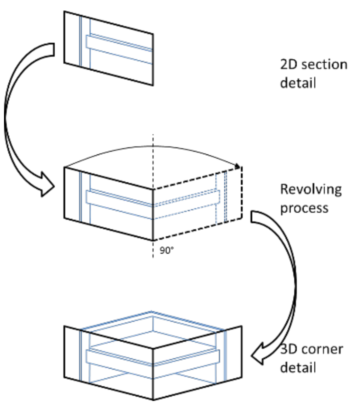

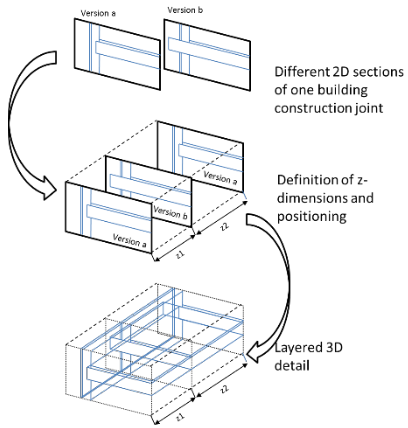

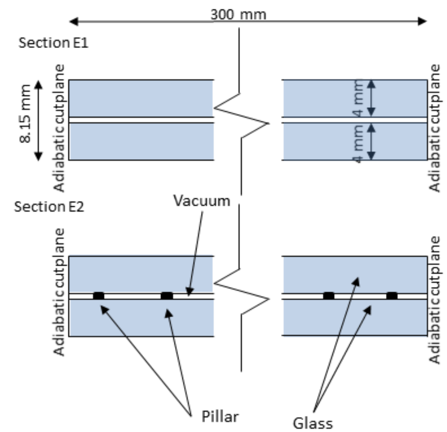

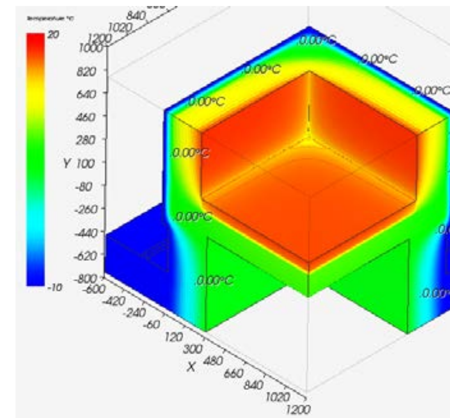

#75 – A comparison of the performance of two- and three-dimensional thermal bridge assessment for construction joints

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Building physics TU WIEN Building ecology

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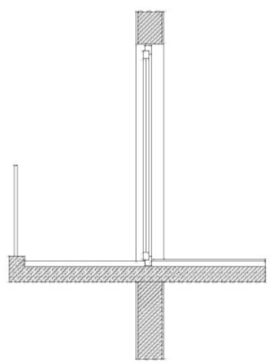
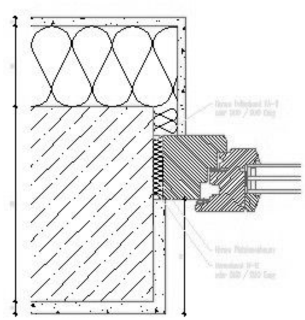
Introduction & Research Objective

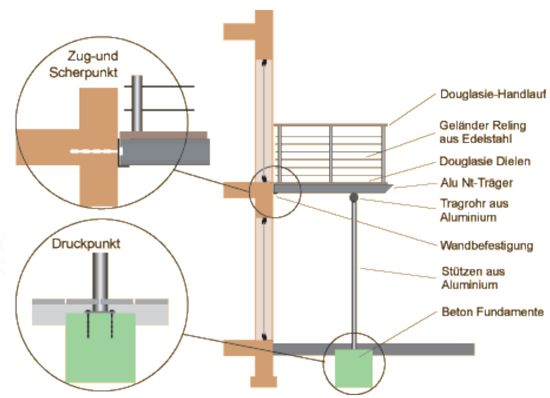
Thermal bridges

- Geometry-based | material-based | combinations
- Negative consequences
  - Mold growth
  - increased thermal transmittance
  - Comfort issues
  - Destruction (worst case)

