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Field Test on Two Interior Insulation Systems with Large Thickness - Influence of Orientation and Airtightness

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Presentation Agenda

- Background
- Research Questions
- Experimantal Setup
- Measurment Results
- Simplified Simulation Study
- Conclusions

Background

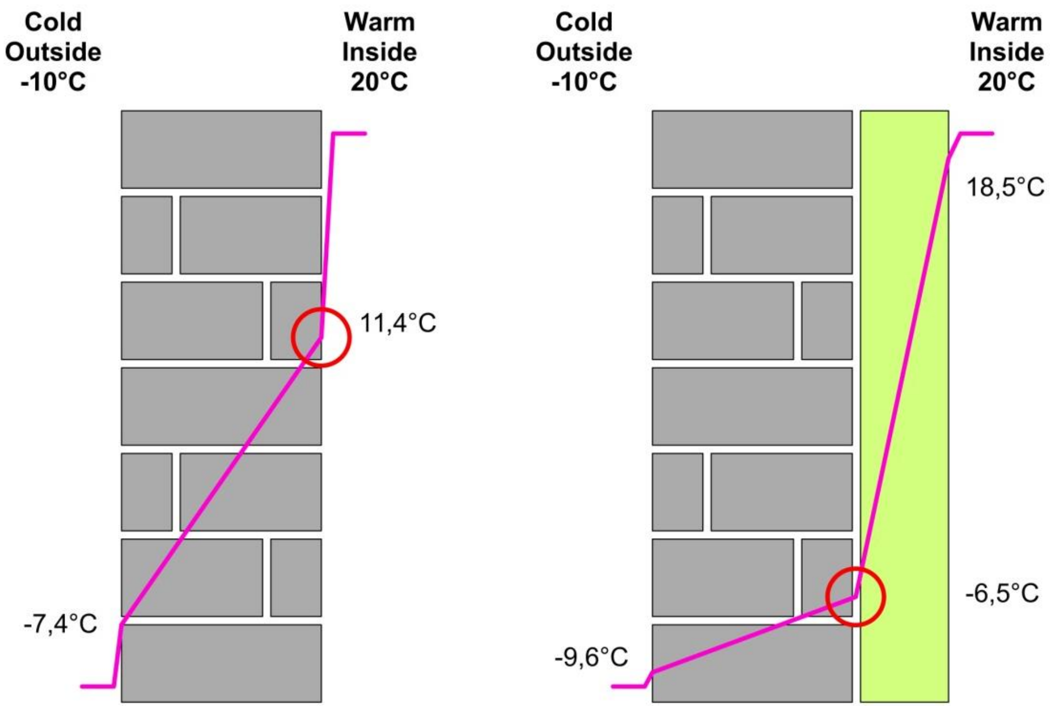
- Interior insulation is used for historical buildings mainly

Source: www.stadtbild-deutschland.org

Carl-von-Ossietzky-Straße, Görlitz, Germany

Background

- Temperature at old masonry decreses → drying is reduced
- Between masonry and insulation, moisture shloud ≤95%RH
- Large insulation thickness + low thermal resistance of the old masonry are more critical

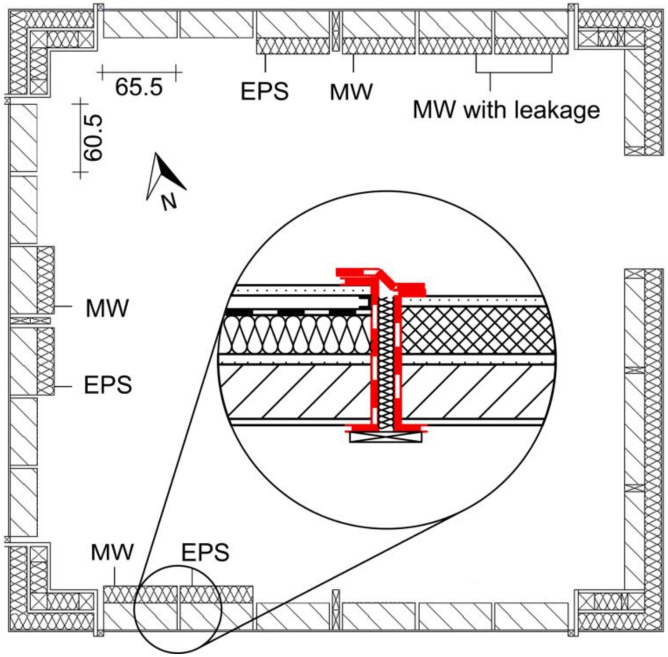


Research Questions

- Did the thermal and moisture performance of inside insulation systems work:
  - in large thickness?
  - at low thermal resistance of masonry?
  - under field conditions?
- Effects of orientation (e.g. wind-driven rain or solar radiation)?
- Effects of small leaks in vapor retarder?
- Measured data confirms to a simplified simulation model?

