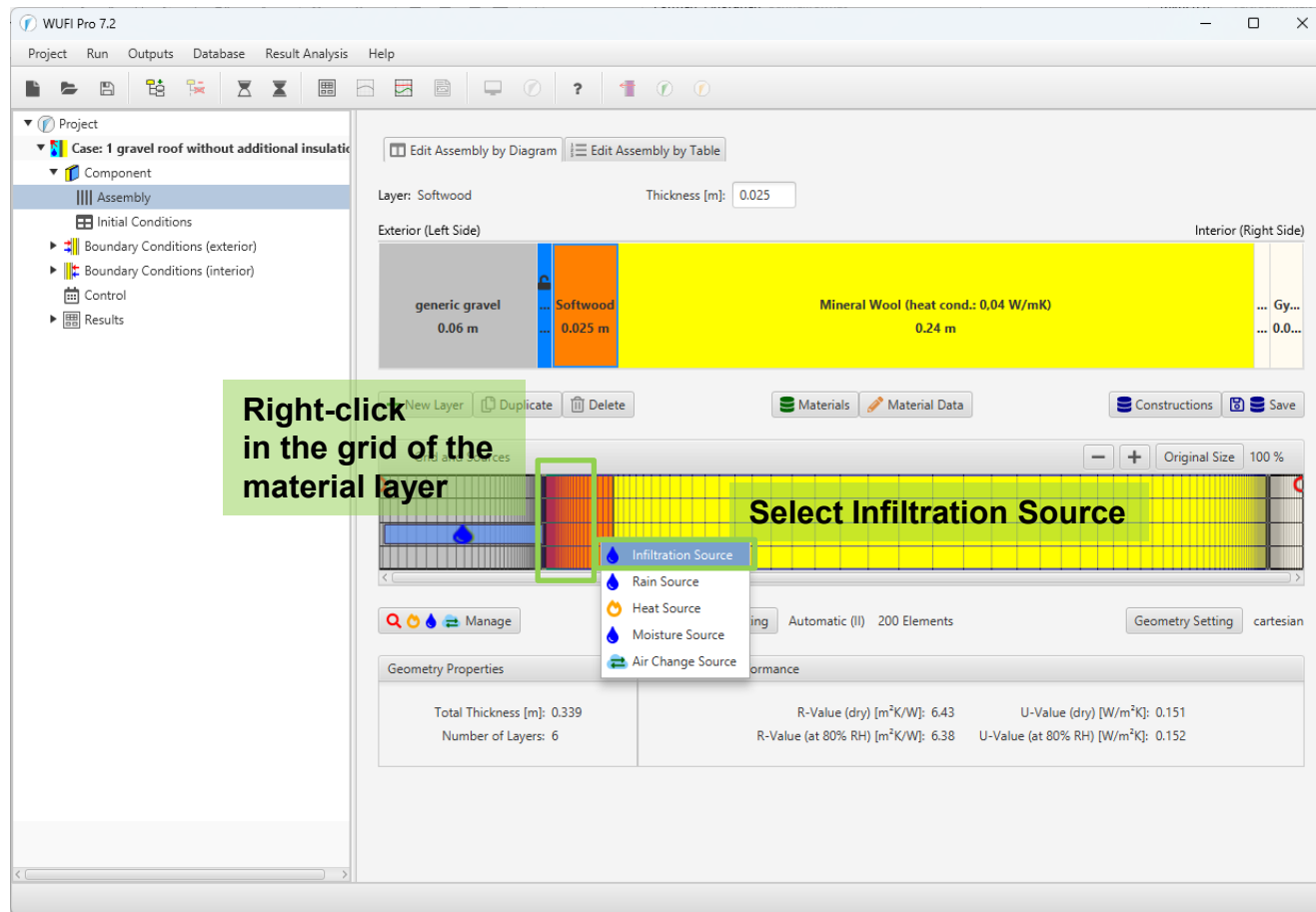
Gravel roof model IBP (in gravel)

Delete source OK Cancel Help

Example A: Infiltration Source

Input: Component – Assembly

Infiltration source according to DIN 68800 in the wooden sheathing



Example A: Infiltration Source

Input: Component – Assembly

Moisture Source in the interior 5 mm of the wooden sheathing.

Hygrothermal Sources

Infiltration Source

Name: Infiltration 1

Spread Area

- ☐ Grid Element
- ☒ Area right-fixed
- ☐ Whole Layer

Thickness [m]: 0.005

Source Type

- ☐ Transient from File
- ☐ Fraction of incident Driving Rain
- ☒ Air Infiltration model IBP
- ☐ Constant Monthly Moisture Load

Source Term Cut-Off [kg/m³]

- ☐ No Cut-Off
- ☐ Cut-Off at Max. Water Content
- ☒ Cut-Off at Free Water Saturation
- ☐ User-Defined

Envelope Infiltration q50 [m³/m²h]

3 Air Tightness Class B (DIN 4108, tested <= 3 m³/m²h)

Stack Height [m]: 5

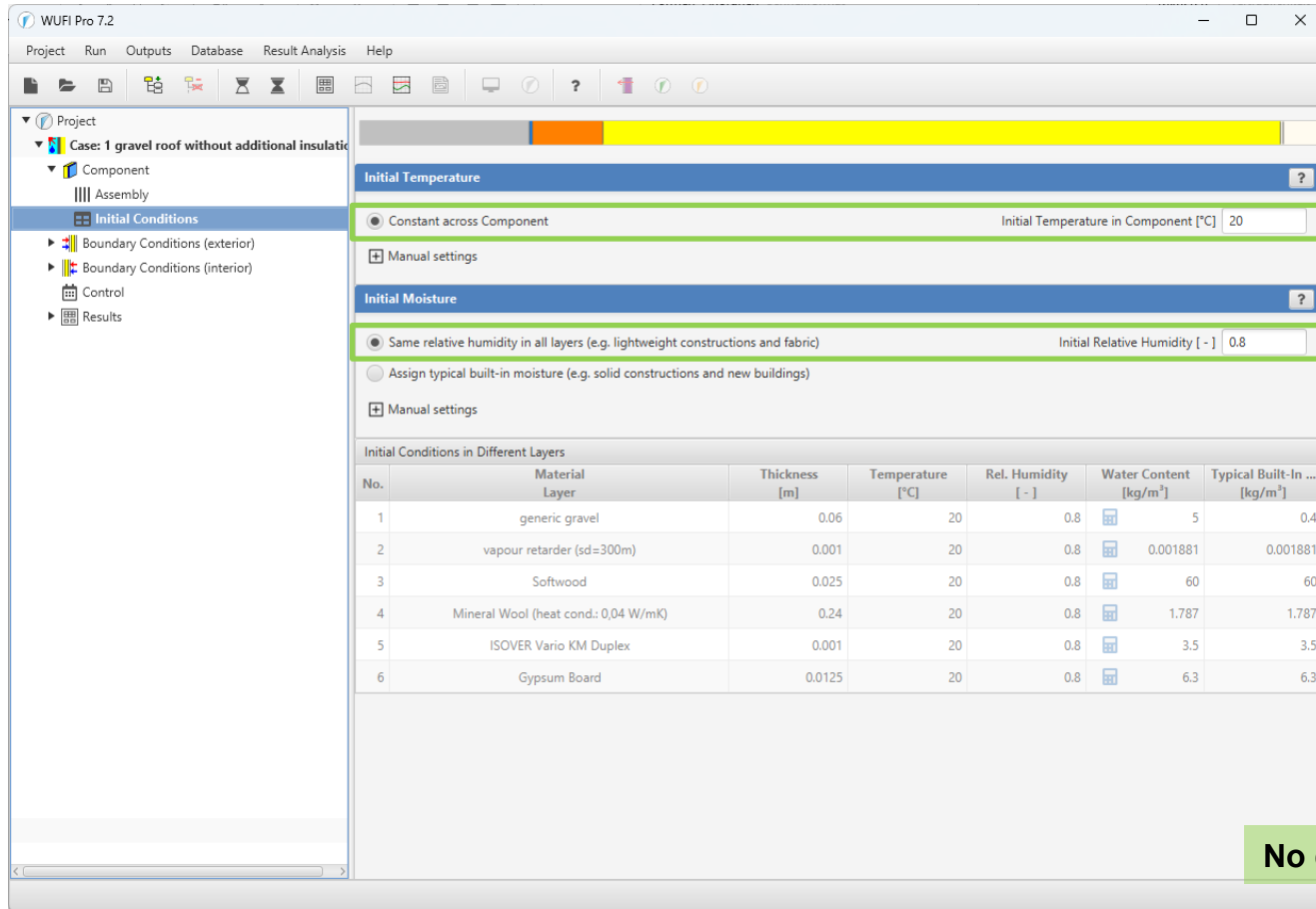
Mechanical Ventilation Overpressure [Pa]: 0

Adjust infiltration source

Delete source OK Cancel Help

Example A: Initial Conditions

Input: Component – Initial Conditions



The screenshot shows the WUFI Pro 7.2 software interface. The left sidebar displays a project tree with the following structure:

- Project
 - Case: 1 gravel roof without additional insulation
 - Component
 - Assembly
 - Initial Conditions**
 - Boundary Conditions (exterior)
 - Boundary Conditions (interior)
 - Control
 - Results

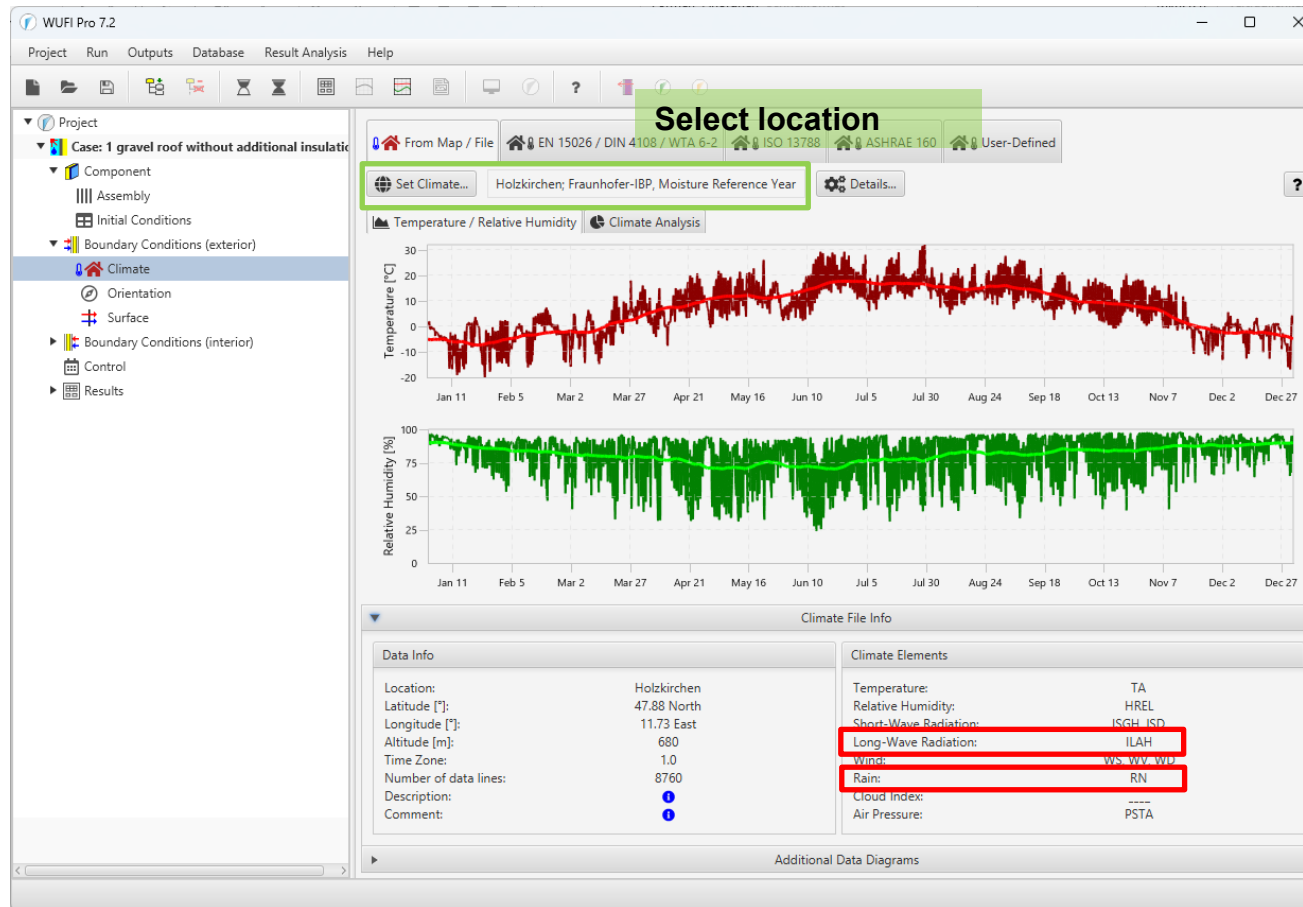
The main window displays the 'Initial Conditions' settings for the selected component. The 'Initial Temperature' section is set to 'Constant across Component' with a value of 20 °C. The 'Initial Moisture' section is set to 'Same relative humidity in all layers (e.g. lightweight constructions and fabric)' with a value of 0.8. Below these settings is a table titled 'Initial Conditions in Different Layers'.