- 2D / 3D







Introduction & Research Objective

2 common (Research / Planners) questions:

- How do typical details perform, given the large range of thermal properties of applied materials?
  - catalogues such as OENORM B 8110-7, baubook, ..
  - Definite material decision often late in planning process
  - Public competitions
  - Detail catalogues lack thermal bridge information
- How does the performance of the 3D-thermal bridges compare to their constituent 2D-details, and is it possible to use 2D results to approximate the results of 3D thermal bridges?
  - Effort vs quality of results

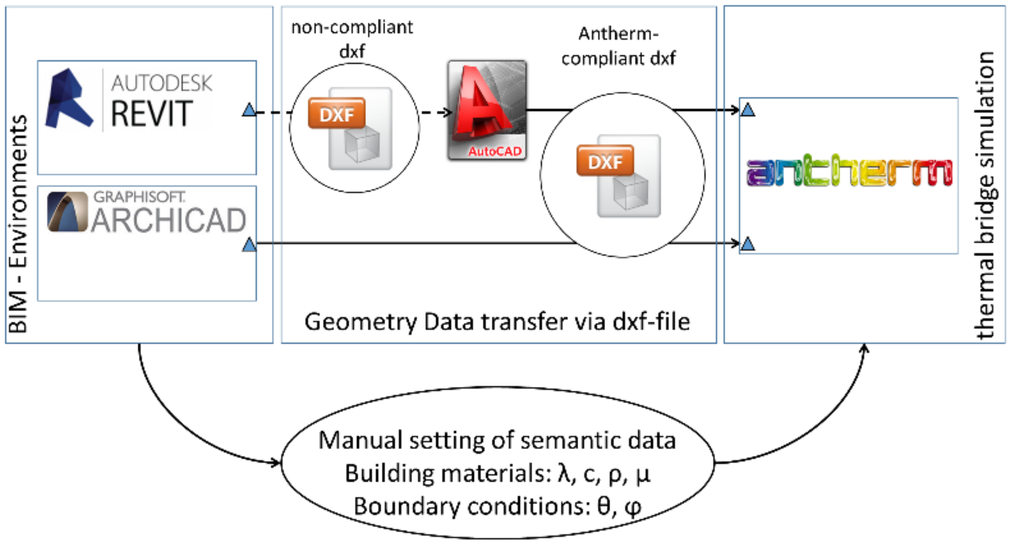
Introduction & Research Objective

2 common (Research / Planners) questions:

- To be assessed via
  - Numeric thermal bridge simulation
  - Typical building assembly joints
  - Ranges of input data (Lambda-values)
  - Considering typical boundary conditions

Methodology: Used tools

- CAD: Draftsight
- Numeric thermal bridge assessment: AnTherm 8.132 (www.antherm.eu)
- Yesterday's presentation on workflow



Methodology: Material properties | boundary conditions | scenarios

Material properties: taken from OENORM B 8110-7

- Min, Max, average values derived from standard

Boundary conditions:

- Inside spaces: 20 C
- Outside spaces: -10 C
- Unconditioned spaces: 5 C

ID / Hatch	Name	Min. λ [W.m⁻¹.K⁻¹]	Max. λ [W.m⁻¹.K⁻¹]	Average λ [W.m⁻¹.K⁻¹]
1	Flexible insulation	0.031	0.066	0.049
2	Rigid insulation	0.031	0.066	0.049
3	Concrete (reinforced)	2.300	2.500	2.400
4	Masonry (<30 cm)	0.230	0.577	0.404
5	Masonry (≥30 cm)	0.089	0.130	0.110
6	Insulated wall element	0,230	0,577	0,404
7	Plaster (inside)	0.180	0.570	0.375
8	Plaster (outside)	0.120	1.050	0.585
9	Screed	0.470	1.580	1.025
10	Foil	0.130	0.400	0.265
11	Water proofing	0.130	0.400	0.265
12	Perimeter protection	0.100	0.500	0.300
13	Soil / gravel	1.500	2.000	1.750
14	Natural stone element	0.120	6.000	3.060
15	Glass	1.000	1.000	1.000
16	(Stainless) Steel	30.000	50.000	40.000
17	Timber	0.110	0.240	0.175
18	Vacuum	0.00001	0.00001	0.00001

