

## *Session III. Building physics*

### **Insulation of buildings:**

- differences of different insulation materials;
- avoiding thermal bridges.

Dr.sc.ing.Anatolijs Borodiņecs

Riga Technical University, Latvia

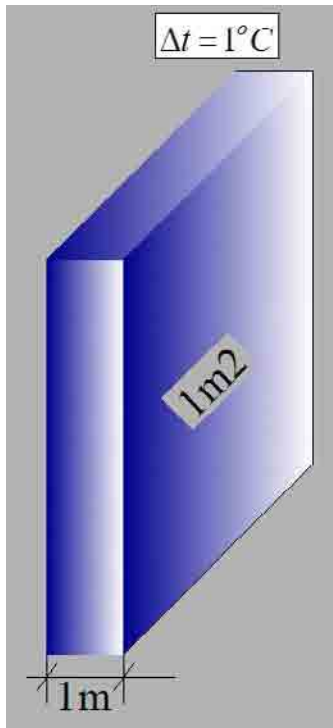
# Insulation materials

- Stone wool
- Glass wool
- Expanded polystyrene foam (EPS)
- Extruded polystyrene foam (XPS)
- Cellulose fibre insulation
- Polyurethane foam
- Foamglas
- .....
- .....



# Thermal conductivity, $\lambda W/mK$

- is the property of a material that indicates its ability to conduct heat;
- Thermal conductivity is measured in watts per kelvin per meter.



Material	Thermal conductivity, $\lambda W/mK$
Reinforced concrete	2.0
Brick wall	0.52 – 0.87
Wood	0.07 – 0.24
Insulation materials	<0.04

$$\lambda = \lambda d + \Delta \lambda w \quad W/(m \times K)$$

# Correction coefficient $\Delta\lambda_w$ W/(m × K)

Insulation material	Expluatation conditions of insulation materials		Standard
	Ventilated $\Delta\lambda_w$ (W/mK)	Non-ventilated $\Delta\lambda_w$ (W/mK)	
Stone wool, glass wool: $R_a \leq 6 \text{ kPa} \times \text{s} \times \text{m}^{-2}$	0,006	0,008	LVS EN 13162:2003
Stone wool, glass wool: $R_a > 6 \text{ kPa} \times \text{s} \times \text{m}^{-2}$	0,001	0,002	LVS EN 13162:2003
Blowing wool : $R_a \leq 6 \text{ kPa} \times \text{s} \times \text{m}^{-2}$	0,008	should not be used	
Blowing cellulose $\rho > 25 \text{ kg/m}^3$ ( $R_a > 6 \text{ kPa} \times \text{s} \times \text{m}^{-2}$ )	0,008	should not be used	
Blowing cellulose $\rho = 35\text{--}75 \text{ kg/m}^3$ $\rho(R_a > 6 \text{ kPa} \times \text{s} \times \text{m}^{-2})$	0,008	0,02	
Extruded polystyrene	0,001	0,002	LVS EN 13164:2003

# Heat transfer coefficients, “U-value”, W/ (m<sup>2</sup> x K)

A measure of heat transmission through a building part, expressed as watt (W) that will flow in 1 hour through 1 square meter (1m<sup>2</sup>) of the structure with a temperature differential of 1°K.

$$R_n = \frac{d_n}{\lambda_n} \text{ m}^2 \times \text{K/W} \longrightarrow U = \frac{1}{R_n} \text{ W}/(\text{m}^2 \times \text{K})$$

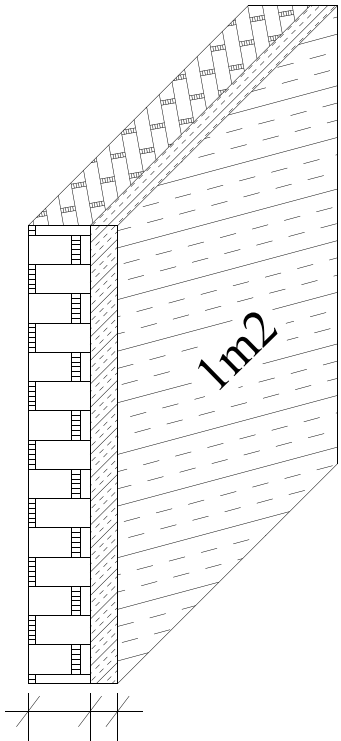
$$U = \frac{1}{R_{SI} + R_1 + R_2 + \dots + R_n + R_{SE}} \text{ W}/(\text{m}^2 \times \text{K}),$$