No.	Material Layer	Thickness [m]	Temperature [°C]	Rel. Humidity [-]	Water Content [kg/m³]	Typical Built-In ... [kg/m³]
1	generic gravel	0.06	20	0.8	5	0.4
2	vapour retarder (sd=300m)	0.001	20	0.8	0.001881	0.001881
3	Softwood	0.025	20	0.8	60	60
4	Mineral Wool (heat cond.: 0.04 W/mK)	0.24	20	0.8	1.787	1.787
5	ISOVER Vario KM Duplex	0.001	20	0.8	3.5	3.5
6	Gypsum Board	0.0125	20	0.8	6.3	6.3

A green box in the bottom right corner of the interface contains the text: **No changes required**

Example A: Outdoor Climate

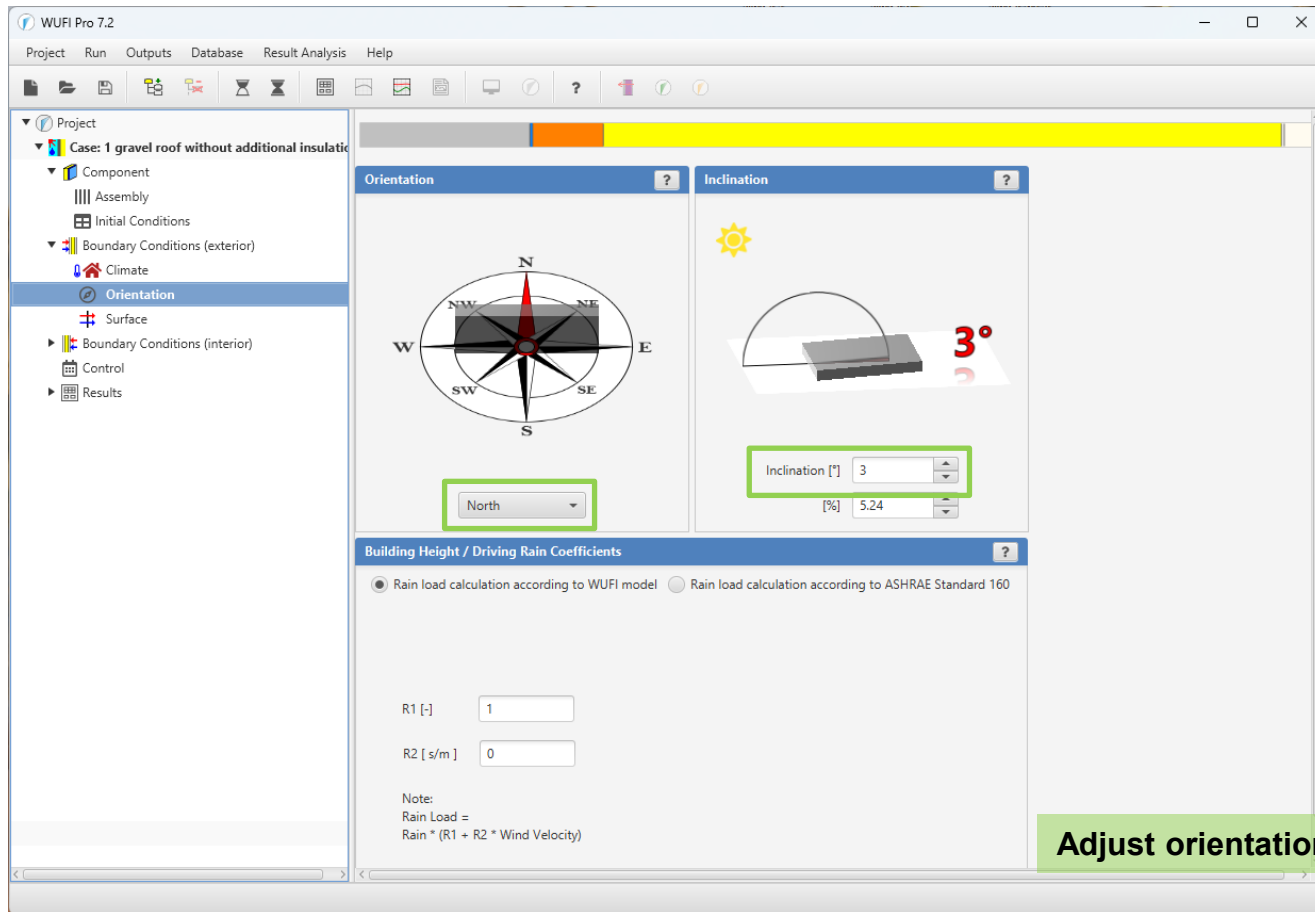
Input: Boundary Conditions (exterior) – Climate



Note:
For the application of the generic gravel roof model, climate data with long-wave radiation and rain data are necessary!

Example A: Orientation / Inclination

Input: Boundary Conditions (exterior) – Orientation



Example A: Surface Transfer Coefficients (exterior)

Input: Boundary Conditions (exterior) – Surface

The screenshot shows the WUFI Pro 7.2 software interface. The left sidebar displays a project tree with the following structure:

- Project
 - Case: 1 gravel roof without additional insulation
 - Component
 - Assembly
 - Initial Conditions
 - Boundary Conditions (exterior)
 - Climate
 - Orientation
 - Surface**
 - Boundary Conditions (interior)
 - Control
 - Results

The main panel displays the 'Surface' settings for the selected case. The settings are organized into sections:

- Heat Transfer**
 - Heat Transfer Coefficient [W/m²K]: 19 (Gravel roof (IBP model))
 - long-wave radiation parts Heat Transfer Coefficient [W/m²K]: 6.5
 - wind-dependent: ☐
 - Wind-dependence formula: ☐
- Vapor Transfer**
 - Additional diffusion resistance (e.g. coating), sd-Value [m]: ---- (No coating)
 - Note: This setting does not affect rain absorption.
- Radiation**
 - Short-wave absorptivity, e.g. solar radiation [-]: 0.5 (Gravel roof, generic model)
 - Radiative overcooling**: ☒ (Note: Explicit Radiation Balance, includes radiative cooling due to long-wave emission.)
 - Long-wave emissivity, e.g. nighttime radiative cooling [-]: 0.93
 - Additional radiation parameters: ☐
 - Reduction factors: ☐
- Rain**
 - Simulation takes rain into account**: ☒
 - Rain parameters: ☐

Heat transfer coefficient
(from list: gravel roof)

Absorption
(from list: gravel roof,
generic model)

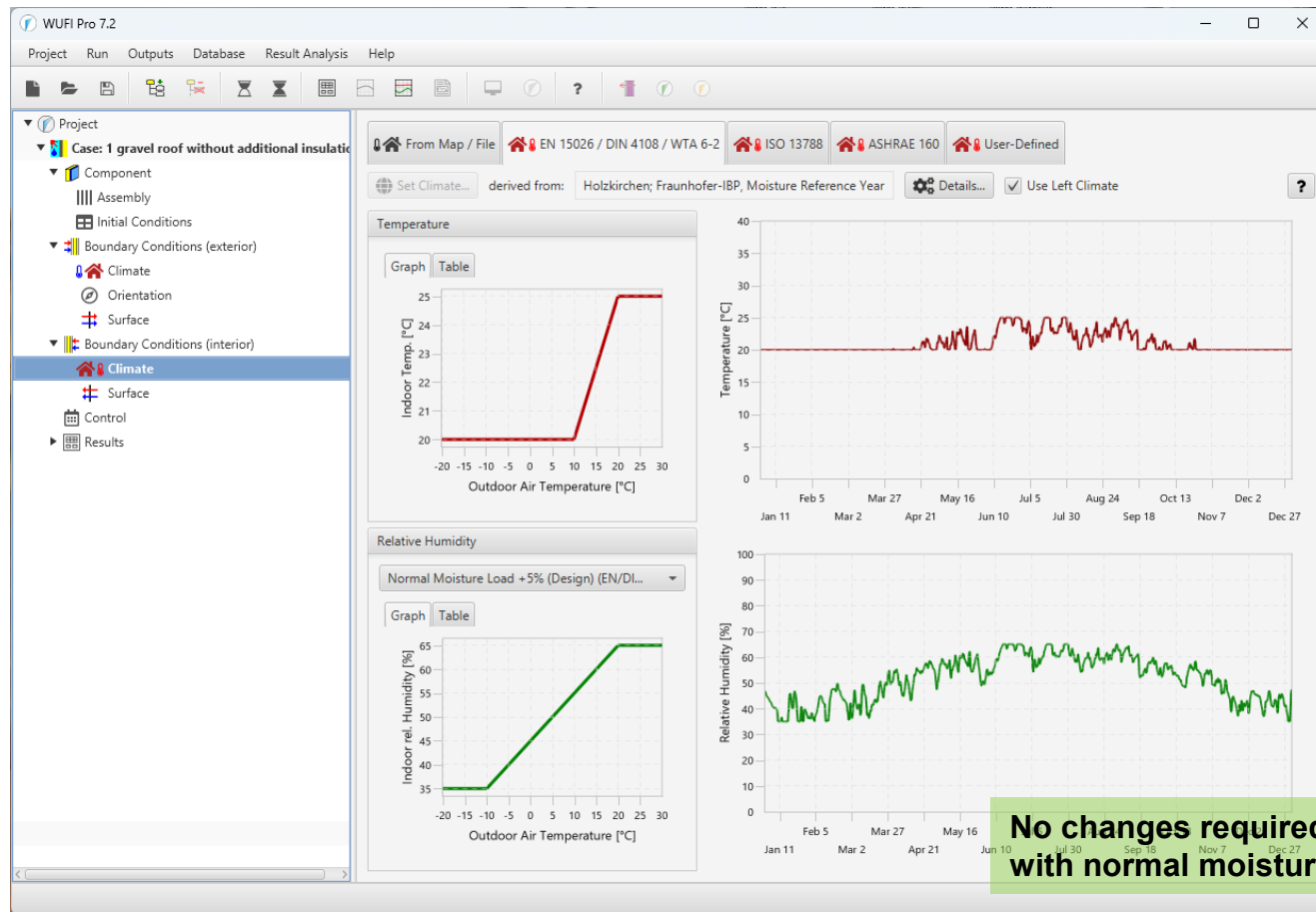
Use the radiative
overcooling!

Rain is taken into account

Adjust surface transfer coefficients!

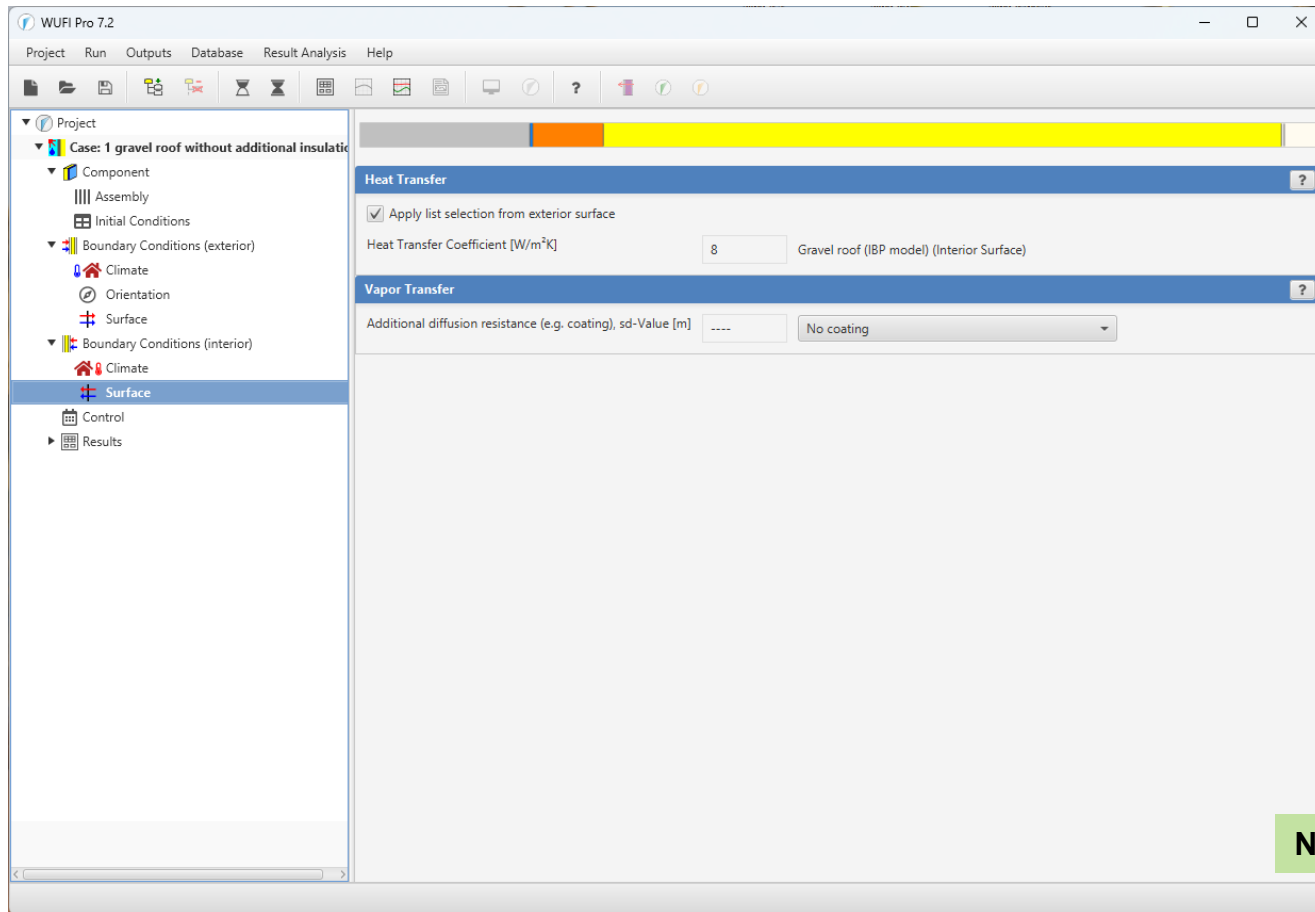
Example A: Indoor Climate

Input: Boundary Conditions (interior) – Climate



Example A: Surface Transfer Coefficients (interior)