Methodology: Material properties | boundary conditions | scenarios

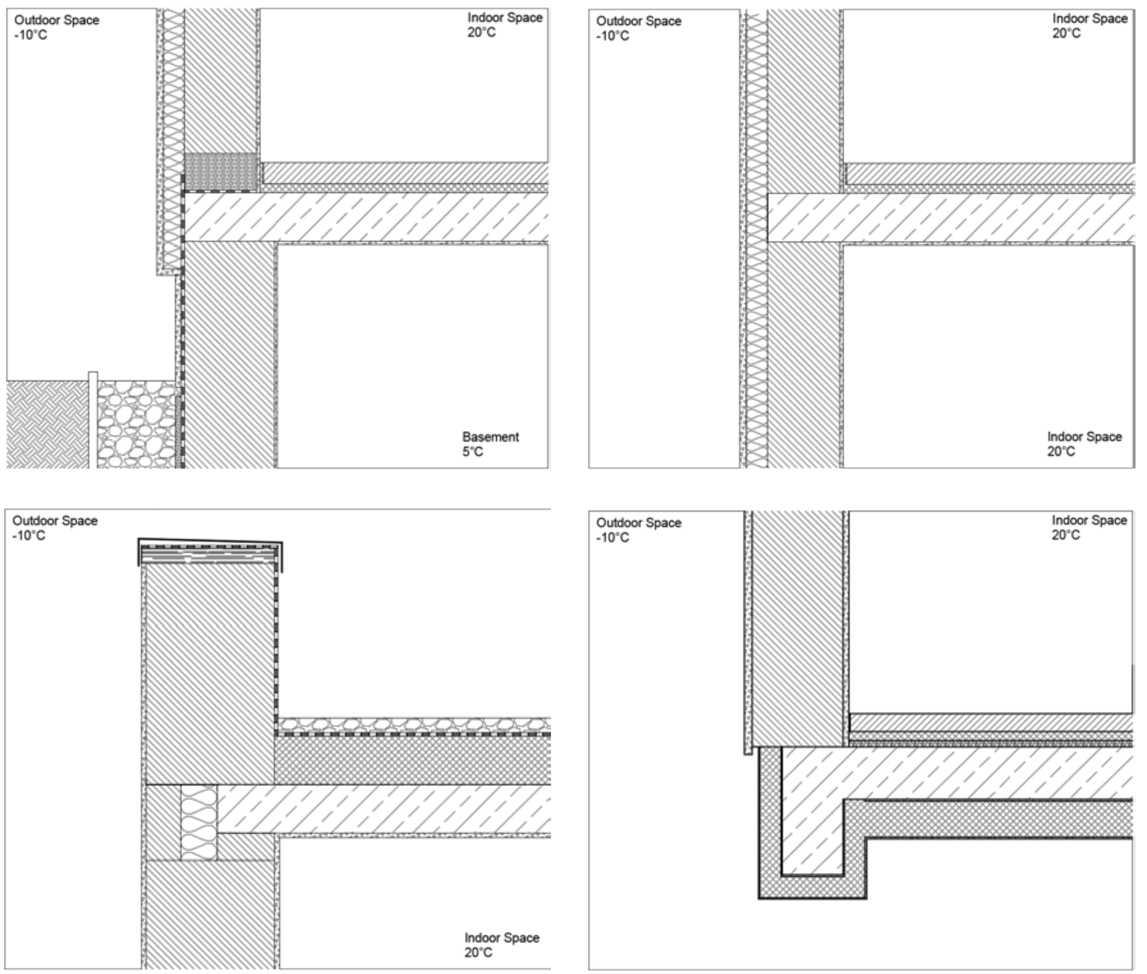
Scenarios:

Scenario	Description
S1	All conductivities set to minimum
S2	All conductivities set to maximum
S3	All conductivities set to average
S4	As S3, but insulation materials set to min.
S5	As S2, but insulation materials set to min.