**EXAMPLE:**

Stone wool d=150mm and λ=0.037 W/(m × K):

$$U = \frac{1}{\left(\frac{0.15}{0.037 + 0.002}\right)} = 0.26 \text{ W}/(\text{m}^2 \times \text{K})$$

~~$$U = \frac{1}{\left(\frac{0.15}{0.037}\right)} = 0.25 \text{ W}/(\text{m}^2 \times \text{K})$$~~



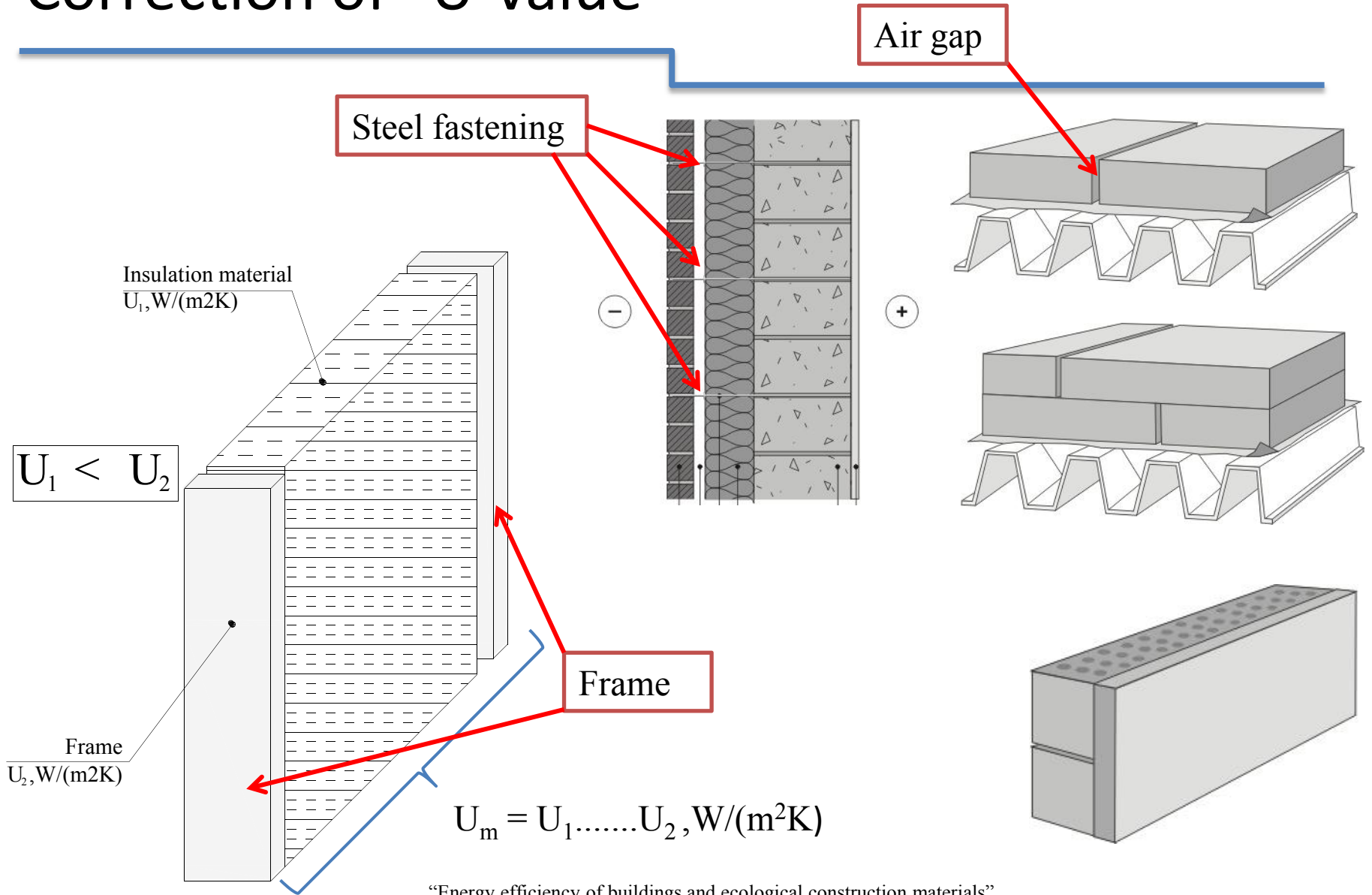
# Normative and maximal values of heat transfer coefficients according to LBN002-01 “Thermal Performance of Building Envelope”. , W/(m<sup>2</sup>K)