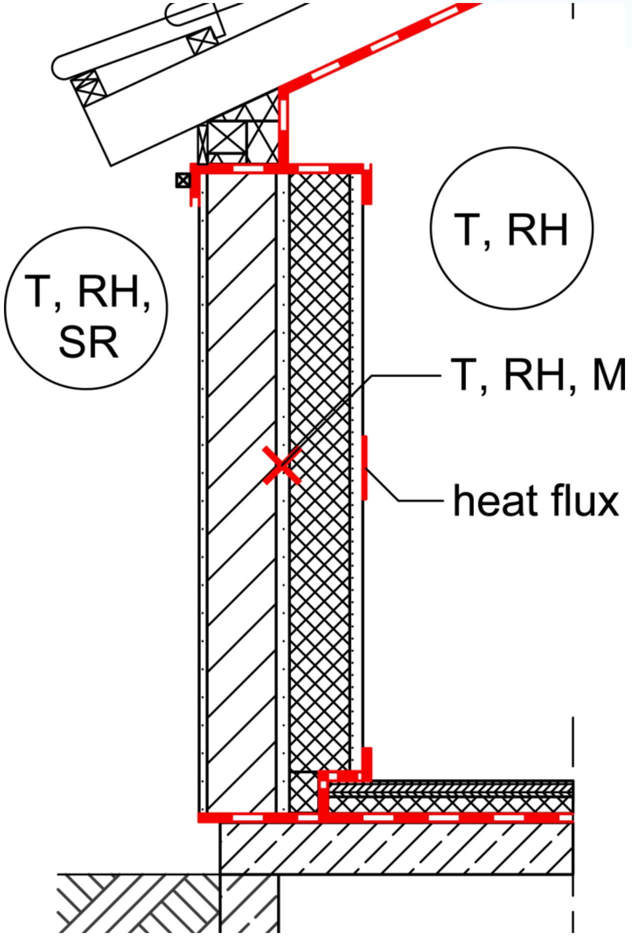
Experimental Setup - Test House

- Testhouse with seperated wall sections
- EPS (200mm) and mineral wool (160 mm) interior insulation systems
- Two mineral wool systems with leaks in the vapor retarder
- Testperiod from 10-2014 to 10-2016



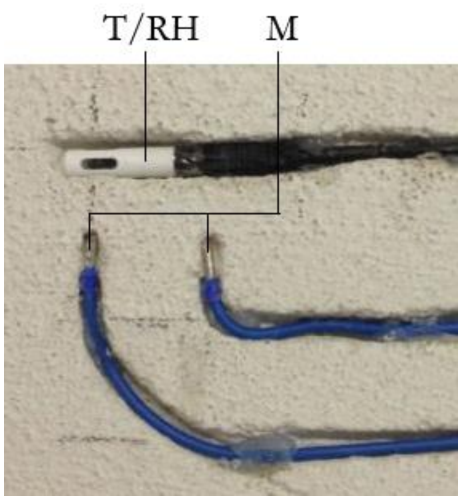
Experimental Setup - Test House

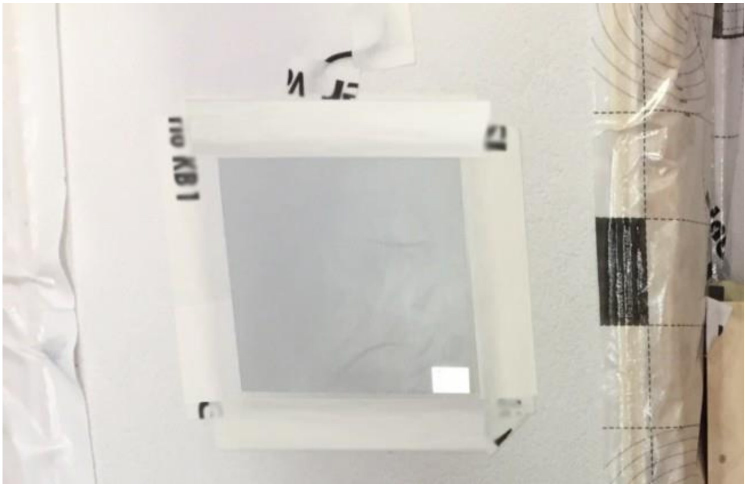
- Hollow block concrete masonry, plastered on both sides
- The room conditions was controlled by air conditioning system



Experimental Setup - Sensors

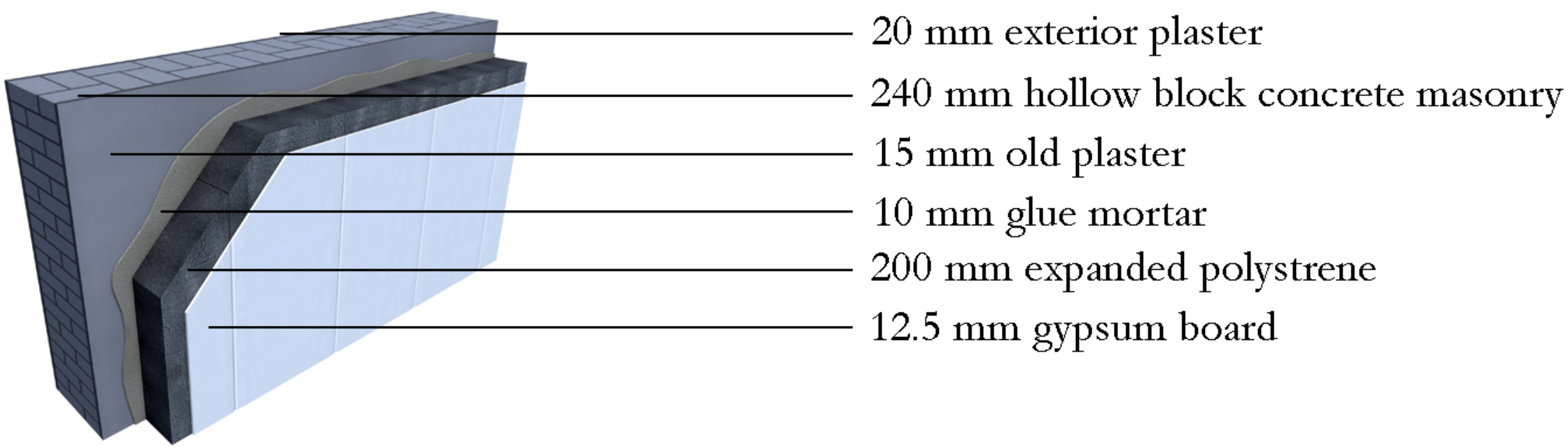
- Outdoor climate: Temperature, Relative Humidity, Diffuse and Direct Solar Radiation
- Room climate: Temperature and Relative Humidity
- Insulation Sytems: Heat Flux, Temperature, Relative Humidity and Moisture Content (electric conductivity)