All Scenarios are applied to 2D & 3D assessment

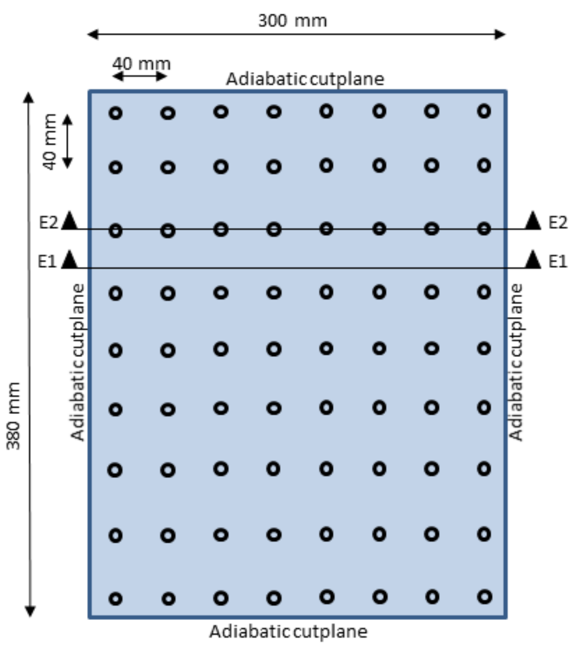
Methodology: Example building construction joints

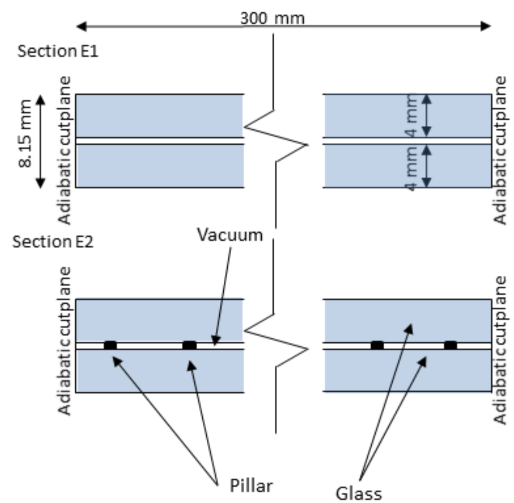
A – D (taken from building construction literature)



Methodology: Example building construction joints

E (taken from a vacuum glazing/window project)





Methodology: 2D vs 3D (Transfer 2D ➔ 3D)

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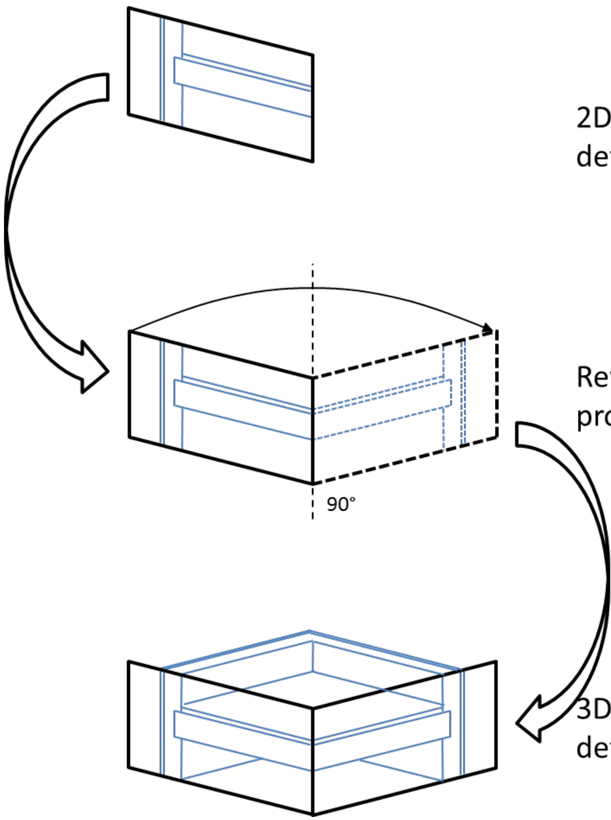
Revolving (Detail A,B,C,D)

