WUFI® Tutorial 2014

Handling of typical constructions in WUFI
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Flat roof
Pitched Roof
Exterior wall with ETICS
Exterior wall with interior insulation
Ventilated timber frame construction
Basement wall (without ground water)
Flat roof

Construction drawing

1. Roofing membrane
2. Exterior insulation
3. Vapour retarder
4. Wooden sheathing
5. Insulation
6. Rafter
7. Vapour retarder
8. Installation Layer
9. Gypsum board
10. Simulated cross-section

Construction in WUFI
Please note

- Insert an air infiltration source at the cold side of the construction (at the position where condensation would occur) ⇒ source strength depending on the air tightness and height of the connected air column
- Orientation/ Inclination according to planning
- Heat transfer resistance „roof“
- Roofing membrane can be taken in account by using an $s_d$-value on the outer surface (selectable in the surface transfer coefficient dialog, numerical more favorable)
  ⇒ if doing so, use no roofing membrane in the construction setup
  ⇒ rain water absorption then has to be set to zero (“adhering fraction of rain”)
- Short wave radiation absorptivity depending on color of roof surface
- Long wave emissivity depending on the material of the surface
- Switch explicit radiation balance on
*) Material in which the condensate is expected due to convection which can not be simulated in a 1D program. The infiltration source is either in the inner 5 mm of the wooden sheathing or – if there is no sheathing – in the outer 5 mm of the insulation between the rafters.
Moisture source setup

3. Select „New Moisture Source“
Moisture source setup

- Air Infiltration Model
Flat roof

Result analysis*

- Check total water content (accumulation of moisture in whole construction); must not keep increasing
- Check water content in wooden sheathing
- In a construction without wood-based or moisture sensitive materials: Examination of amount of dew water (max. 500 g/m² / 200 g/m² according to DIN 4108 / EN ISO 13788 which equals max. 50 kg/m³ / 20 kg/m³ in outer centimeter of insulation)
  Further check influence of moisture content on the thermal conductivity in the material datas table „thermal conductivity, moisture-dependent“
- You may check moisture accumulation in the exterior insulation

*) Note: List not necessarily complete. Depending on boundary conditions additional critical positions may occur => Check in film display
Flat roof

Additional information

- Be careful with bright roofing membranes, the drying potential of the construction is greatly reduced.

- Shading / green roof has to be treated by using more elaborate models (Topic of the advanced workshop).

- In case of modeling the roofing membrane as $s_d$-value on the exterior surface, this only models the vapor-retarding property of the membrane, not its rain-tightness → Don't forget to switch off rain!

- Considering an insulated roof with rafters, usually the cross section through the insulation is relevant.

- Metal roof: Metal layer is taken into account as $s_d$-value at the exterior surface, absorptivity and emissivity according to material.
  - Unsealed seams: effective $s_d$-value around 25 m – 75 m
  - Sealed seams: effective $s_d$-value > 300 m
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Flat roof

Pitched Roof

Exterior wall with ETICS

Exterior wall with interior insulation

Ventilated timber frame construction

Basement wall (without ground water)
Pitched roof

Construction drawing

1  Roofing tiles and battens
2  Weather-protecting membrane
3  Wooden sheathing
4  Insulation
5  Vapor retarder
6  Installation layer
7  Gypsum board

Construction in WUFI

Exterior side

Interior side
Pitched roof

Please note

- Insert an air infiltration source at the cold side of the construction (at the position where condensation would occur)
- Relevant orientation: usually north
- Heat transfer resistance „roof“
- Ventilated roofing is omitted for the calculation
  ⇒ rain water absorption has to be set to zero ("adhering fraction of rain")
- Weather-protection layer can be taken into account by using an $s_d$-value on the outer surface (selectable in the surface transfer coefficient dialog, numerical more favorable)
  ⇒ if doing so use no roofing membrane in the construction setup
- Short wave radiation absorptivity depending on color of roofing tiles
- Long wave radiation emissivity depending on the material of roofing tiles
- Switch on explicit radiation balance
Pitched roof

Moisture source setup

- Air Infiltration Model

For procedure see "flat roof"
Result analysis*

- Check total water content (accumulation of moisture in whole construction); must not keep increasing.

- Check water content in wooden sheathing.

- In a construction without wood-based or moisture sensitive materials:
  Examination of amount of dew water (max. 500 g/m² / 200 g/m² according to DIN 4108 / EN ISO 13788 which equals max. 50 kg/m³ / 20 kg/m³ in outer centimeter of insulation)
  Further check influence of moisture content on the thermal conductivity in the material datas table „thermal conductivity, moisture-dependent“

*) Note: List not necessarily complete. Depending on boundary conditions additional critical positions may occur => Check in film display
Pitched roof

Additional information

- The heat transfer resistance for roofs was experimentally determined below the roof covering on pitched roofs.