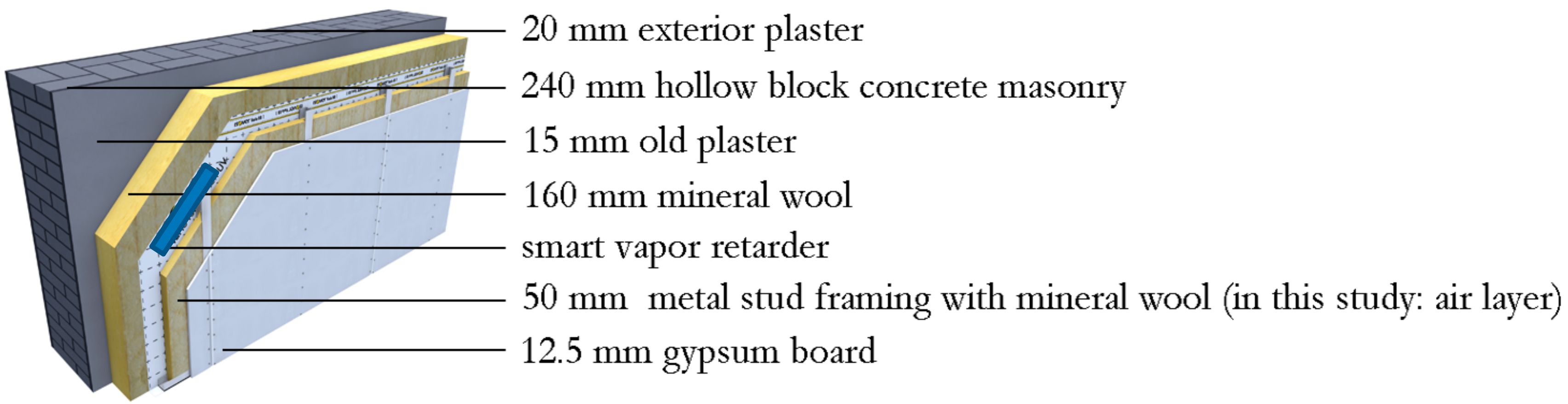
Experimental Setup - EPS System

- Expanded polystyrene (EPS) inside insulation system
- 200 mm EPS, $\lambda = 0.032\ W \cdot m^{-1} \cdot K^{-1}$
- Fix $s_{d,i} = 10\ m$
- Heat transfer coefficient $U = 0.15\ W \cdot m^{-2} \cdot K^{-1}$



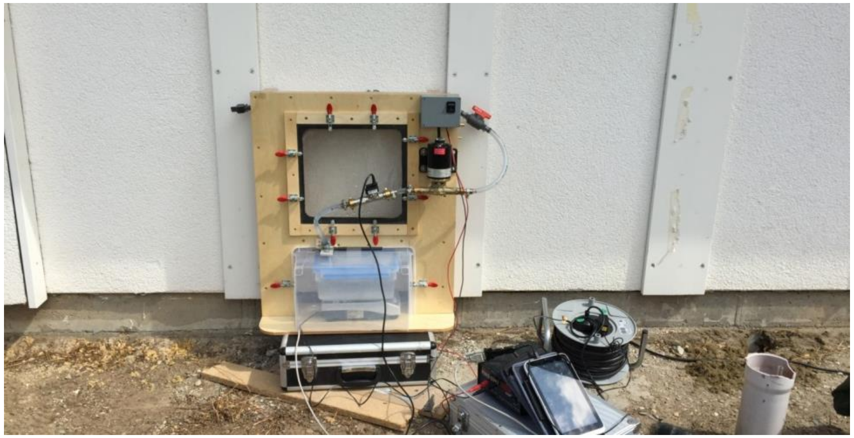
Experimental Setup - Mineral Wool System

- Mineral wool (MW) inside insulation system
- 160 mm mineral wool, $\lambda = 0.032\ W \cdot m^{-1} \cdot K^{-1}$
- Polyamide vapor retarder with variable $s_{d,i} = 0.5 \ldots 25$ m
- Heat transfer coefficient $U = 0.17\ W \cdot m^{-2} \cdot K^{-1}$



Experimental Setup - Wind Driven Rain (WDR)