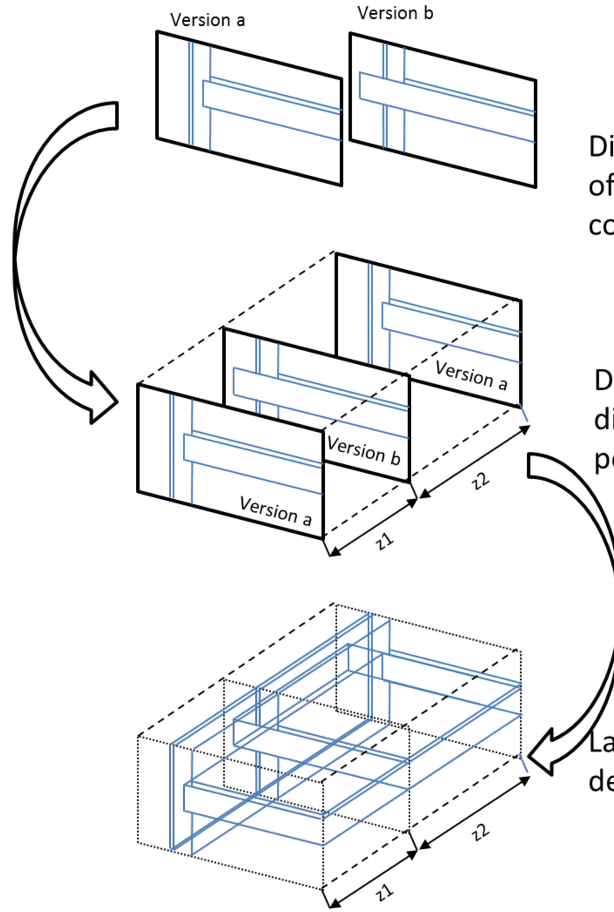


2D section detail

Revolving process

3D corner detail

Layering (Detail E)



Different 2D sections of one building construction joint

Definition of z-dimensions and positioning

Layered 3D detail

Methodology: Simulation Settings & Indicators

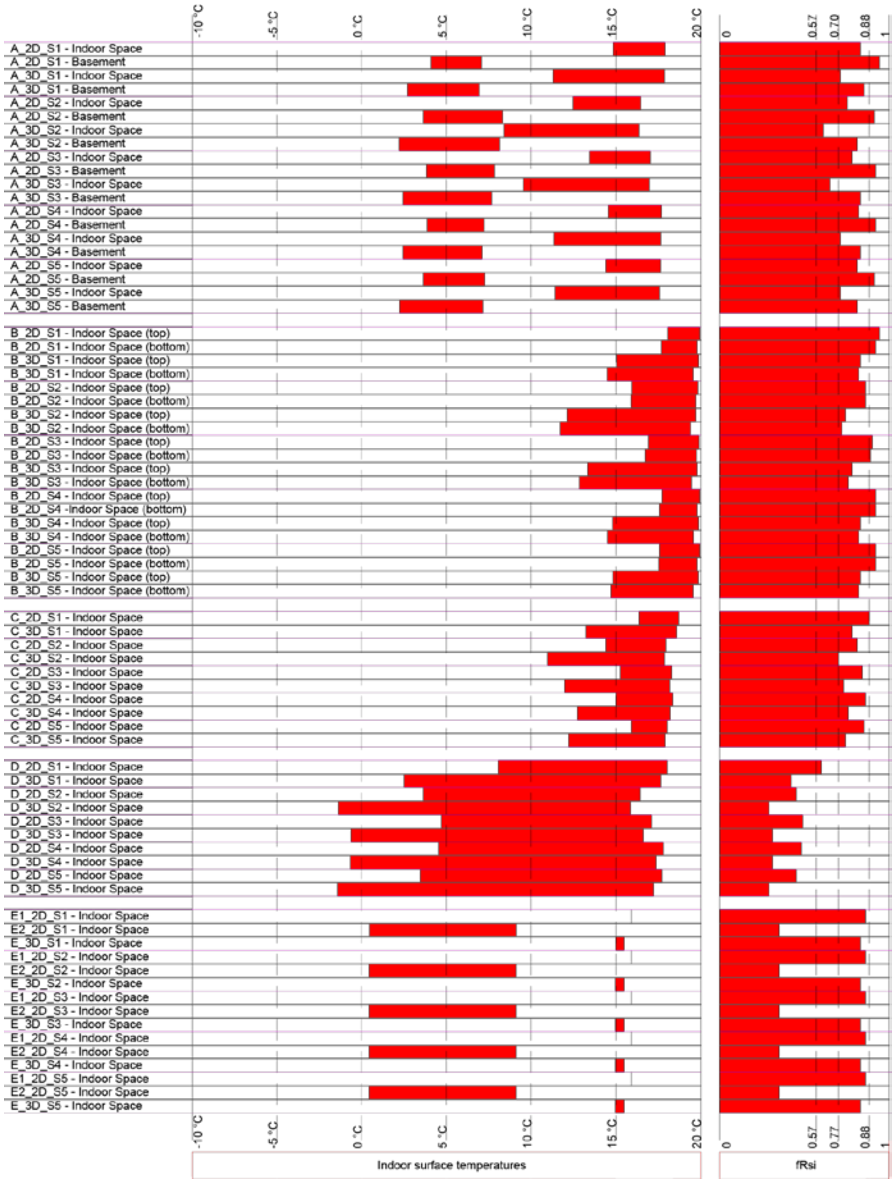
Simulation settings:

- Minimum cell size 5 mm (A-D), 0.02 mm (E)
- Adiabatic cut planes
- Dimensions following EN ISO 10211

Indicators:

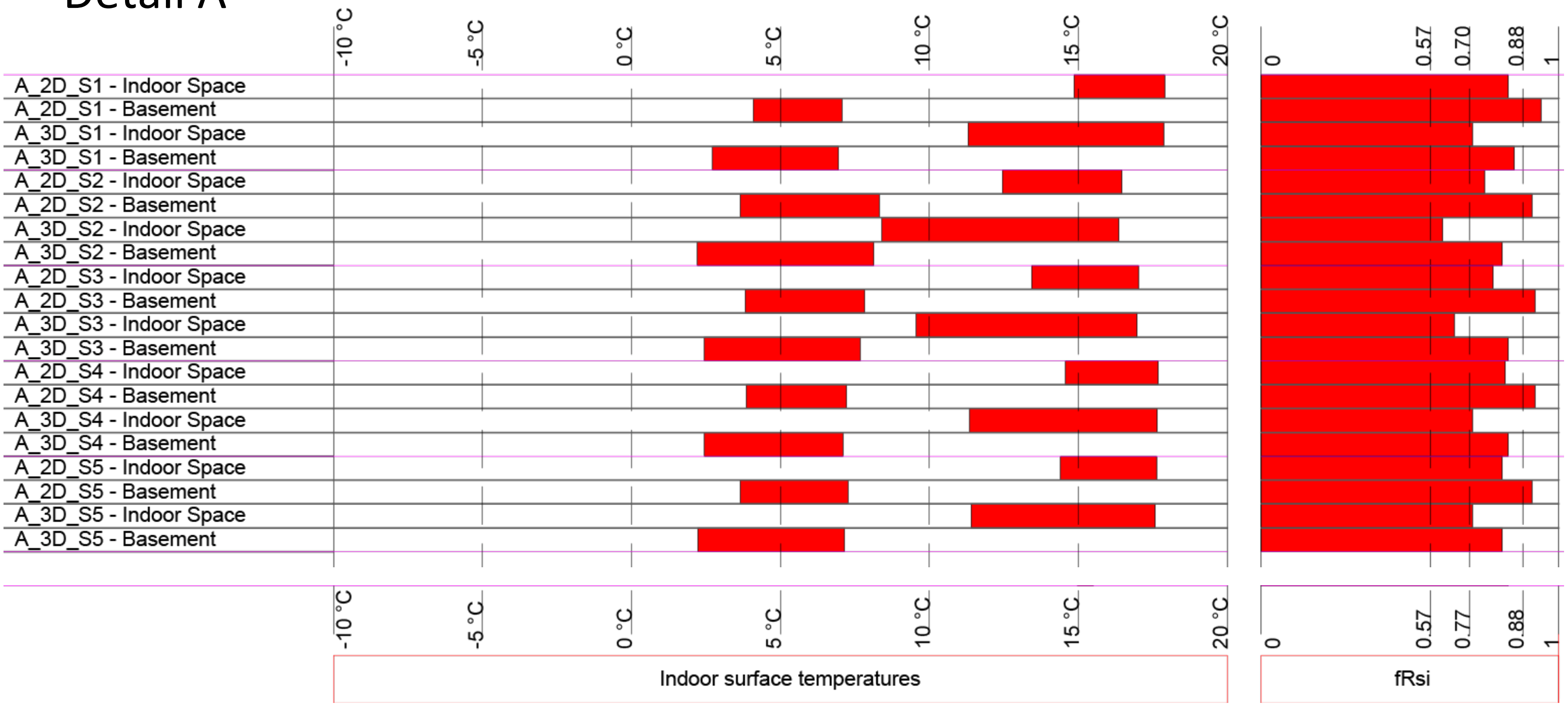
- Temperature & Saturation rela. Humidity
- f_{Rsi} $$f_{Rsi} = \frac{\theta_{si} - \theta_e}{\theta_i - \theta_e} \; [-]$$
- L_{2D} / L_{3D} $$L^{2D} = \frac{Q}{\theta_i - \theta_e} [W.m^{-1}.K^{-1}] \qquad L^{3D} = \frac{Q}{\theta_i - \theta_e} [W.K^{-1}]$$
- Heatflow Q