Building element	Dwelling houses		Public buildings		Industrial buildings	
	$U_{RN}$	$U_{RM}$	$U_{RN}$	$U_{RM}$	$U_{RN}$	$U_{RM}$
Roofs and slabs that are in contact with outside air	0,2κ	0,25κ	0,25κ	0,35κ	0,35κ	0,5κ
Slab on ground	0,25κ	0,35κ	0,35κ	0,5κ	0,45κ	0,7κ
Walls with $\rho < 100 \text{kg/m}^3$	0,25κ	0,30κ	0,35κ	0,4κ	0,45κ	0,5κ
Walls with $\rho \geq 100 \text{kg/m}^3$	0,3κ	0,40κ	0,4κ	0,5κ	0,5κ	0,6κ
Windows, doors and glassed walls	1,8κ	2,7κ	2,2κ	2,9κ	2,4κ	2,9κ

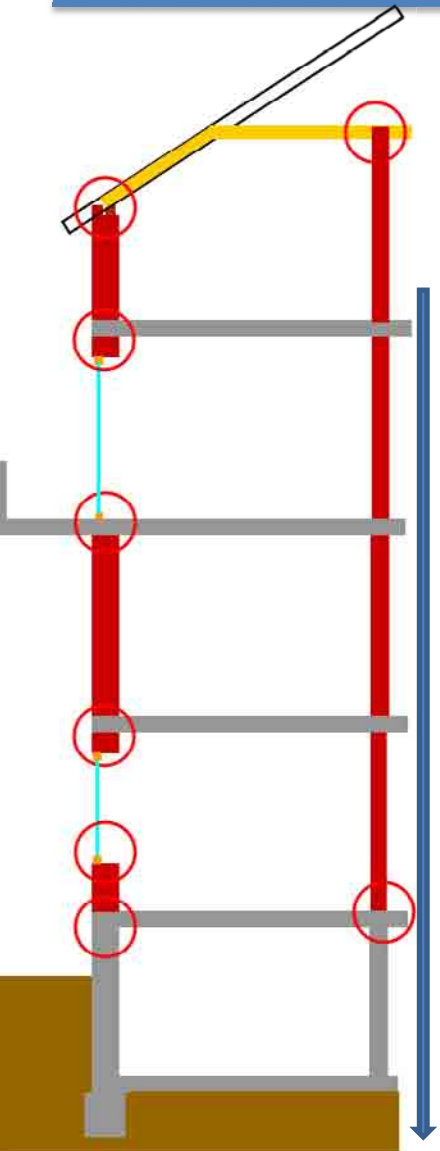
# Existing building “U-value”

	Type of building envelope	U, W /m <sup>2</sup> K
103/5	Attic ceiling	0.75
	Aerated concrete panel wall	0.89
	Brick wall	1.27
	Basement ceilings	1.03
	Window	2.56
464/5	Attic ceiling	0.81
	Claydite-concrete panel wall	1.48
	Basement ceilings	1.33
	Window	2.56
467/5	Attic ceiling	1.13
	Claydite-concrete panel wall	1.48
	Basement ceilings	1.01
	Window	2.56
467/5	Attic ceiling	1.54
	Claydite-concrete panel wall	1.48
	Basement ceilings	1.49
	Window	2.56
602/9	Attic ceiling	0.8
	Claydite-concrete panel wall	1.48
		1.14