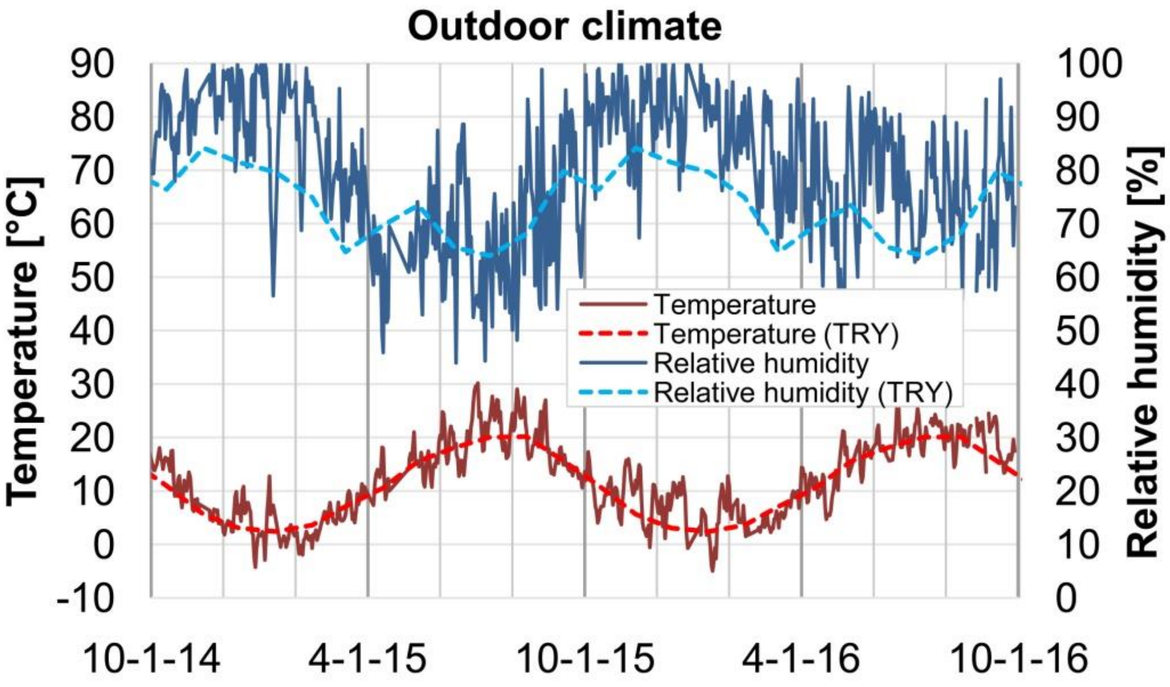
- Effects of WDR are neglected in this study
  - External plaster with an high WDR-resistance
  - Single-story test building + medium WDR loads
  - Waterabsorption coefficient of the plaster material was controlled by in situ technology[1)]



1) Stelzmann, M., Möller, U. and R. Plagge. 2015. Water-Absorption-Measurement instrument for masonry façades, in: ETNDT6, Emerging Technologies in NonDestructive Testing 6, 27-29 May 2015, Brussels, Belgium

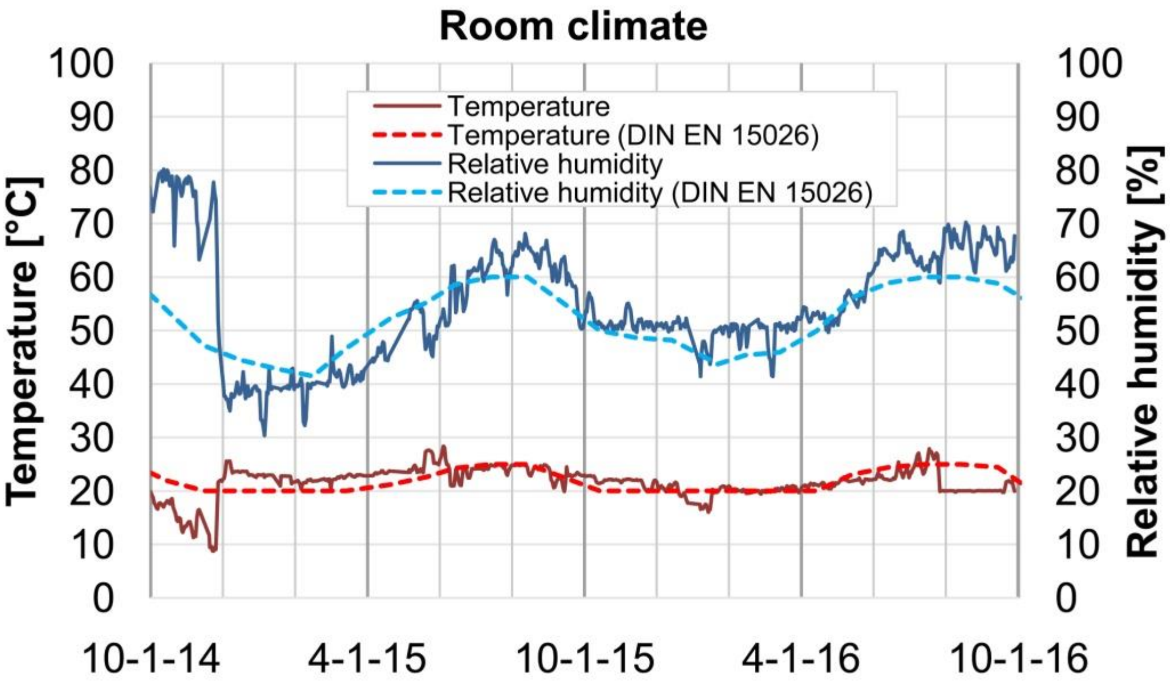
Measurment Results - Boundary Conditions