Results & Discussion



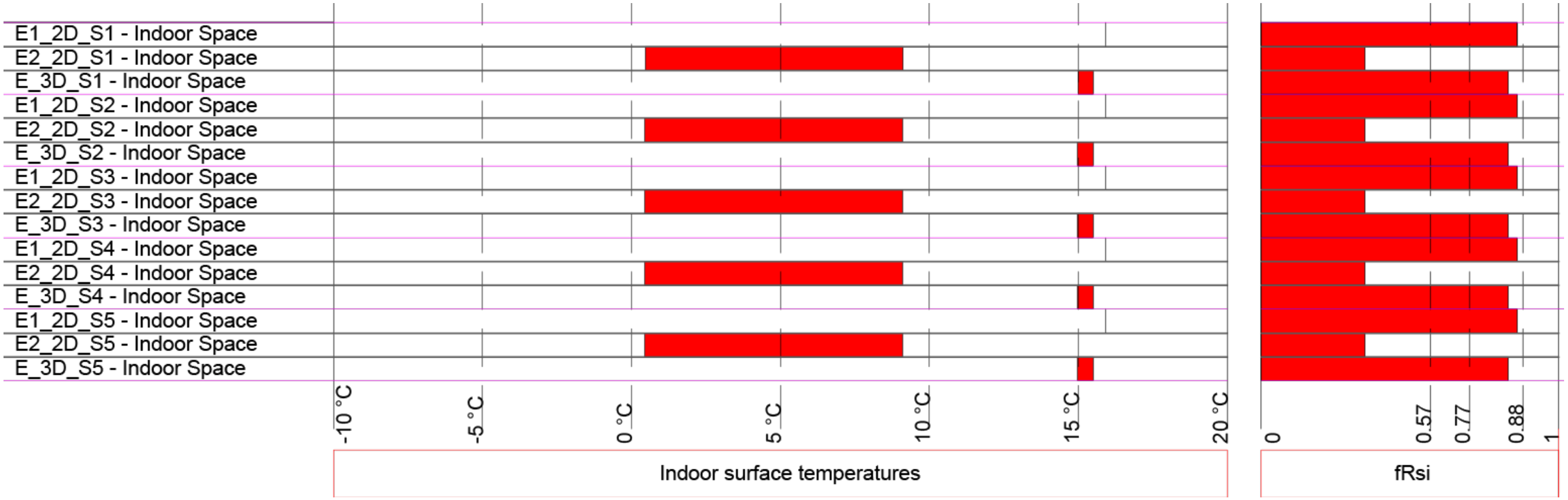
Results & Discussion

Detail A



Results & Discussion

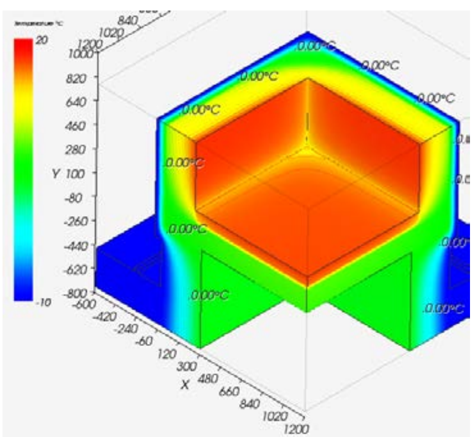
Detail E

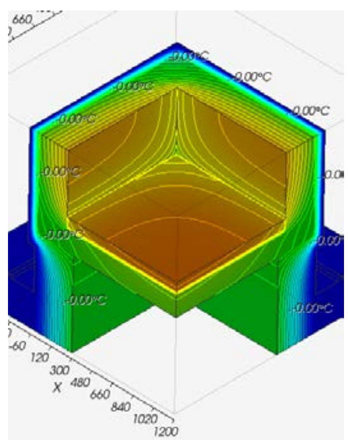


Results & Discussion

Conductivity assumptions:

- 2D simulation $\Delta\Theta_{si}$ 1.77 – 4.43 K
- 3D simulation $\Delta\Theta_{si}$ 2.28 – 3.88 K
- 2D: rel. Δf_{Rsi} 7 – 25%
- 3D: rel. Δf_{Rsi} 10 – 31%
- Partly crossing thresholds (same detail, different Lambda assumptions)



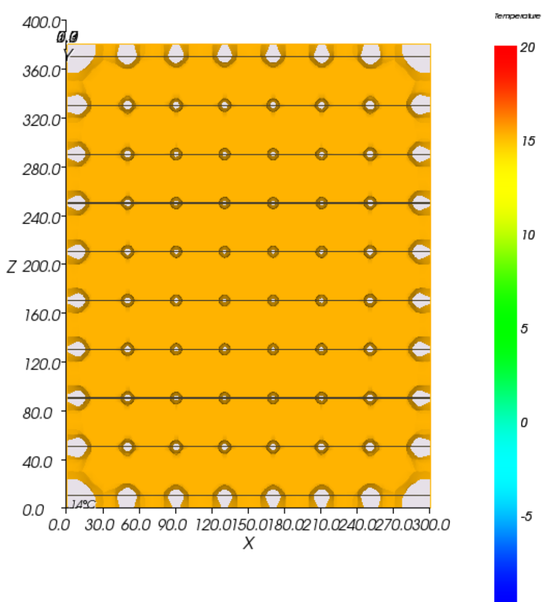


Results & Discussion

2D versus 3D:

- A-D (corner situation) $\Delta\Theta_{si}$ 2.74 – 5.58 K

- E (layered construction)
  - 2D without pillars close to 3D Layered but far away from 2D with Pillars