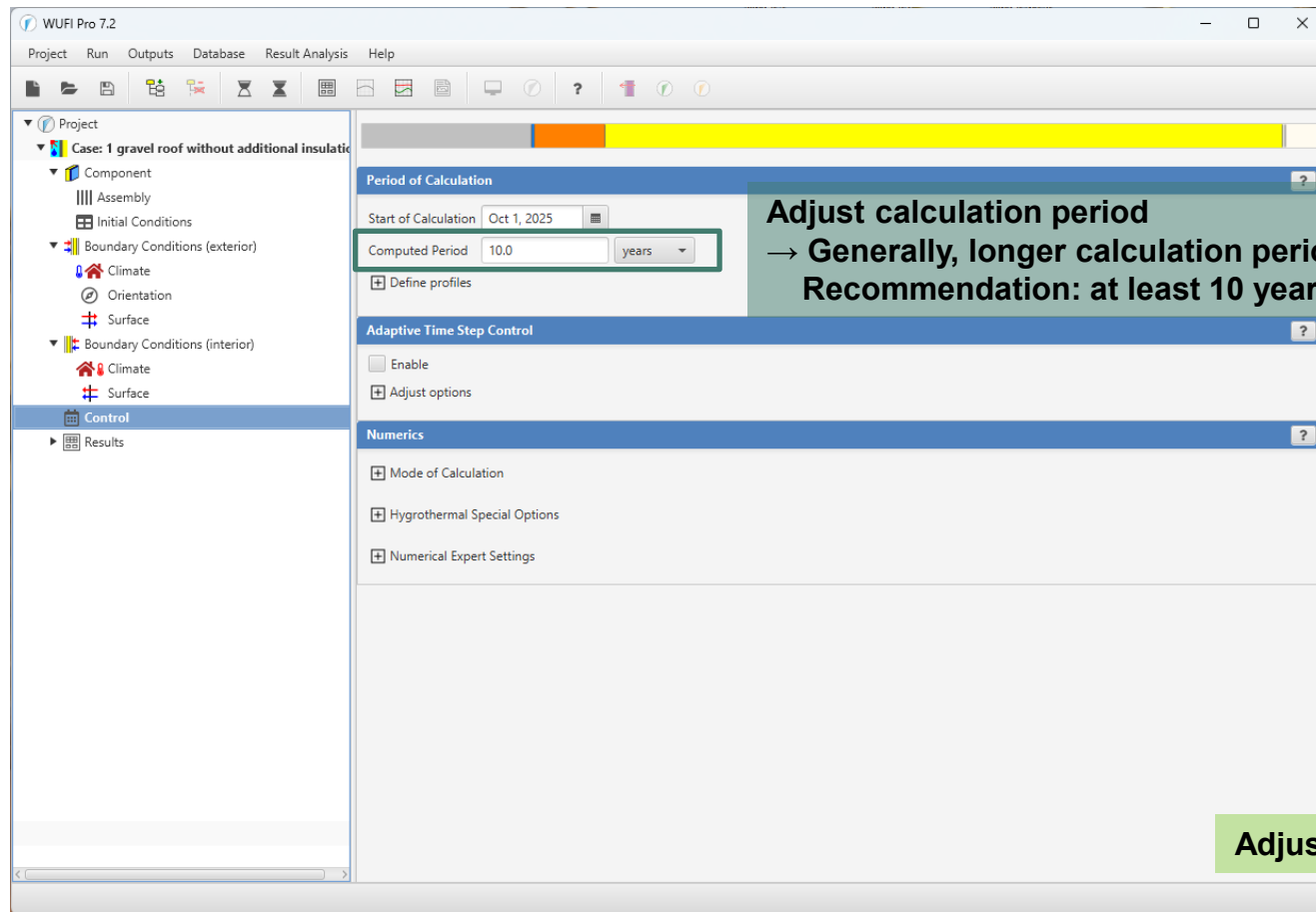
Input: Boundary Conditions (interior) – Surface



No changes required

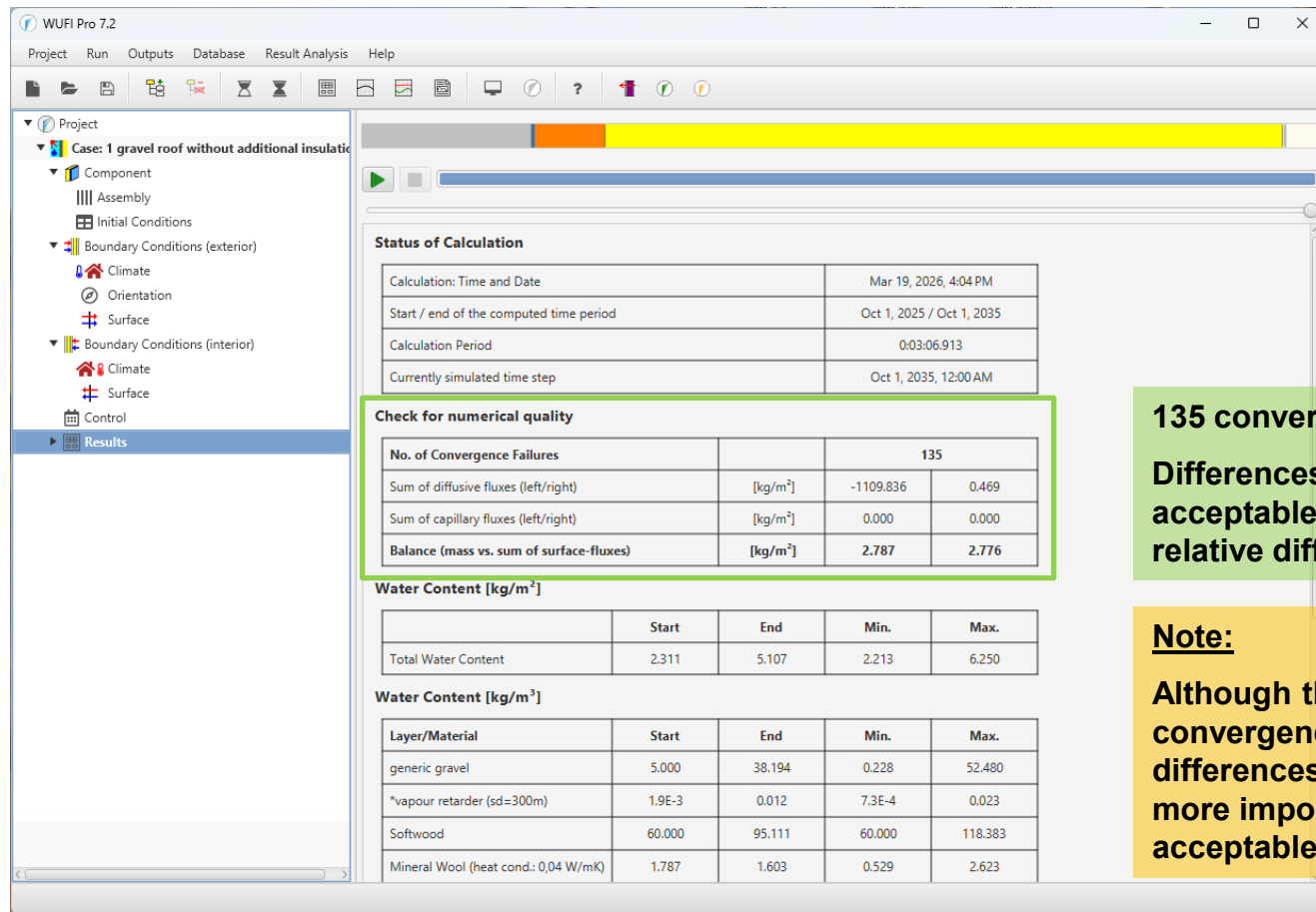
Example A: Period of Calculation and Numerics

Input: Control



Example A: Check for Numerical Quality

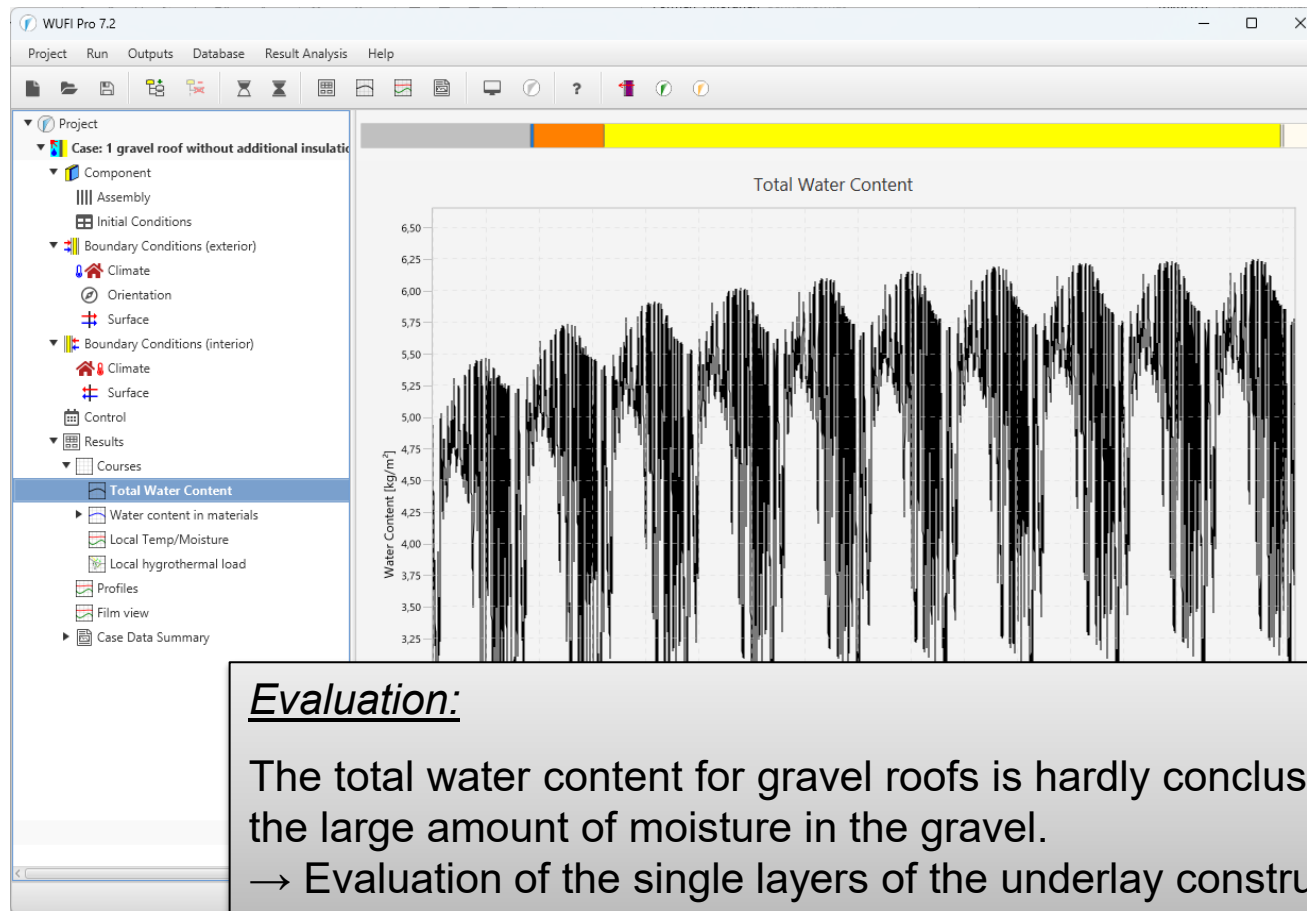
Results:



Example A: Evaluation of Total Water Content

Evaluation:

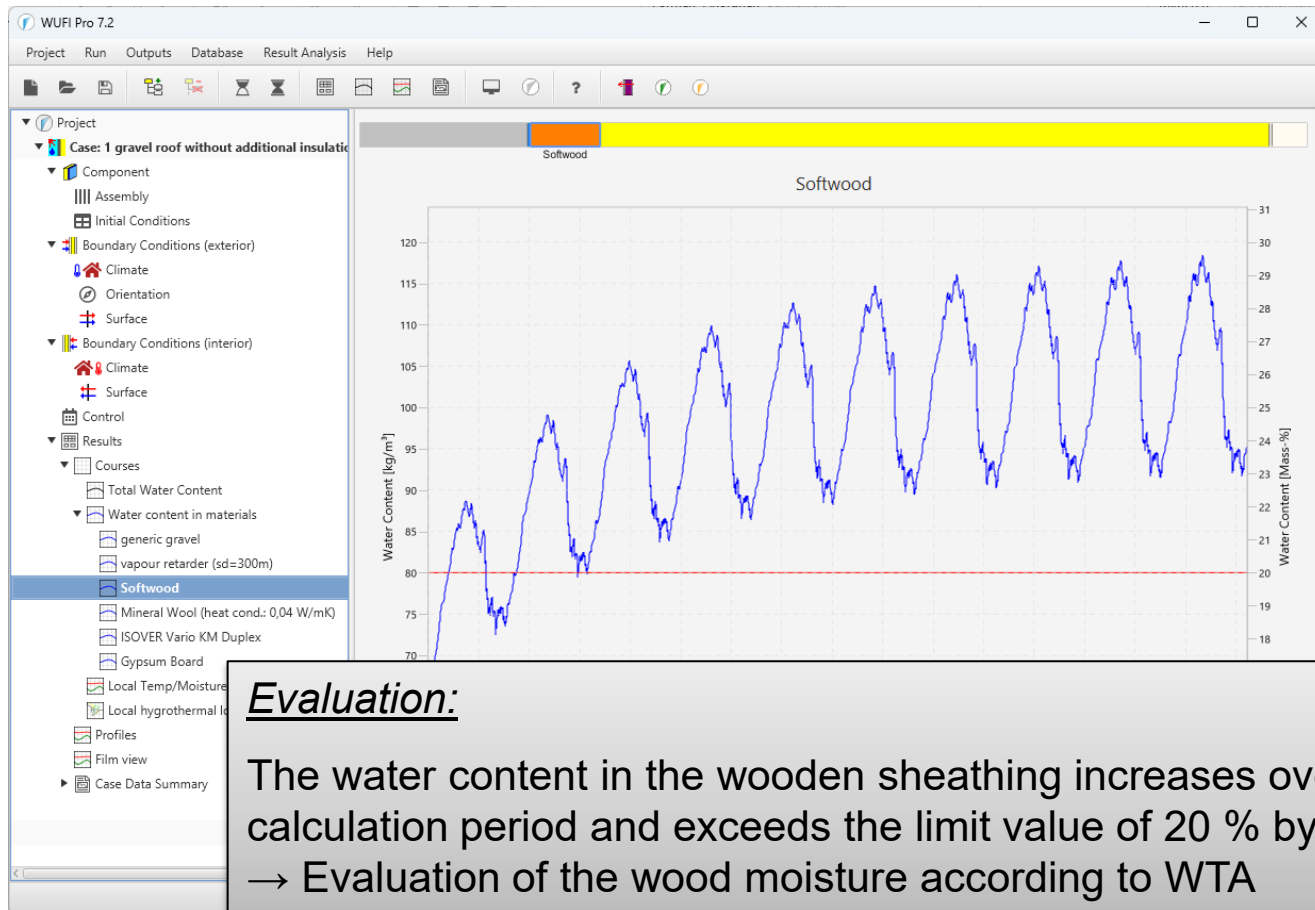
Total water content



Example A: Evaluation of Wood Moisture

Evaluation:

Water content in the wooden sheathing



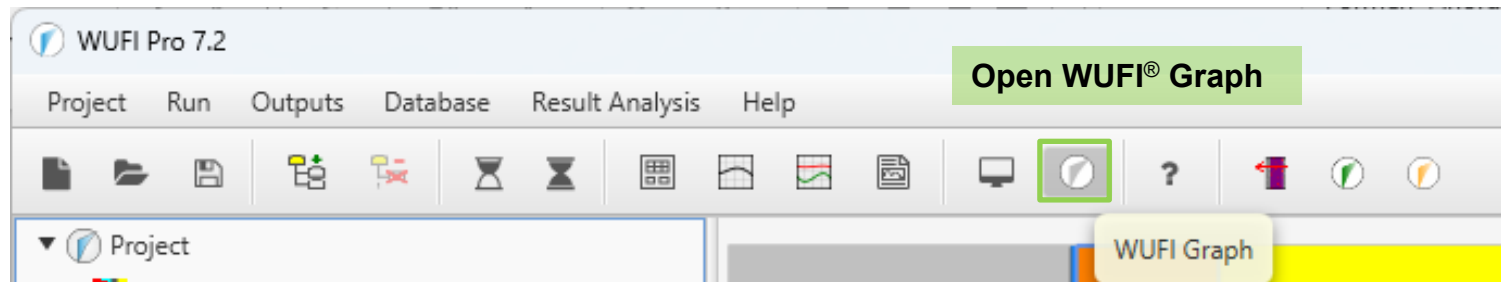
Example A: Evaluation of Wood Moisture with WUFI® Graph

Evaluation with WUFI® Graph:

Wood moisture in the wooden sheathing according to WTA 6-8

Note:

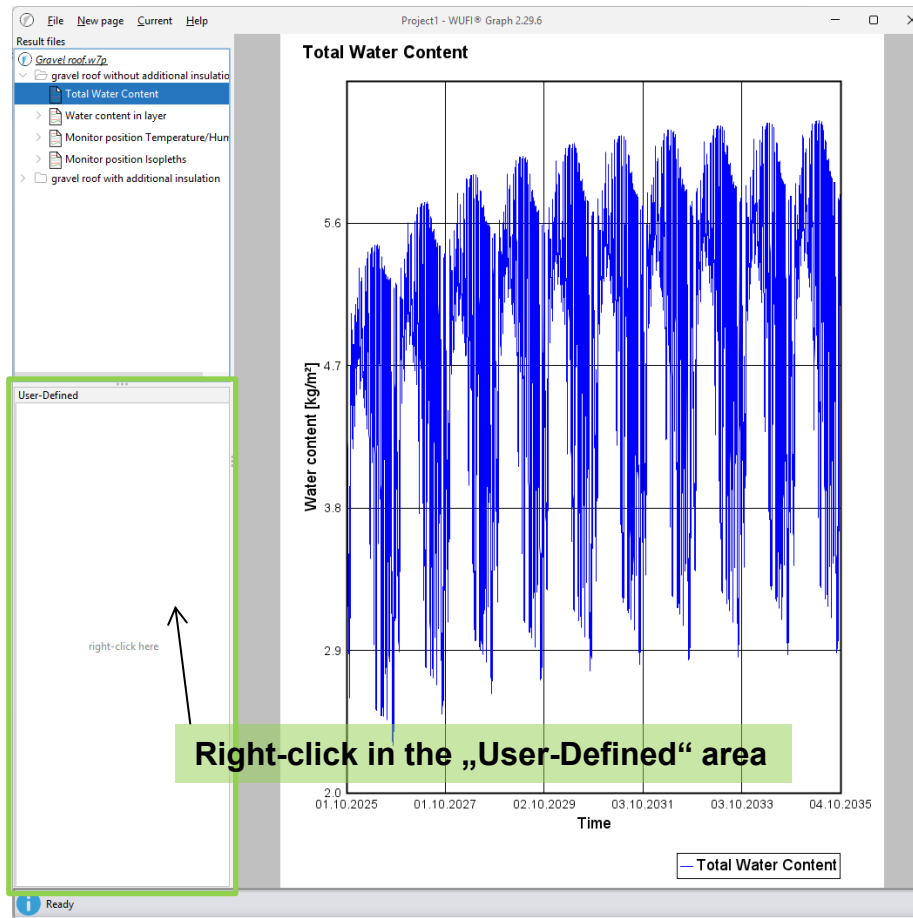
To open WUFI® Graph, the WUFI® project must first be saved!



Example A: Evaluation of Wood Moisture with WUFI® Graph

Evaluation with WUFI® Graph:

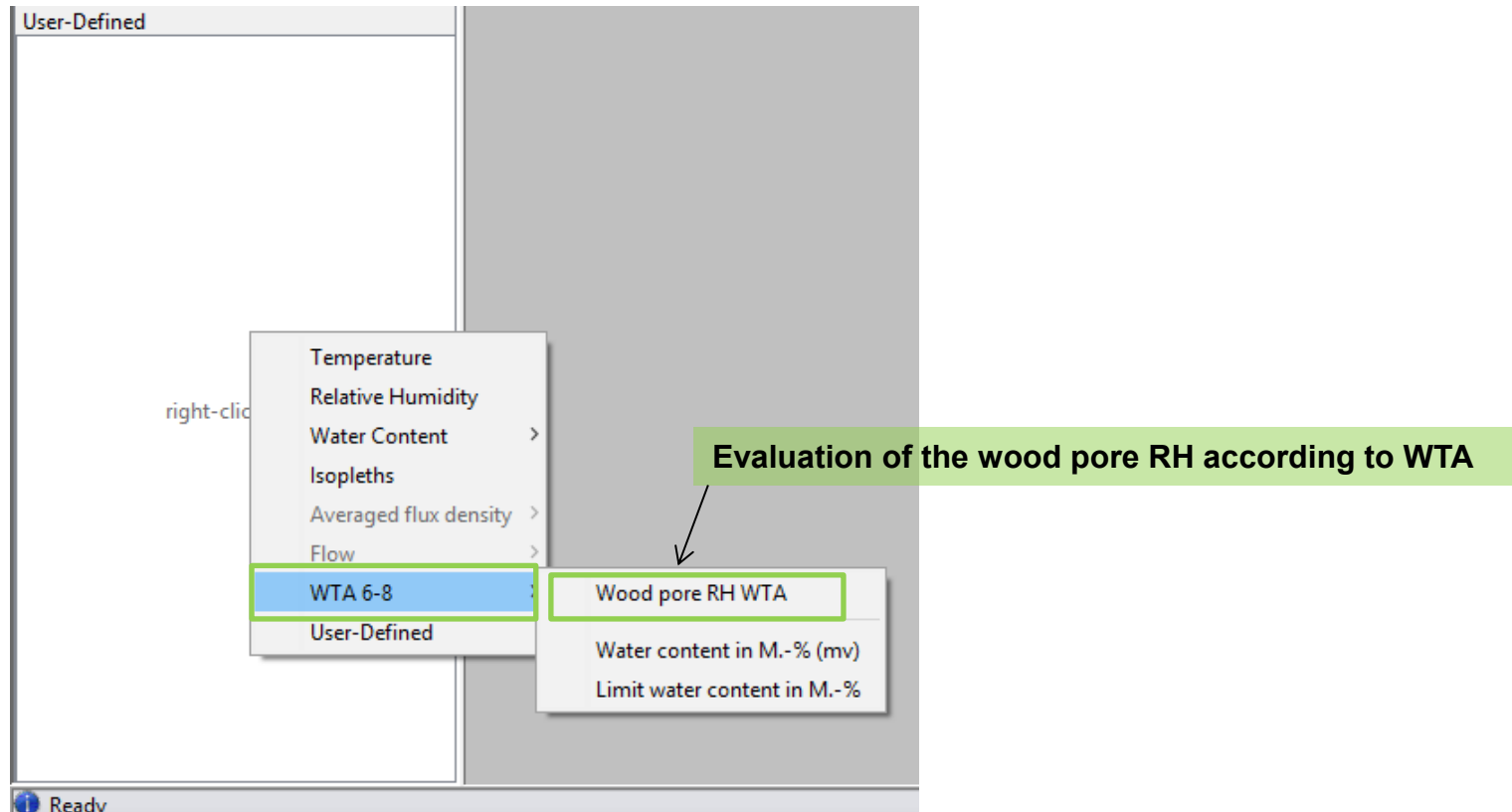
Wood moisture in the wooden sheathing according to WTA 6-8



Example A: Evaluation of Wood Moisture with WUFI® Graph

Evaluation with WUFI® Graph:

Wood moisture in the wooden sheathing according to WTA 6-8

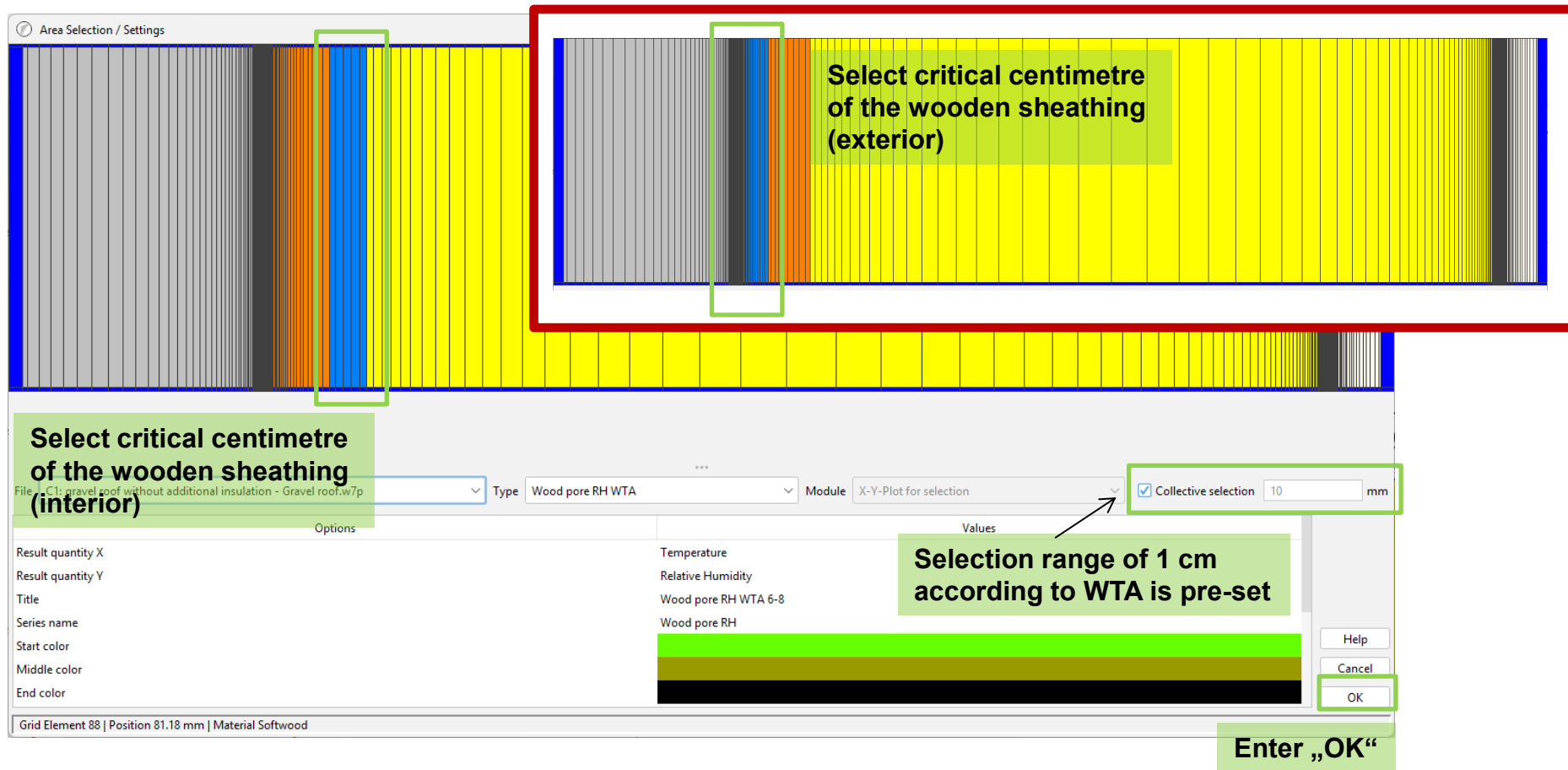


Example A: Evaluation of Wood Moisture with WUFI® Graph

Evaluation with WUFI® Graph:

Wood moisture in the wooden sheathing according to WTA 6-8

Evaluation in the most critical centimetre (in case of doubt, consider both sides)



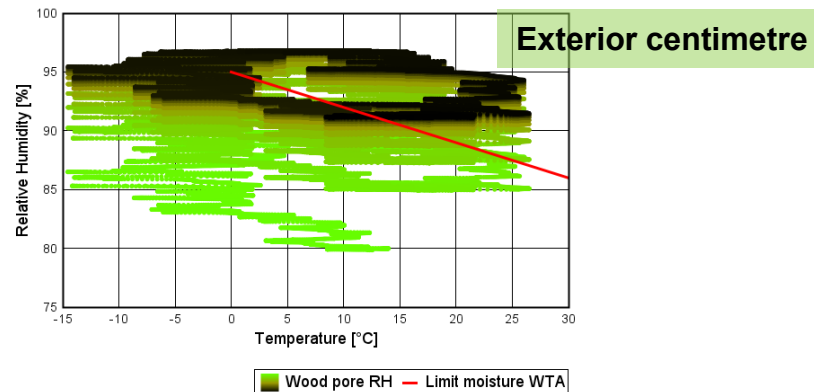
Example A: Evaluation of Wood Moisture with WUFI® Graph

Evaluation with WUFI® Graph:

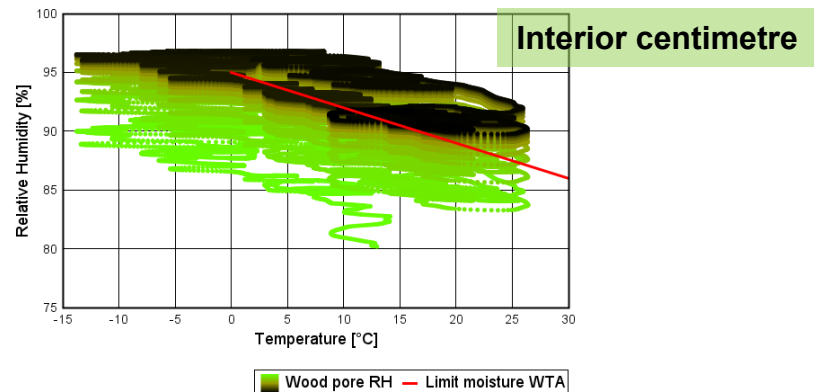
Wood moisture in the wooden sheathing according to WTA 6-8

Evaluation in the most critical centimetre (in case of doubt, consider both sides)

Wood pore RH WTA 6-8



Wood pore RH WTA 6-8



Evaluation:

The relative pore air moisture in the interior and the exterior centimetre of the sheathing exceeds the limit moisture according to WTA also clearly.