- Outdoor climate follows Test Reference Year data for the region (TRY12, Mannheim, Germany)



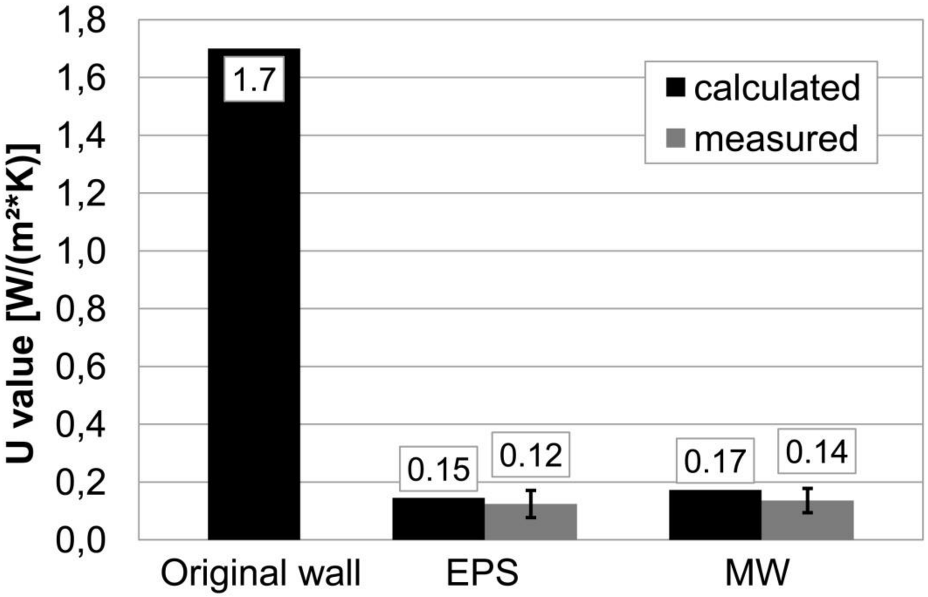
Measurment Results - Boundary Conditions

- Room climate follows the standard for hygrothermal simulation (EN15026, normal moisture load)



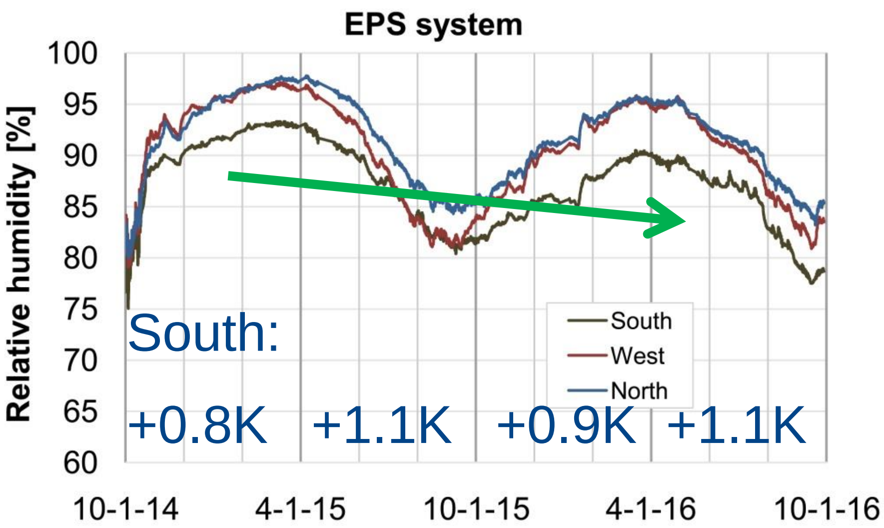
Measurment Results - Thermal Resistance

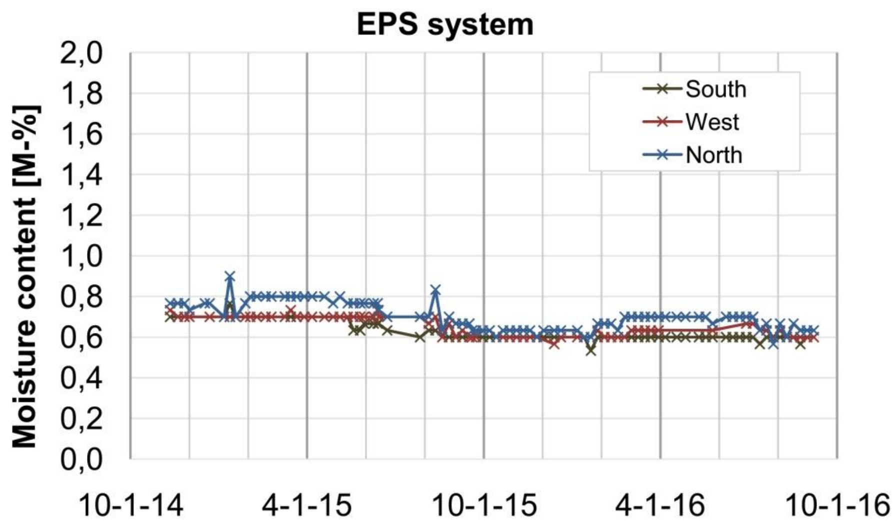
- 24cm hollow block concrete masonry U = 1.7 $W \cdot m^{-2} \cdot K^{-1}$
- Transmission heat loss is reduced to ≤10%
- Results of heat flow measurement matches to calculations