# Correction of “U-value”

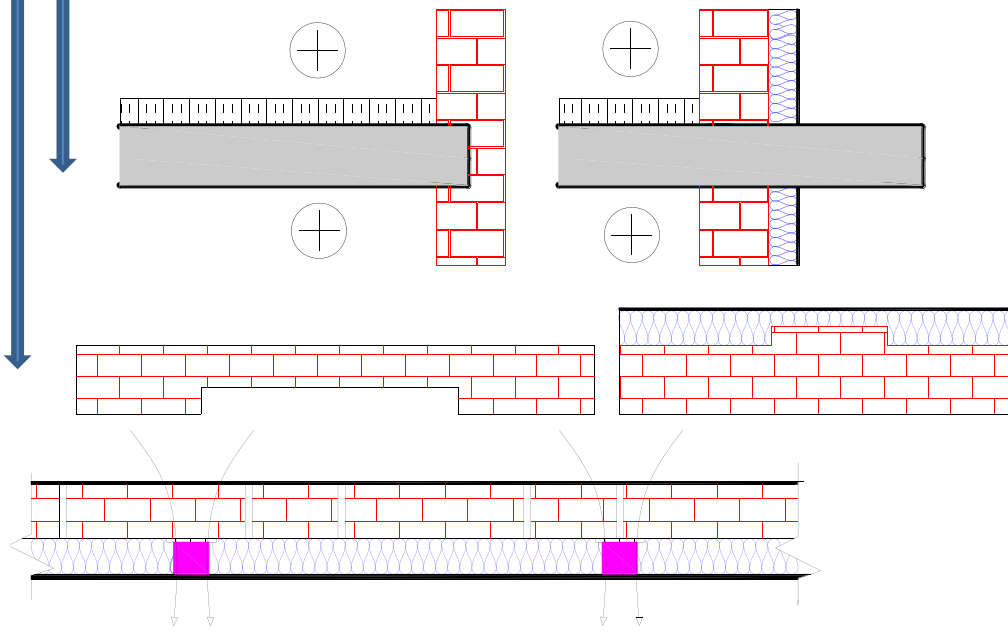


# Thermal Bridge

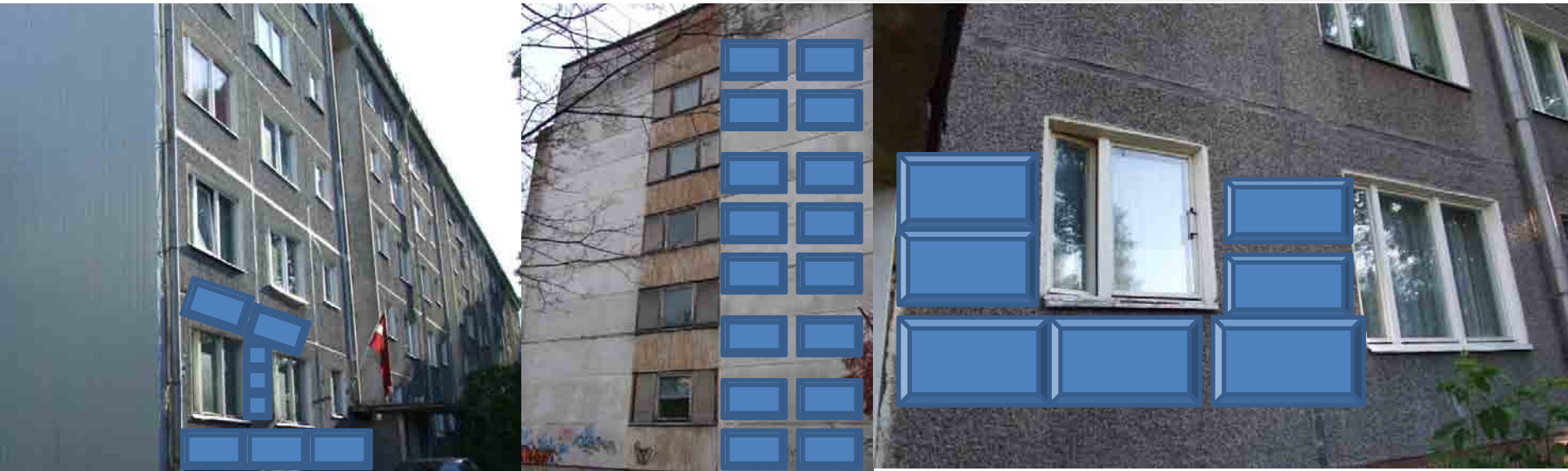


Thermal bridge – part of the building where thermal resistance of homogeneous parts of the building envelope is defected by the following factors:

- material with higher heat conductivity crosses building envelope or its part;