→ High risk regarding damage of the wood

Example B: Assembly

Assembly (from outside to inside):

- Generic Gravel 0.06 m
- Roofing Membrane ($s_d = 300$ m) 0.001 m
- EPS (heat cond.: 0.04 W/mK – density: 30 kg/m³) 0.1 m
- Wooden sheathing (Softwood) 0.025 m
- Mineral Wool (heat cond.: 0.04 W/mK) 0.24 m
- Moisture-variable vapour retarder (Vario KM Duplex) 0.001 m
- Gypsum Board 0.0125 m

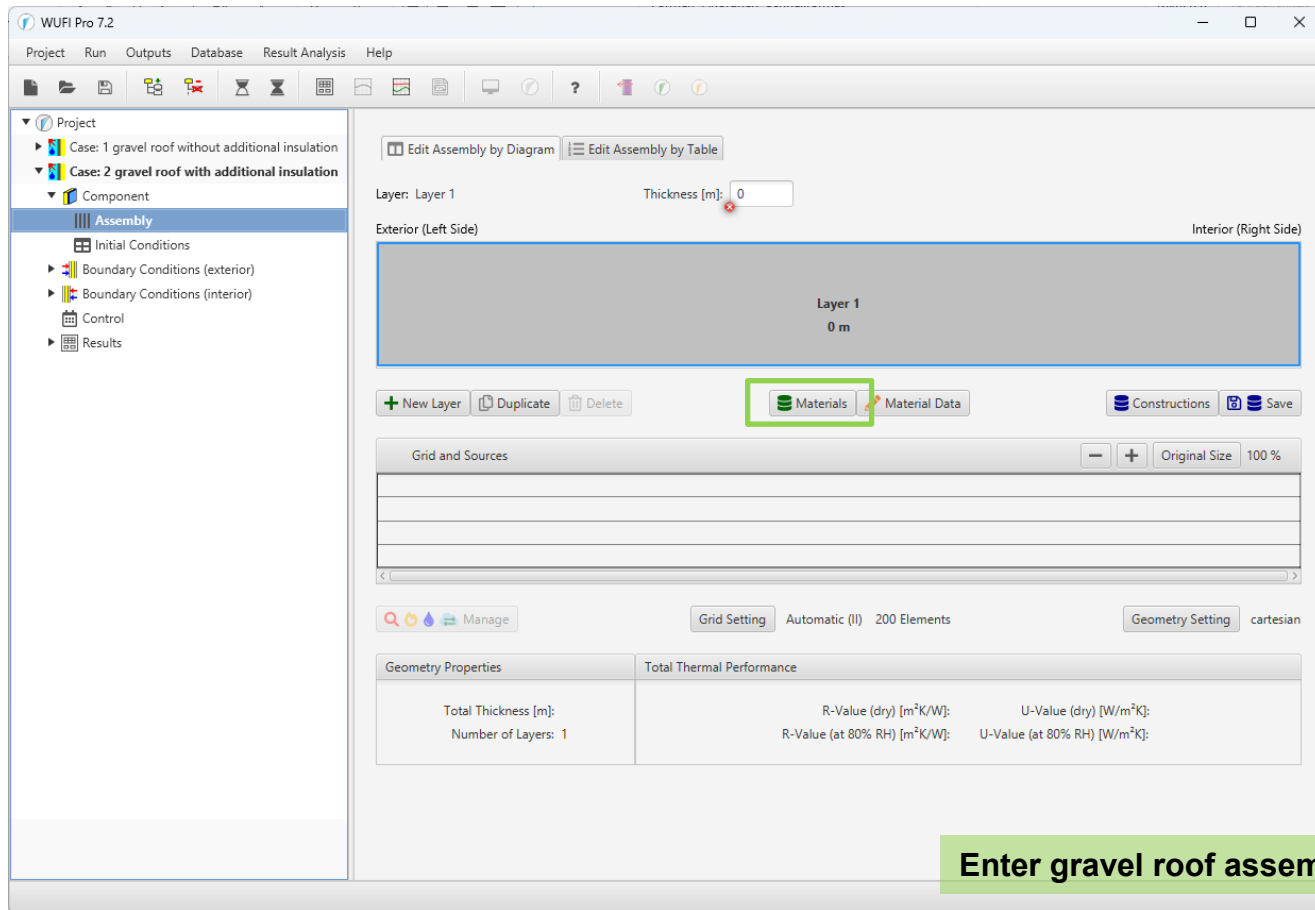
Example B: Boundary Conditions

Boundary conditions:

- Flat roof (3° to the North)
- Short-Wave Radiation Absorptivity / Long-Wave Radiation Emissivity: according to the generic gravel roof model
- Outdoor Climate: Holzkirchen
- Indoor Climate: Medium Moisture Load + 5 %
according to DIN 4108-3
- Air Tightness of the Envelope: $q_{50} = 3 \text{ m}^3/\text{m}^2\text{h}$
- Stack Height: 5 m

Example B: Component Assembly

Input: Component – Assembly



Example B: Component Assembly

Input: Component – Assembly

The screenshot displays the WUFI materials software interface. The left sidebar shows a tree view of material sources, with 'Green and Gravel Roofs' highlighted. The main window shows a table of materials with columns for Material Name, Bulk density, Porosity, Heat Cap., Therm. Cond., and Vap. Res. The 'generic gravel' material is highlighted in green. Below the table, the 'Material Information' tab is active, showing a list of functions and a graph of Water Content [kg/m³] vs. Relative Humidity [-]. The graph shows a sharp increase in water content as relative humidity approaches 1.0.

Material Name	Bulk density [kg/m³]	Porosity [-]	Heat Cap. [J/kgK]	Therm. Cond. [W/mK]	Vap. Res. [-]
generic gravel	1400	0.3	1000	0.7	1
generic substrate	1500	0.5	1500	0.9	5
Optigreen Economy Roof 1					
Optigreen Economy Roof 2					
Optigreen Light-weight Roof Solution 1					
Optigreen Nature Roof Solution 1					
Optigreen Pitched Roof 5° - 45°					

Hygrothermal Functions | Material Information

Moisture Storage Function

No.	RH [-]	Water Con... [kg/m³]
1	0	0
2	0.1	0.154
3	0.2	0.345
4	0.3	0.588
5	0.4	0.909
6	0.5	1.35
7	0.55	1.64
8	0.6	2
9	0.65	2.45
10	0.7	3.04
11	0.75	3.85

Water Content [kg/m³] vs. Relative Humidity [-]

Green and gravel roofs → Generic gravel

Example B: Component Assembly

Input: Component – Assembly

WUFI Pro 7.2

Project Run Outputs Database Result Analysis Help

Project

- Case: 1 gravel roof without additional insulation
- Case: 2 gravel roof with additional insulation
- Component
- Assembly**
- Initial Conditions
- Boundary Conditions (exterior)
- Boundary Conditions (interior)
- Control
- Results

Edit Assembly by Diagram Edit Assembly by Table

Layer: Gypsum Board Thickness [m]: 0.0125

Exterior (Left Side) Interior (Right Side)

Layer	Material	Thickness [m]
1	generic gravel	0.06 m
2	EPS (heat cond.: 0.04 W/mK - d...	0.1 m
3	Softw...	0.025 m
4	Mineral Wool (heat cond.: 0.04 W/mK)	0.24 m

+ New Layer Duplicate Delete Materials Material Data Constructions Save

Grid and Sources

Grid Setting Automatic (II) 200 Elements Geometry Setting cartesian

Geometry Properties	Total Thermal Performance
Total Thickness [m]: 0.441	R-Value (dry) [m ² K/W]: 8.93 U-Value (dry) [W/m ² K]: 0.11
Number of Layers: 8	R-Value (at 80% RH) [m ² K/W]: 8.88 U-Value (at 80% RH) [W/m ² K]: 0.11

Enter underlying roof construction;
adjust layer thicknesses if necessary

Example B: Moisture Source in the Gravel Layer

Input: Component – Assembly

Insert moisture source in the layer "Generic Gravel"

The screenshot shows the WUFI Pro 7.2 software interface. The left sidebar displays the project hierarchy: Project > Case: 2 gravel roof with additional insulation > Component > Assembly. The main window shows the assembly editor for the 'generic gravel' layer. The layer thickness is 0.06 m. The assembly diagram shows three layers: generic gravel (0.06 m), EPS (0.1 m), and Mineral Wool (0.24 m). A right-click context menu is open over the generic gravel layer, with 'Rain Source' selected. A green box highlights the right-click action, and a green arrow points to the 'Rain Source' option. The bottom of the window shows the 'Total Thermal Performance' section with the following data:

Total Thermal Performance	
Total Thickness [m]: 0.441	R-Value (dry) [m ² K/W]: 8.93
Number of Layers: 8	U-Value (dry) [W/m ² K]: 0.11
	R-Value (at 80% RH) [m ² K/W]: 8.88
	U-Value (at 80% RH) [W/m ² K]: 0.11

Example B: Moisture Source in the Gravel Layer

Input: Component – Assembly

Moisture source in the whole gravel layer with the exception of the outermost element.

Note:

By adding the moisture source in the outermost element numerical problems and differences in the balances may be caused.

Hygrothermal Sources

Rain Source

Name: Rain 1

Spread Area

☐ Grid Element

☒ Area right-fixed

☐ Whole Layer

Thickness [m]: 0.057

Source Type

☐ Transient from File

☒ Fraction of incident Driving Rain

☐ Air Infiltration model IBP

☐ Constant Monthly Moisture Load

Source Term Cut-Off [kg/m³]

☐ No Cut-Off

☐ Cut-Off at Max. Water Content

☒ Cut-Off at Free Water Saturation

☐ User-Defined

Fraction [%]: 40

Gravel roof model IBP (in gravel)

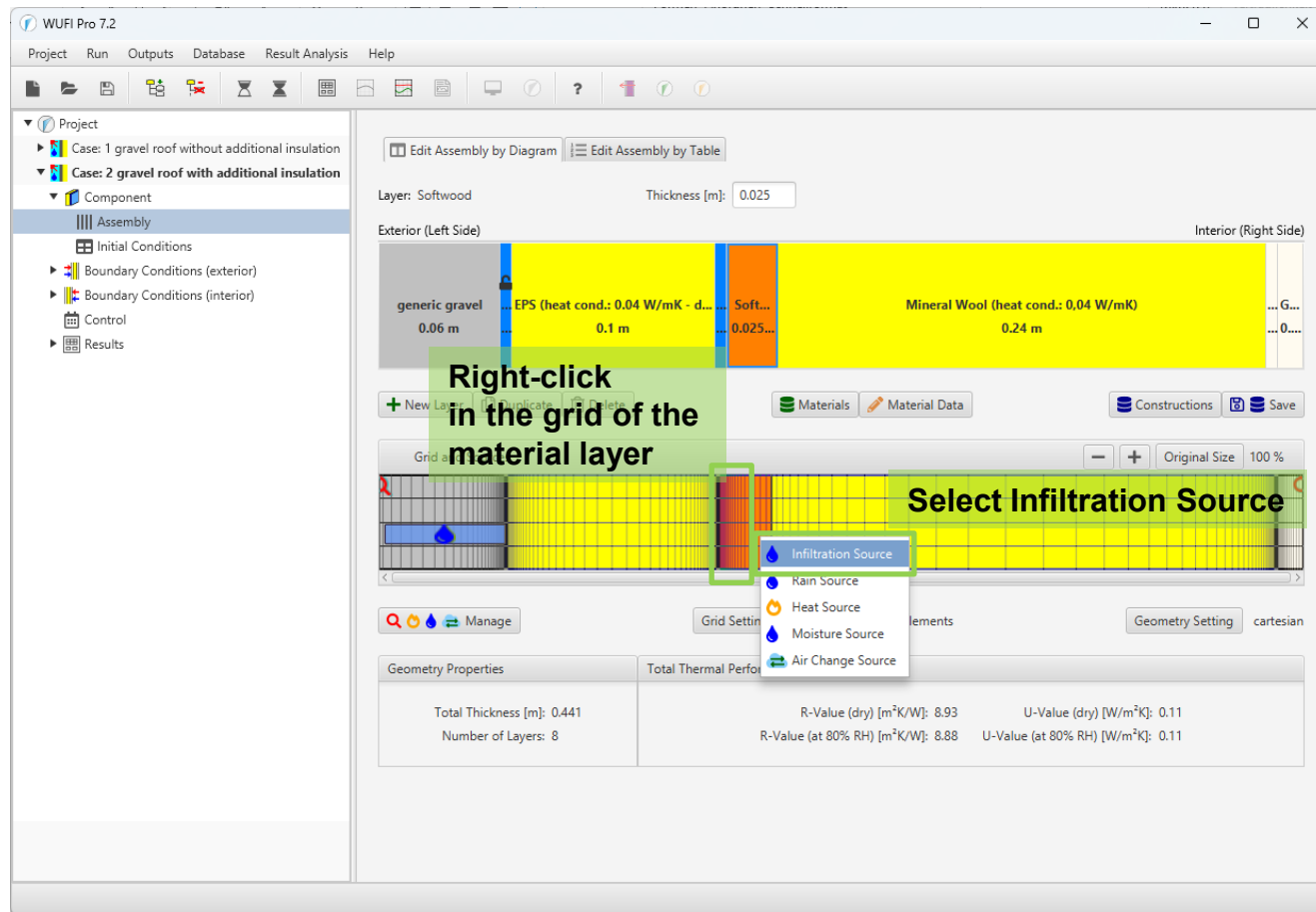
Fraction: 40% (Gravel roof model IBP)

Delete source OK Cancel Help

Example B: Infiltration Source

Input: Component – Assembly

Infiltration source according to DIN 68800 in the wooden sheathing



Example B: Infiltration Source

Input: Component – Assembly

Moisture Source in the interior 5 mm of the wooden sheathing.