- In case of modeling the roofing membrane as sd-value on the exterior surface, this only models the vapor-retarding property of the membrane, not its rain-tightness → Don't forget to switch off rain!

- Metal roof: Metal layer is taken into account as sd-value at the exterior surface, absorptivity and emissivity according to material
  - unsealed seams: effective sd-value around 25 m – 75 m
  - sealed seams: effective sd-value > 300 m
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Pitched Roof
**Exterior wall with ETICS**
Exterior wall with interior insulation
Ventilated timber frame construction
Basement wall (without ground water)
Exterior wall with ETICS

Construction drawing

1 Exterior plaster
2 Insulation
3 Plaster
4 Masonry/ concrete
5 Interior plaster

Construction in WUFI

Exterior side

Interior side
Please note

- Moisture source behind ETICS: 1% of driving rain
- Relevant orientations: Prevailing direction of driving rain and north
- Short wave radiation absorptivity depending on color of exterior plaster
- Long wave radiation emissivity for plaster (if not known: 0.9)
- If the short-term hygrothermal behavior of the outer surface is to be evaluated (e.g. dew position), turn on explicit radiation balance
- “Adhering Fraction of Rain” according to inclination and construction type (vertical wall: 0.7)
Moisture source setup

1. Select layer
2. Select „Sources, Sinks“

*) Driving Rain source is inserted in the outer 5 mm of the layer behind the insulation.
Exterior wall with ETICS

Moisture source setup

3. Select „New Moisture Source“
Exterior wall with ETICS

Moisture source setup

- Fraction of driving rain
Exterior wall with ETICS

Result analysis*

- Check total water content (accumulation of moisture in whole construction); must not keep increasing
- Check water content in the insulation → Possible reduction of insulating capability
- Relative humidity at the interface between exterior plaster and insulation during winter time → risk of frost damage
- At warm and humid sites check relative humidity between insulation and wall (dew water and failure of adhesive may occur)

*) Note: List not necessarily complete. Depending on boundary conditions more critical positions may occur => Check in film display
Exterior wall with ETICS

Additional information

- The prevailing direction of driving rain can be found by using the Climate Analysis dialog (usually west in Middle Europe)

- The moisture source of 1% of the driving rain behind the ETICS is regulated in the ASHRAE Standard 160 and represents critical positions e.g. in the area of window frames
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Ventilated timber frame construction
Basement wall (without ground water)
Exterior wall with interior insulation

1 Facing brickwork
2 Interior plaster or adhesive
3 Interior insulation
4 Vapor retarder
5 Gypsum board
**Exterior wall with interior insulation**

Please note

- Relevant orientations: Prevailing direction of driving rain and north
- Short wave radiation absorptivity depending on color of exterior surface
- Long wave radiation emissivity for exterior surface (if not known: 0.9)
- Explicit radiation balance usually not necessary
- “Adhering fraction of rain” according to inclination and construction type (vertical wall: 0.7)
- If needed: Water-repellent treatment of the exterior surface to reduce rain water absorption
Allowing for the effect of water-repellent treatment on façade materials

Modification of the A-value without influencing other material properties

Step by step:

1) Split the exterior layer into a surface layer (0,5 – 1,0 cm depending on penetration depth of treatment) and the remaining layer. To do this, duplicate the original layer and then adjust the two thicknesses as needed.

2) Edit the material properties of the new exterior layer:
   - Unlock the material
   - Switch “Liquid Transport Coefficients” for suction and redistribution to “generate”
   - Adjust “Water absorption coefficient”
     Be careful with the units: [kg/m²√s] is the A-value in [kg/m²√h] divided by 60 !!!
   - If needed, adjust the μ-value as well
Water-repellent treatment of façades

1. Select exterior layer

2. Duplicate layer
Exterior wall with interior insulation

Water-repellent treatment of façades

3. Select exterior layer

4. Reduce thickness e.g. 0.01 m
5. Select layer

6. Change thickness e.g. original thickness minus 1cm
Water-repellent treatment of façades

7. Double click on layer (or click „Material Data“)
Water-repellent treatment of façades

8. Unlock material

9. Select „Liquid Transport Coefficient, Suction“
Exterior wall with interior insulation

Water-repellent treatment of façades

10. Check „Generate“
Exterior wall with interior insulation

Water-repellent treatment of façades

11. Select „Liquid Transport Coefficient, Redistribution“

12. Check „Generate“
13. Enter A-value:
In this case:
0,5 kg/m²√h / 60 
= 0,00833 kg/m²√s
Exterior wall with interior insulation