- differs thickness of building's external elements or materials;
- differences in the external and internal dimensions of building's elements, junctions between walls/floors/roof.



# Specifics of insulation works

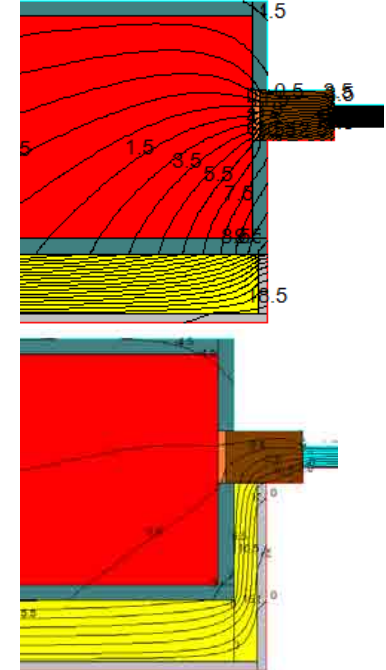
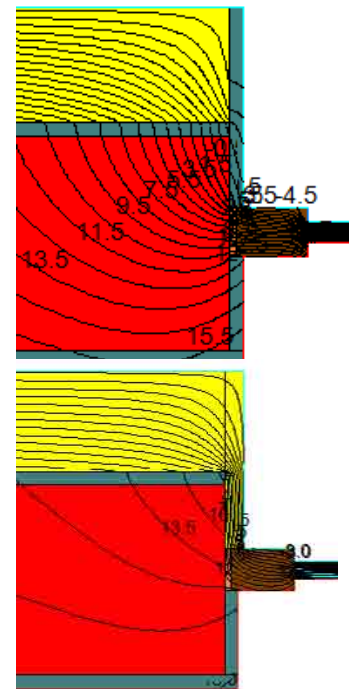
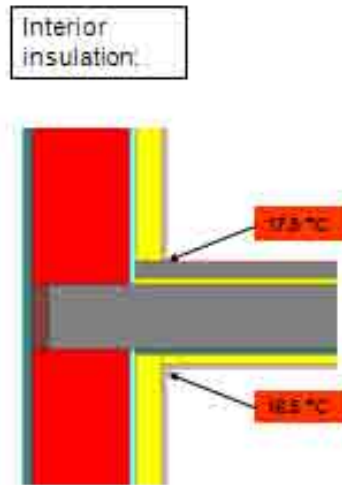
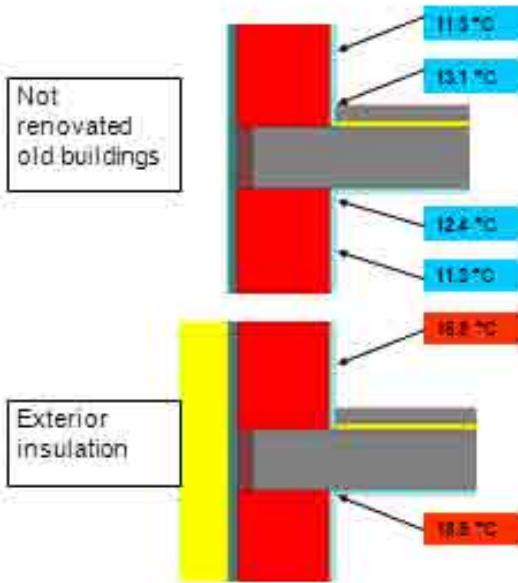