Hygrothermal Sources

Infiltration Source

Name: Infiltration 1

Spread Area

☐ Grid Element

☒ Area right-fixed

☐ Whole Layer

Thickness [m]: 0.005

Source Type

☐ Transient from File

☐ Fraction of incident Driving Rain

☒ Air Infiltration model IBP

☐ Constant Monthly Moisture Load

Source Term Cut-Off [kg/m³]

☐ No Cut-Off

☐ Cut-Off at Max. Water Content

☒ Cut-Off at Free Water Saturation

☐ User-Defined

Envelope Infiltration q50 [m³/m²h]

3

Air Tightness Class B (DIN 4108, tested <= 3 m³/m²h)

Stack Height [m]: 5

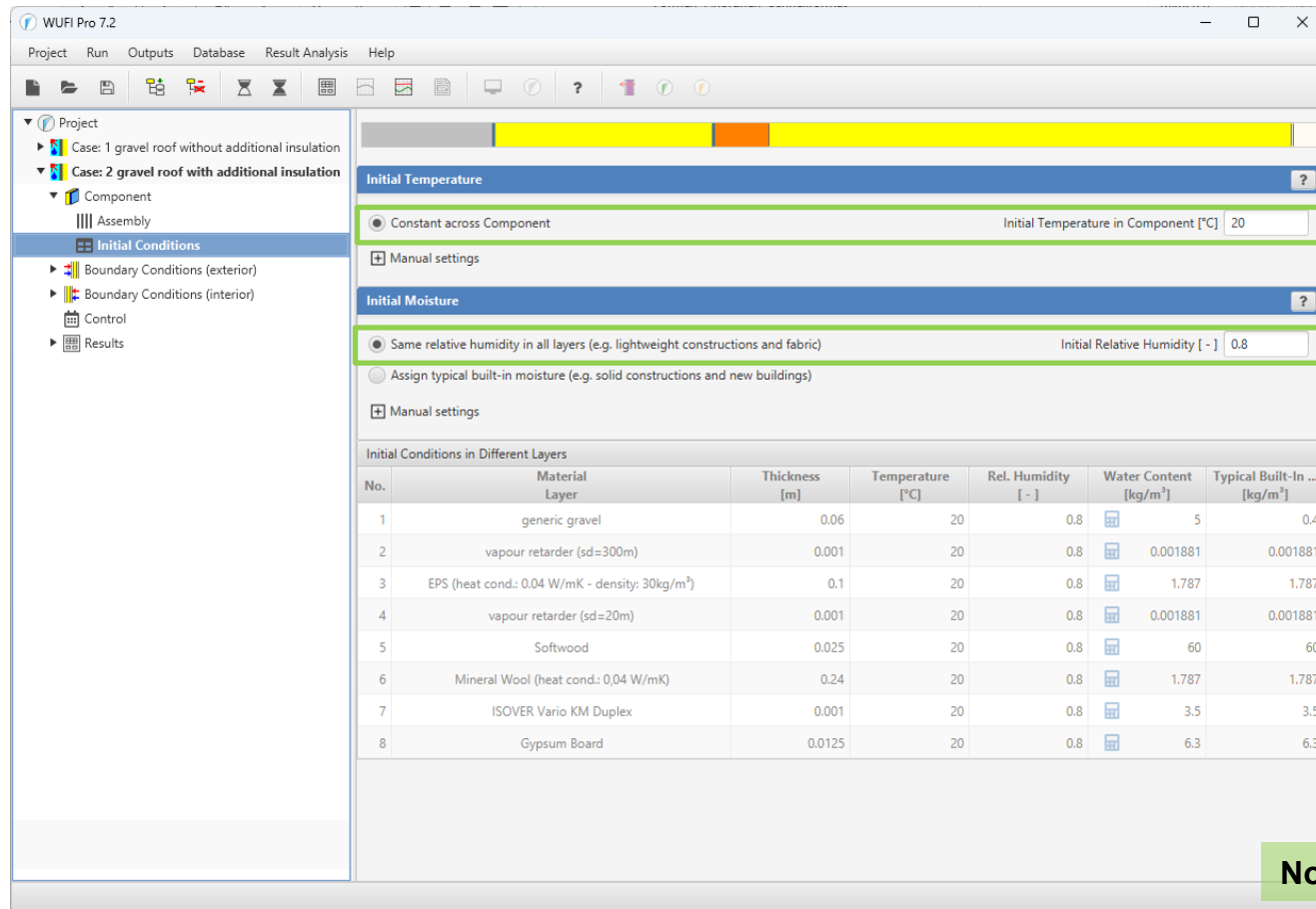
Mechanical Ventilation Overpressure [Pa]: 0

Delete source OK Cancel Help

Adjust infiltration source

Example B: Initial Conditions

Input: Component – Initial Conditions



WUFI Pro 7.2

Project Run Outputs Database Result Analysis Help

Project

- Case: 1 gravel roof without additional insulation
- Case: 2 gravel roof with additional insulation
 - Component
 - Assembly
 - Initial Conditions**
 - Boundary Conditions (exterior)
 - Boundary Conditions (interior)
 - Control
 - Results

Initial Temperature

☒ Constant across Component Initial Temperature in Component [°C] 20

Initial Moisture

☒ Same relative humidity in all layers (e.g. lightweight constructions and fabric) Initial Relative Humidity [-] 0.8

☐ Assign typical built-in moisture (e.g. solid constructions and new buildings)

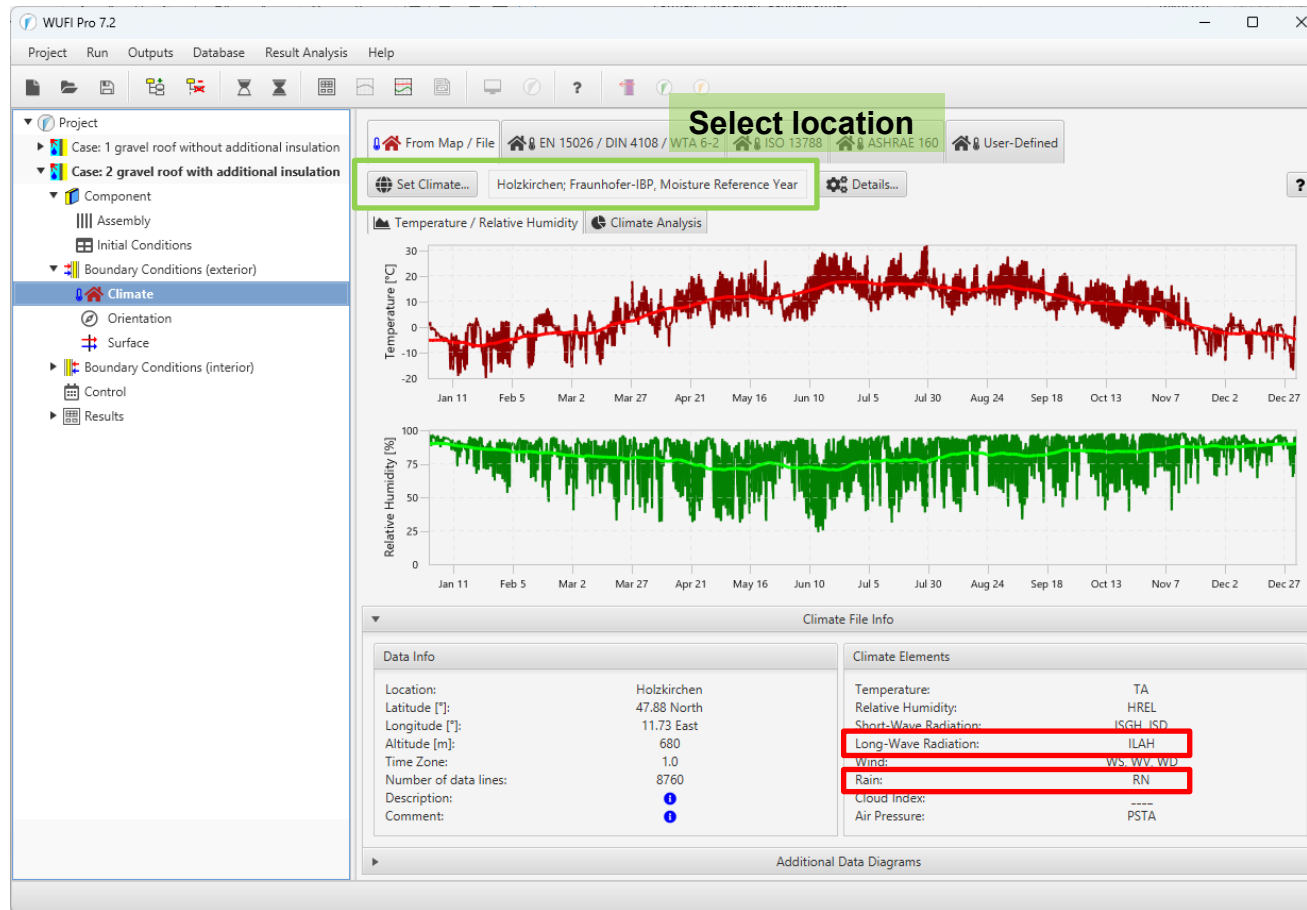
Initial Conditions in Different Layers

No.	Material Layer	Thickness [m]	Temperature [°C]	Rel. Humidity [-]	Water Content [kg/m³]	Typical Built-In ... [kg/m³]
1	generic gravel	0.06	20	0.8	5	0.4
2	vapour retarder (sd=300m)	0.001	20	0.8	0.001881	0.001881
3	EPS (heat cond.: 0.04 W/mK - density: 30kg/m³)	0.1	20	0.8	1.787	1.787
4	vapour retarder (sd=20m)	0.001	20	0.8	0.001881	0.001881
5	Softwood	0.025	20	0.8	60	60
6	Mineral Wool (heat cond.: 0.04 W/mK)	0.24	20	0.8	1.787	1.787
7	ISOVER Vario KM Duplex	0.001	20	0.8	3.5	3.5
8	Gypsum Board	0.0125	20	0.8	6.3	6.3

No changes required

Example B: Outdoor Climate

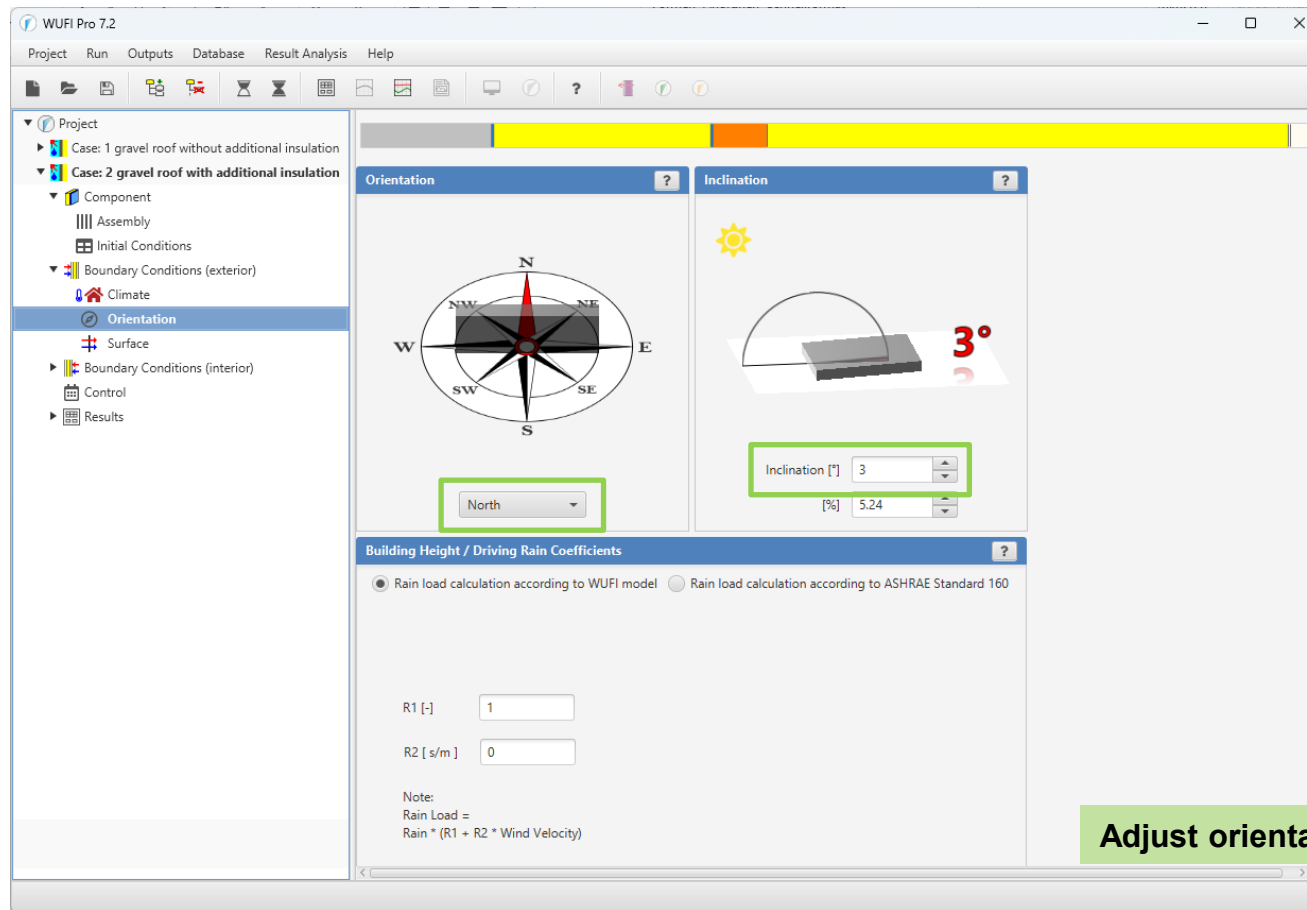
Input: Boundary Conditions (exterior) – Climate



Note:
For the application of the generic gravel roof model, climate data with long-wave radiation and rain data are necessary!