Result analysis*

- Check total water content (accumulation of moisture in whole construction); must not keep increasing

- Relative humidity at the interface between interior plaster and interior insulation < 95 % r.F.
  → risk of frost damage
  → or: frost-resistance of materials necessary
    (Insulation system plaster, wall materials)

*) Note: List not necessarily complete. Depending on boundary conditions additional critical positions may occur => Check in film display
**Additional information**

- An interior insulation reduces the drying potential of a construction due to a lower over-all temperature and a higher diffusion-resistance to the interior side.

- The moisture content at the interface interior plaster / interior insulation usually can be reduced by an enhancement of the protection against driving rain (e.g. by water-repellent treatment, new exterior plaster, paint coat).

- The WTA recommendations* for interior insulation only allow a 50% increase of the $s_d$-value of a surface with a water-repellent treatment.

- Investigations of an exposed masonry need the knowledge of effective material properties, combining the properties of bricks and mortar.

- A gypsum plaster at the interior surface usually has to be removed before applying an interior insulation.

- Smart vapor retarders are favorable since the drying potential to the inside mainly remains unaffected.

*) WTA-Merkblatt 3-17/D - *Hydrophobierende Imprägnierung von mineralischen Baustoffen*
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Exterior wall with ETICS
Exterior wall with interior insulation
**Ventilated timber frame construction**
Basement wall (without ground water)
Ventilated timber frame construction

Construction drawing

1 Planking
2 Battens
3 Counter battens
4 External cladding
5 Insulation
6 Internal Cladding
7 Vapour retarder
8 Gypsum board

Construction in WUFI

Exterior side

Interior side
Please note

- Insert Air Change Source in air layer
  → The exchange rate is dependent on construction, surface color and ventilation openings

- Relevant orientation: usually north

- Short wave radiation absorptivity depending on color of surface

- Long wave radiation emissivity depending on material of surface

- If the short-term hygrothermal behavior of the outer surface is to be evaluated (e.g. dew position), turn on explicit radiation balance

- “Adhering fraction of rain” according to inclination and construction type (vertical wall: 0.7)
1. Select air layer
2. Select „Sources, Sinks“
Air change source setup

3. Select „New Air Change Source“
Ventilated timber frame construction

Air change source setup
Ventilated timber frame construction

**Result analysis**

- Check total water content (accumulation of moisture in whole construction); must not keep increasing
- Check water content in the external cladding
- If necessary check moisture content of the insulation

*) Note: List not necessarily complete. Depending on boundary conditions additional critical positions may occur => Check in film display
Ventilated timber frame construction

Additional information

- As the occurring air exchange rates are often not known, it may be useful to vary the air exchange rate to see its influence on the hygrothermal behavior of the construction.
  (Air exchange rates are usually between 10 and 200 l/h)
Flat roof
Pitched Roof
Exterior wall with ETICS
Exterior wall with interior insulation
Ventilated timber frame construction
Basement wall (without ground water)
Basement wall (without groundwater)

Construction section

1 Perimeter insulation (XPS)
2 Concrete wall
3 Interior plaster

Construction in WUFI

Exterior side

XPS Core
XPS Surface skin

Interior side
Basement wall (without ground water)

Please note

- Heat transfer resistance „Basement“
- No radiation absorptivity / emissivity
- No rain water absorption
- Outdoor Climate: Soil temperature from the climate „Holzkirchen-IBP, Year 1991“, relative humidity constant 99 % or 100 %
- Indoor climate depending on utilization
Using soil temperatures

1. Select climate file „Holzkirchen; Fraunhofer-IBP; Year 1991“
2. Select „Details…“
Using soil temperatures

3. Select ground temperature at 50 cm or 1 m depth

4. Enter Constant Relative Humidity of 99 % or 100 %
Basement wall (without groundwater)

**Result analysis***

- Check total water content (accumulation of moisture in whole construction); must not keep increasing
- Check water content of insulation
- Check water content in masonry / concrete

*) Note: List not necessarily complete. Depending on boundary conditions additional critical positions may occur => Check in film display
The climate file from Holzkirchen 1991 contains measured temperatures in the ground at 50 cm and 100 cm depth. Furthermore one can use temperature values from the literature and implement them as sinusoidal curve.

If the interaction between soil and construction is of interest, the soil has to be implemented as material layer (using appropriate assumptions).

The XPS perimeter insulation consists of core and outer surface skins.