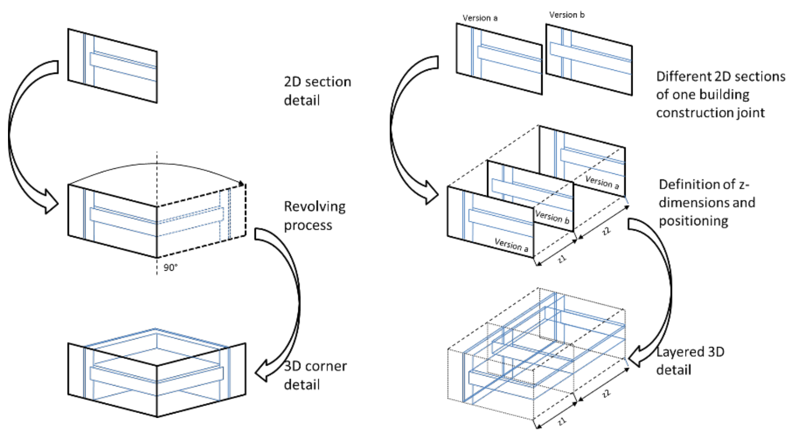


Conclusion & Future Research

- Conductivity assumptions can have impact on functionality of a building construction detail
- 3D situations should not be approximated via 2D in corner situations
- Small breakthroughs in large area constructions might be not as critical as corner situations.

Future Research:

- Humidity / diffusion processes
- Transient processes regarding properties (decay of thermal insulation in case of condensation) & boundary conditions (storage effects)
- ➔ long run: coupling with CFD/convection routines.



!Thank you for your attention!

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