Example B: Orientation / Inclination

Input: Boundary Conditions (exterior) – Orientation



Adjust orientation and inclination

Example B: Surface Transfer Coefficients (exterior)

Input: Boundary Conditions (exterior) – Surface

WUFI Pro 7.2

Project Run Outputs Database Result Analysis Help

Project

- Case: 1 gravel roof without additional insulation
- Case: 2 gravel roof with additional insulation
 - Component
 - Assembly
 - Initial Conditions
 - Boundary Conditions (exterior)
 - Climate
 - Orientation
 - Surface
 - Boundary Conditions (interior)
 - Control
 - Results

Heat Transfer

Heat Transfer Coefficient [W/m²K] 19 Gravel roof (IBP model)

long-wave radiation parts Heat Transfer Coefficient [W/... 6.5

wind-dependent ☐

Wind-dependence formula

Vapor Transfer

Additional diffusion resistance (e.g. coating), sd-Value [m] ---- No coating

Note: This setting does not affect rain absorption.

Radiation

Short-wave absorptivity, e.g. solar radiation [-] 0.5 Gravel roof, generic model

Radiative overcooling ☒ Note: Explicit Radiation Balance, includes radiative cooling due to long-wave emission.

Long-wave emissivity, e.g. nighttime radiative cooling [-] 0.93

Additional radiation parameters

Reduction factors

Rain

Simulation takes rain into account ☒

Rain parameters

Heat transfer coefficient
(from list: gravel roof)

Absorption
(from list: gravel roof,
generic model)

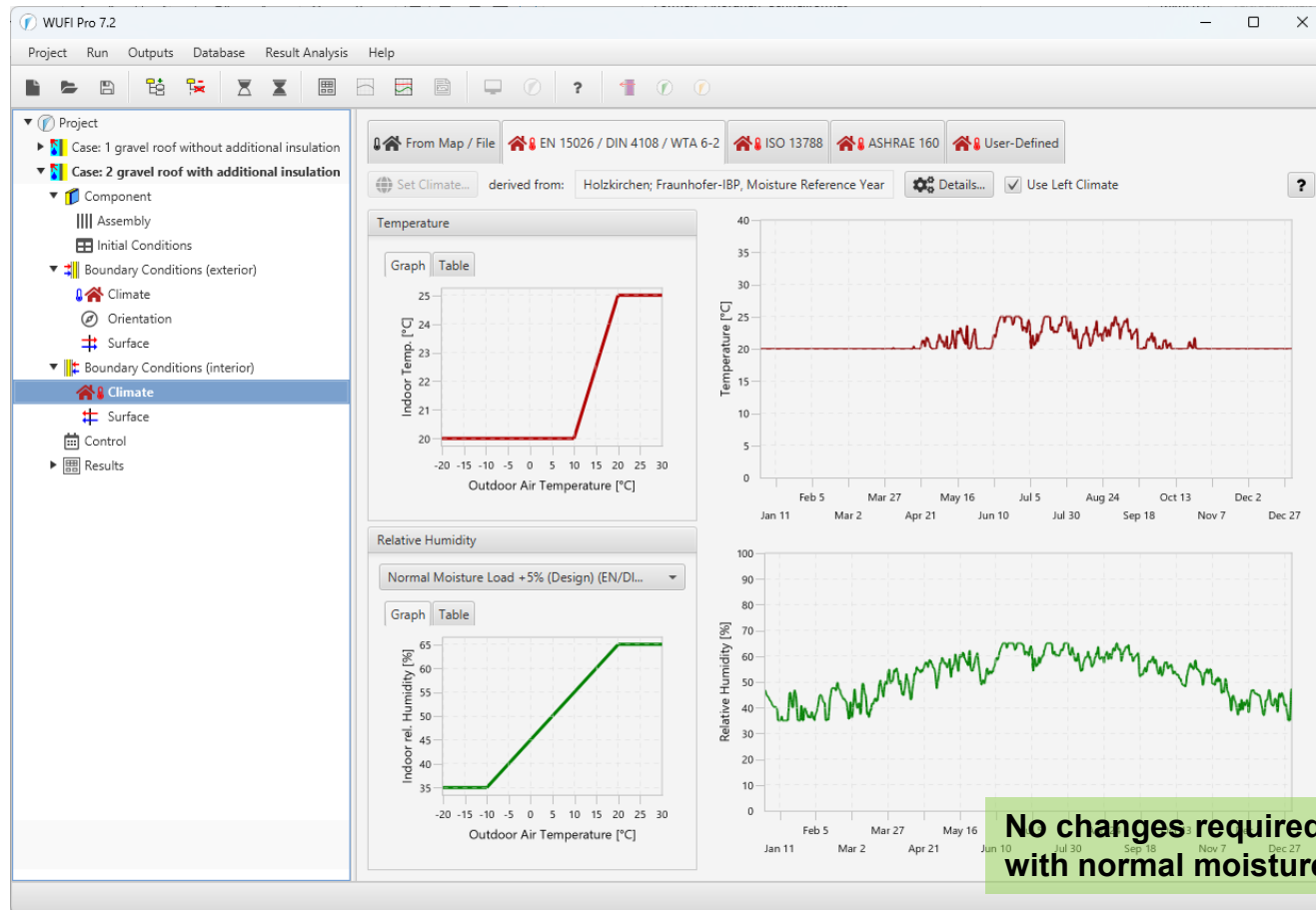
Use the radiative
overcooling!

Rain is taken into account

Adjust surface transfer coefficients!

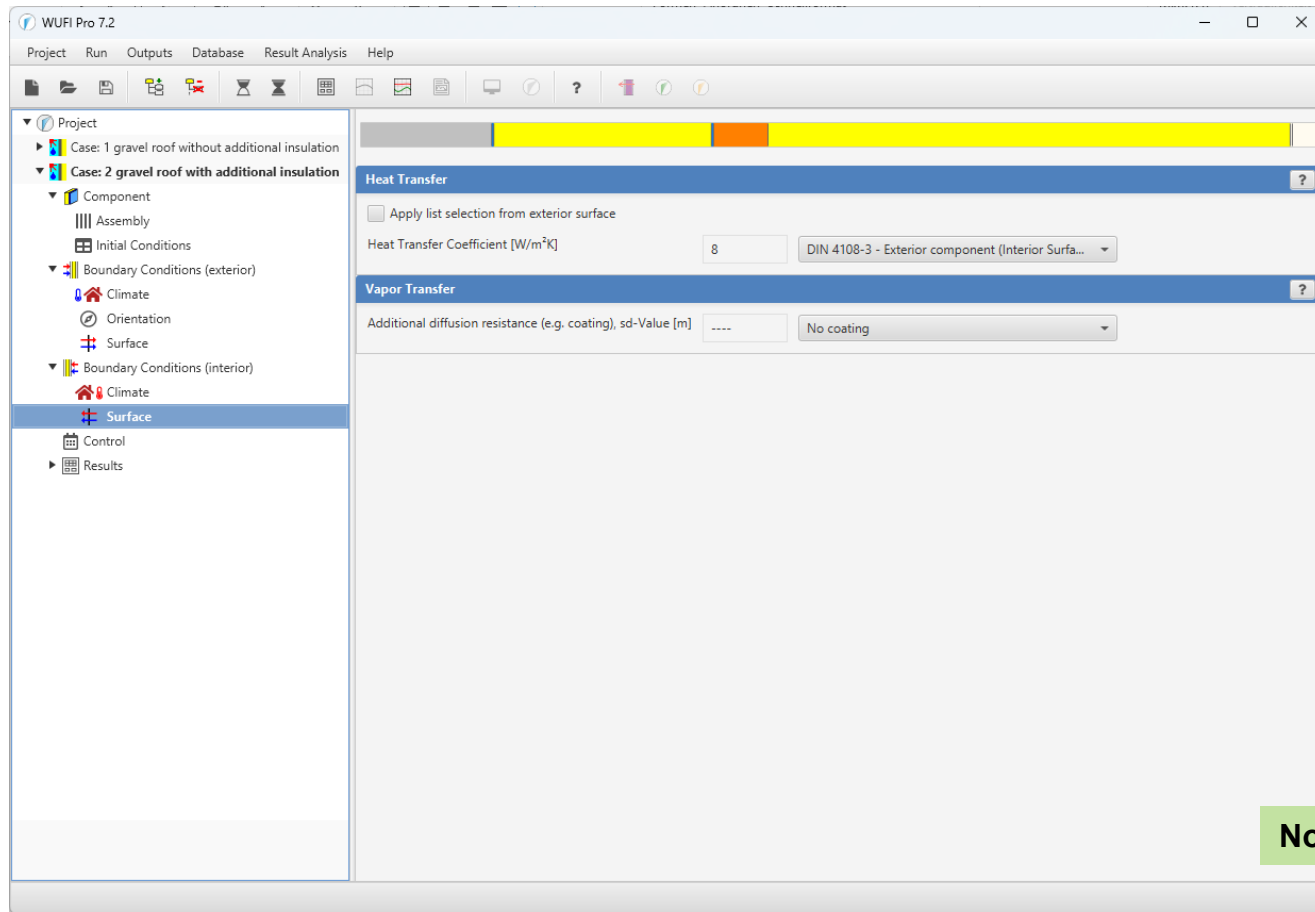
Example B: Indoor Climate

Input: Boundary Conditions (interior) – Climate



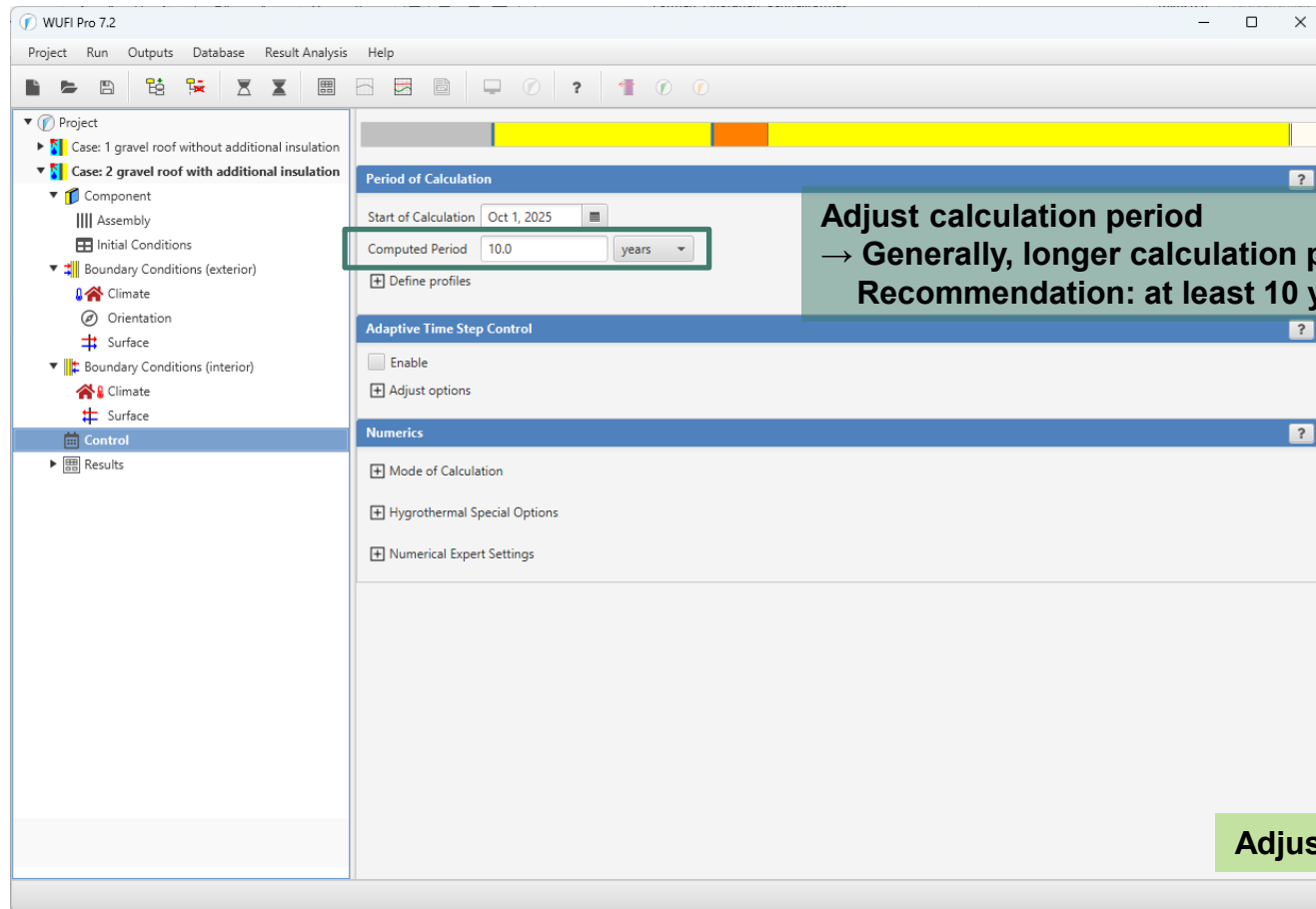
Example B: Surface Transfer Coefficients (interior)