Measurment Results - Influence of Orientation - EPS System

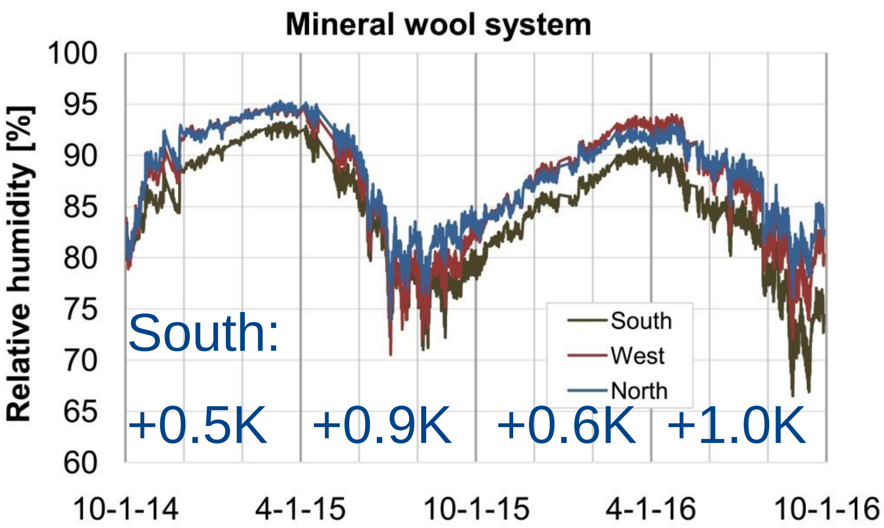
- 95%RH exceeded in 1st and reached in 2nd year at North and West
- Orientation South stays permanently ≤95%RH (+1,0K , -5%RH)
- Moisture content shows low level and little peaks in both winter
- Drying trend for whole period (installation moisture)

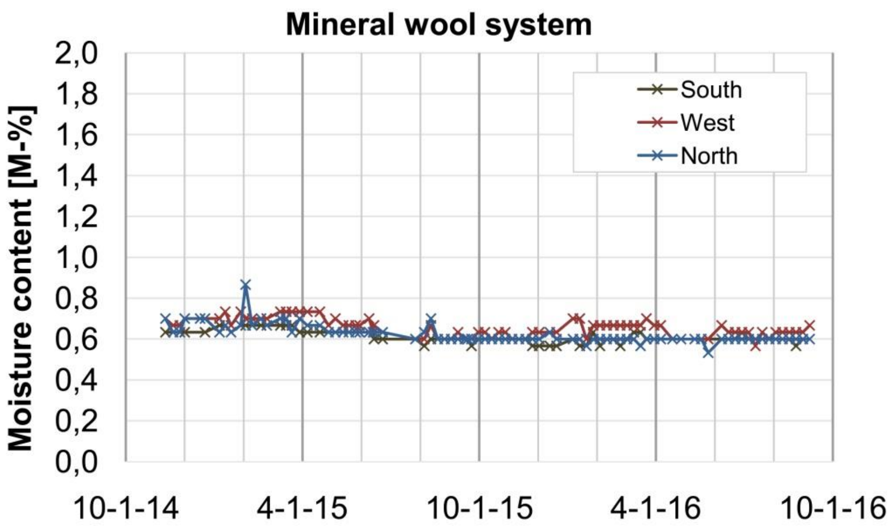




Measurment Results - Influence of Orientation - Mineral Wool Sys.

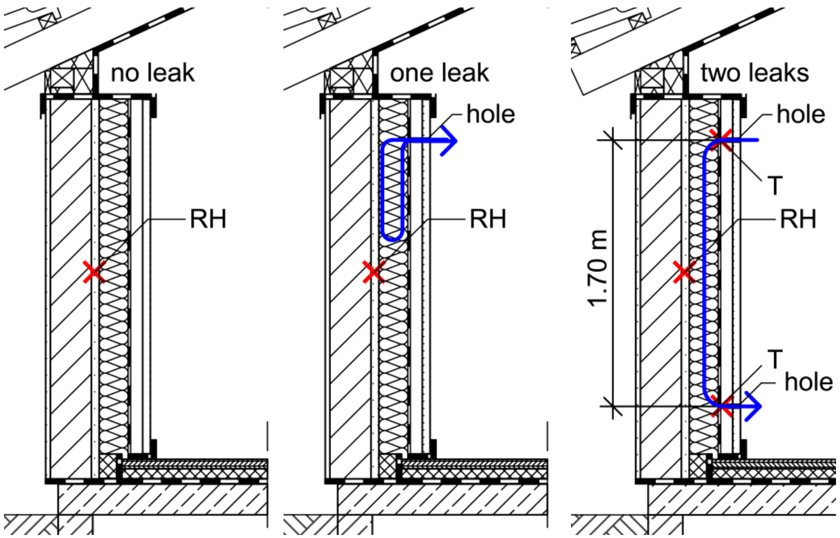
- 95%RH reached in 1st year at North and West (South +0,7K, -3%RH)
- Smart vapor retarder: high s_d in wetting period (low scattering) and low s_d in drying period (high scattering)
- Drying trend from 1st to 2nd year