Input: Boundary conditions (interior) – Surface



Example B: Period of Calculation and Numerics

Input: Control

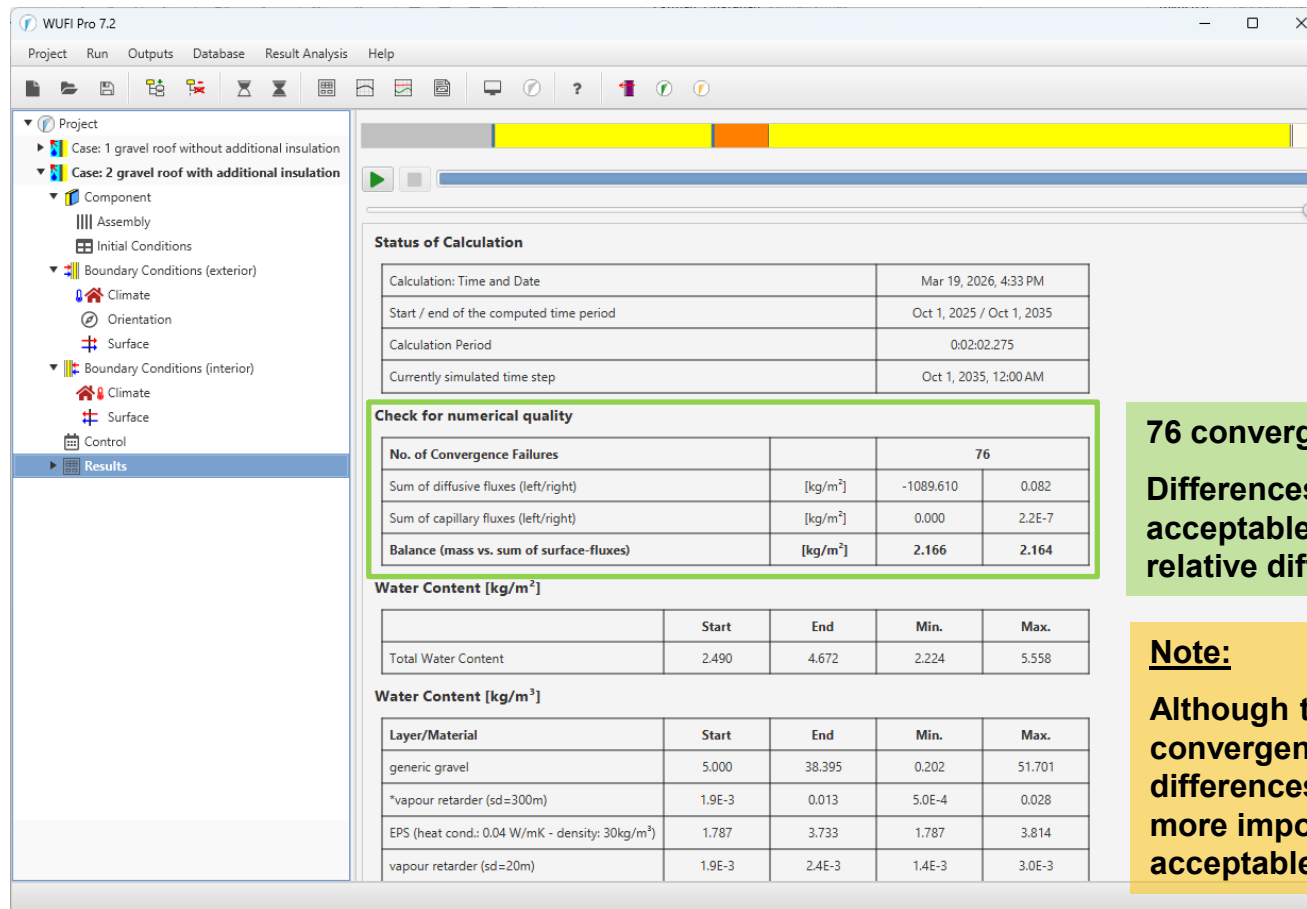


Adjust calculation period
→ Generally, longer calculation periods are required
Recommendation: at least 10 years

Adjust calculation period

Example B: Check for Numerical Quality

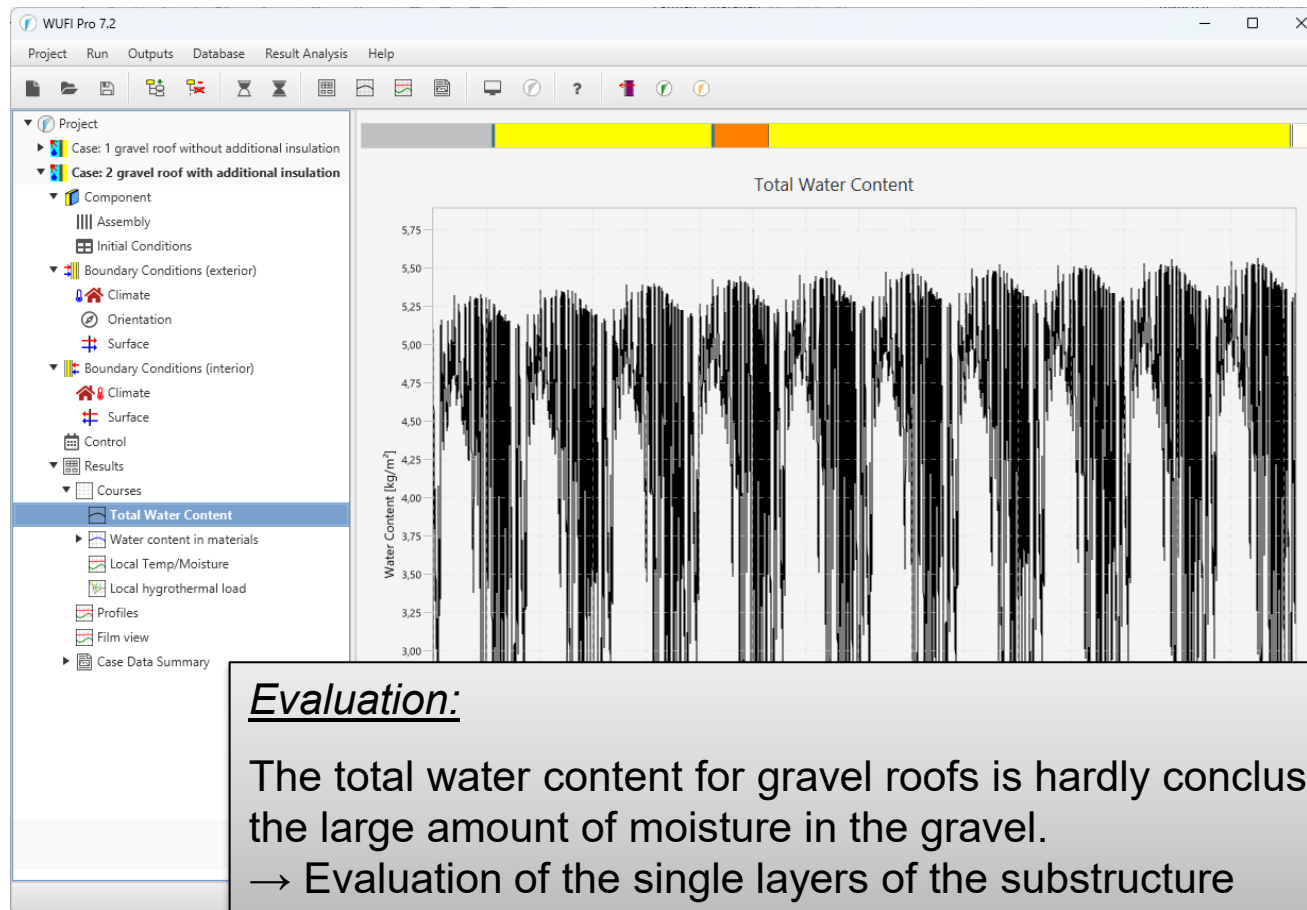
Results:



Example B: Evaluation of Total Water Content

Evaluation:

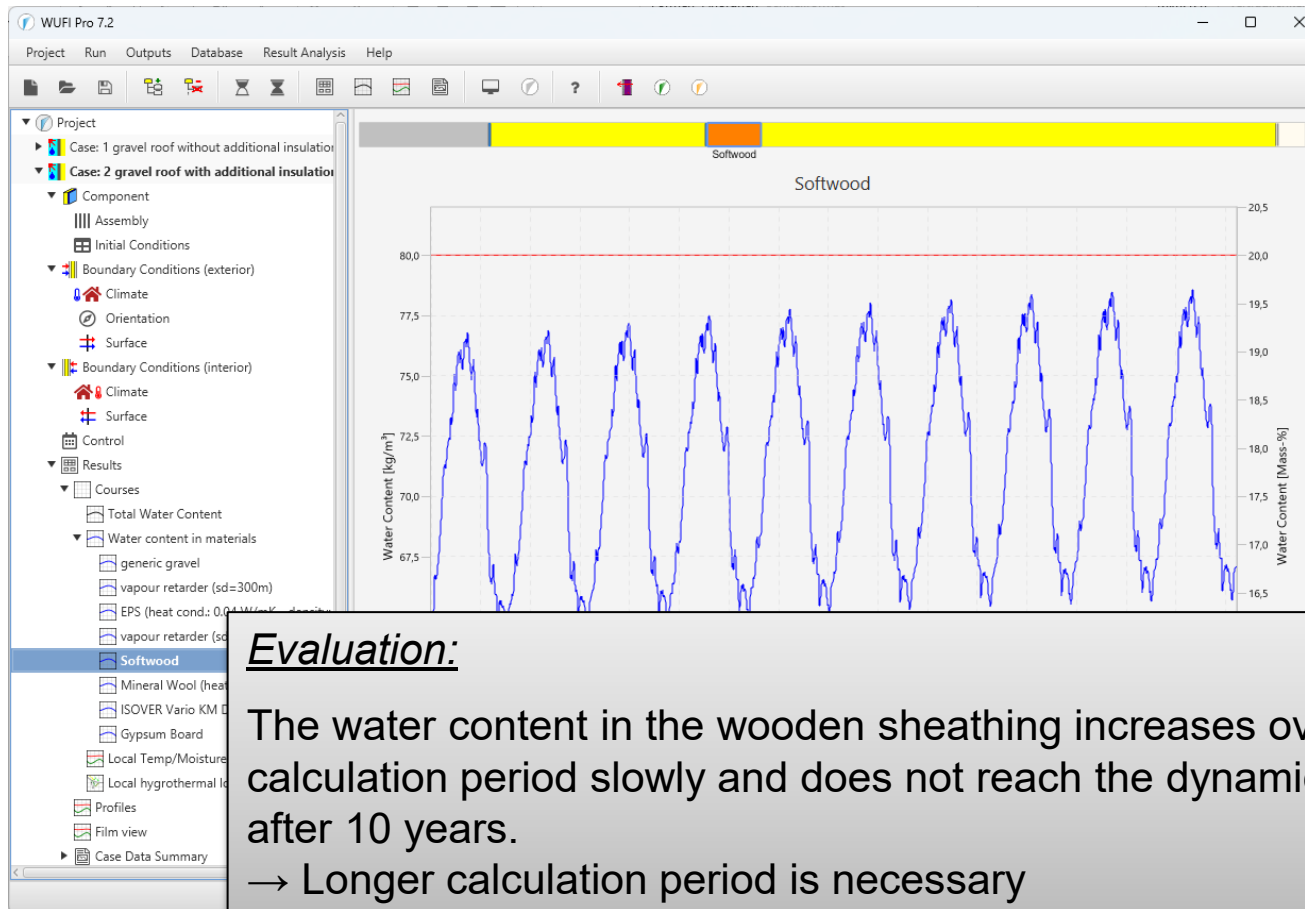
Total water content



Example B: Evaluation of Wood Moisture

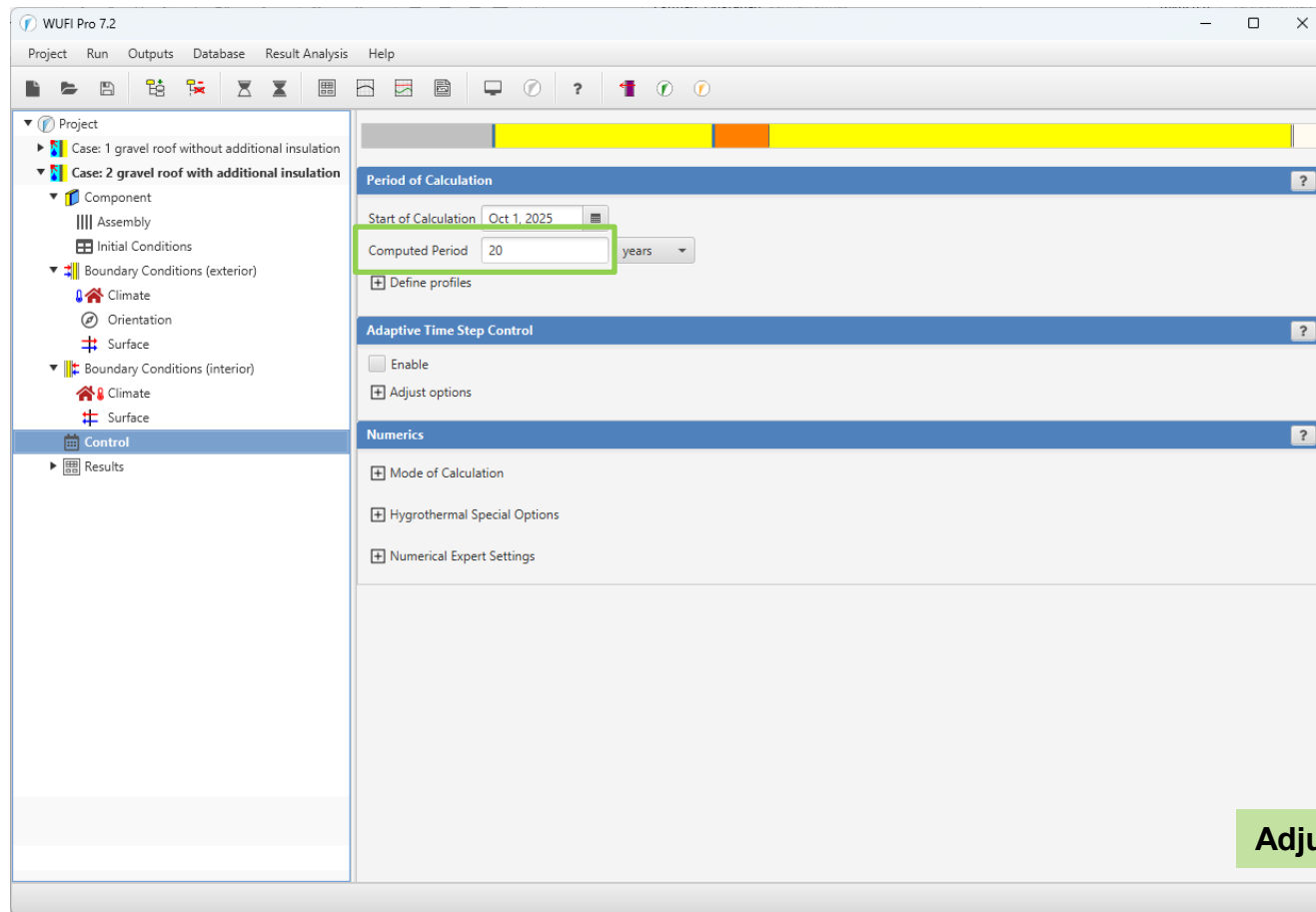
Evaluation:

Water Content in the wooden sheathing



Example B: Evaluation of Wood Moisture

Input: Control



Example B: Evaluation of Wood Moisture

Evaluation:

Water Content in the wooden sheathing