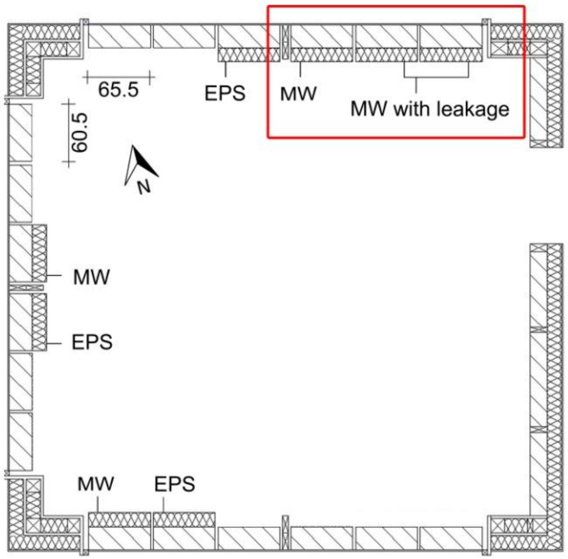




Experimental Setup - Leaks in smart vapor retarder

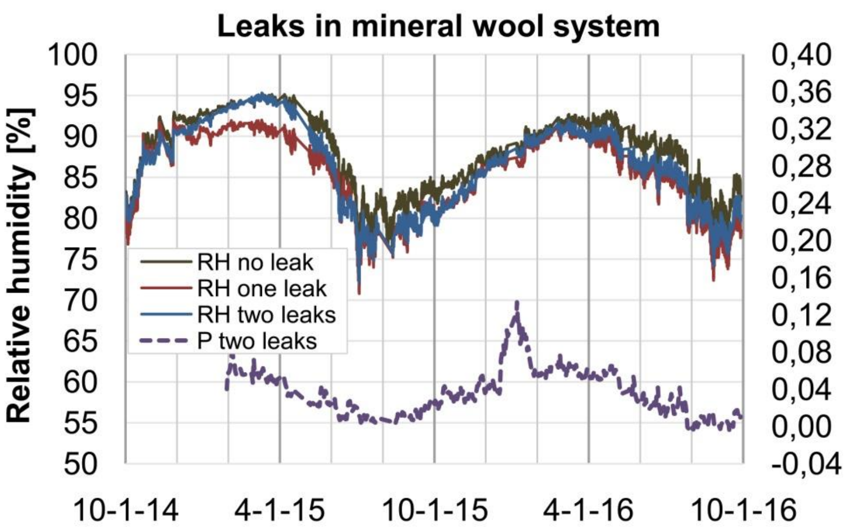
- Three setups were tested: no leak, one leak, two leaks (Ø 5mm)
- Orientation North
- The potential of thermal stack was approximated by temperature differences

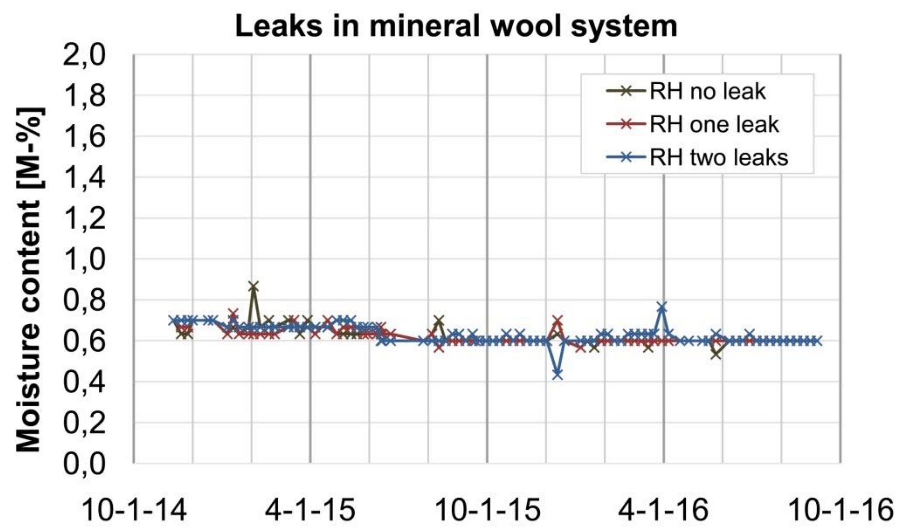




Measurment Results - Leaks in smart vapor retarder

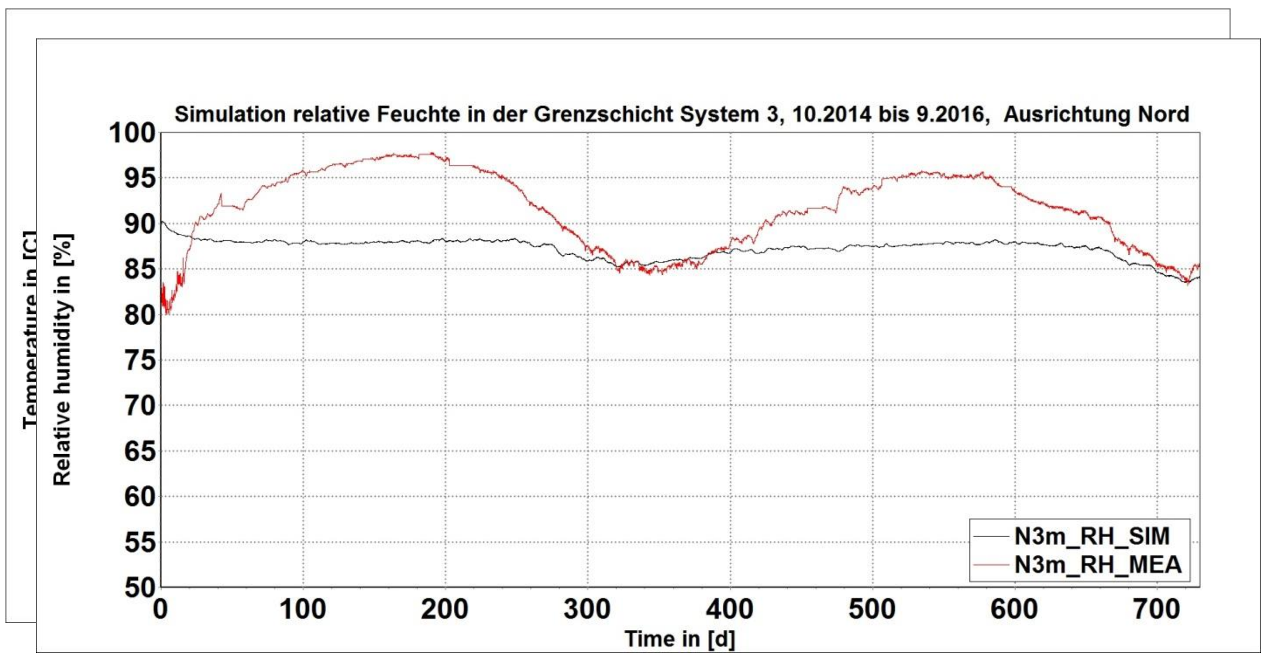
- Start effects in 1st year
- In 2nd year, variants behaves similar
- Pressure difference (by thermal stack) between holes were low





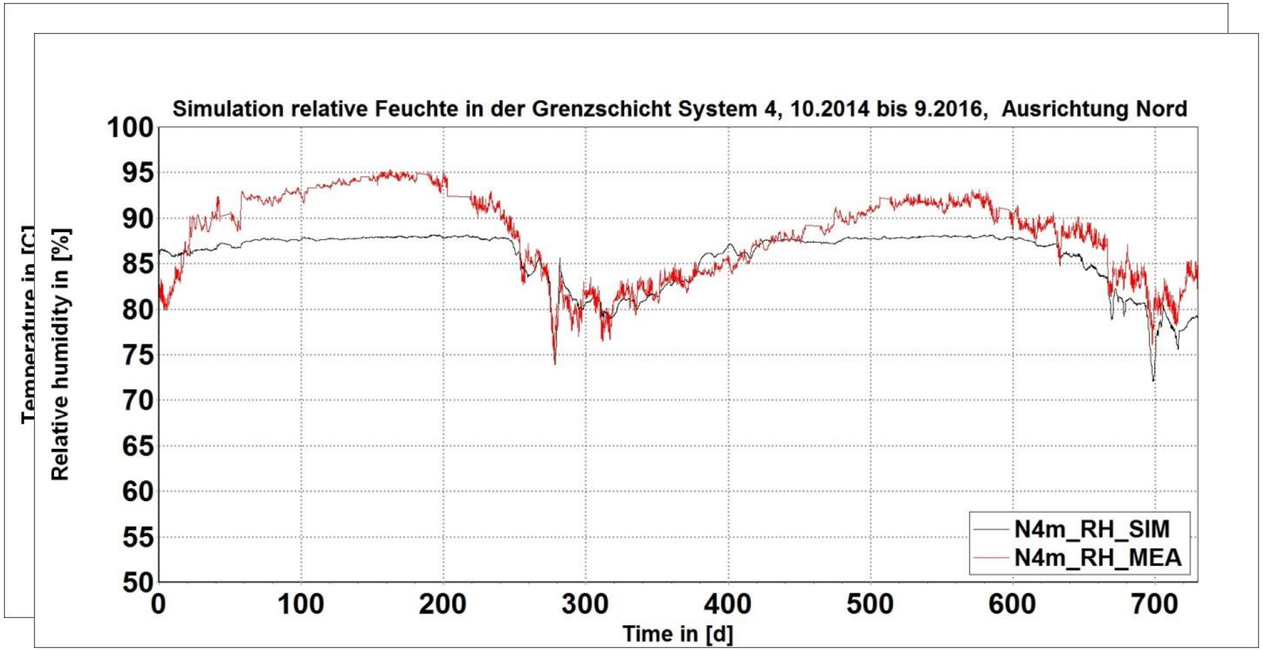
Simulation Study - EPS system

- Simplified simulation model
- Onedimensional mode, no material data measured, no WDR-data
- Orientation North, measured boundary conditions inside and outside
- Poor correlation



Simulation Study - Mineral wool system

- Simplified simulation model
- Onedimensional mode, no material data measured, no WDR-data
- Orientation North, measured boundary conditions inside and outside
- OK correlation



Conclusions

- Both interior insulation systems work in field
- Fragile stability of hygrothermal behavior
- Additional moisture (e.g. by rising moisture, WDR, thermal bridges) =moisture problems
- Solar radiation had an impact to drying potential
- Plastered masonry (WDR+airtight) / using smart vapor retarder leads to a higher level of protection

Thank you – Comments and Questions are welcome!