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# Negative impact of Thermal Bridge

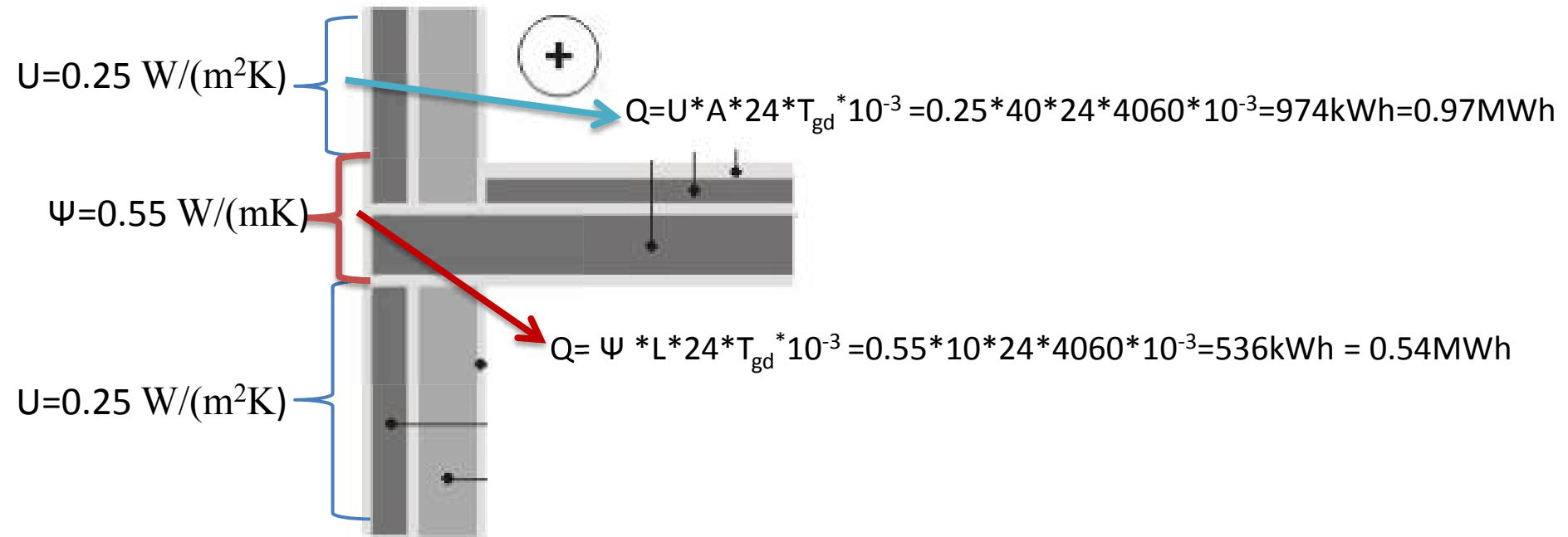
- Low temperature!**

Connections of Concrete Slabs

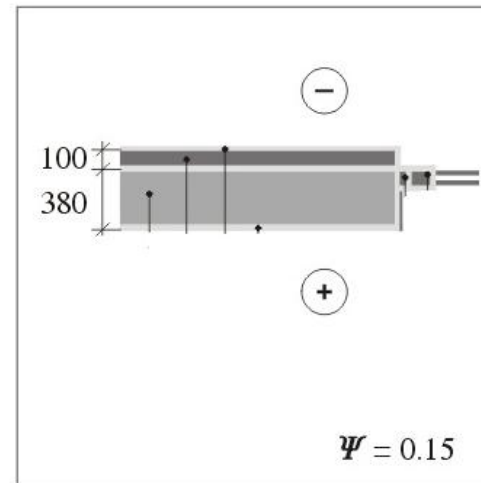
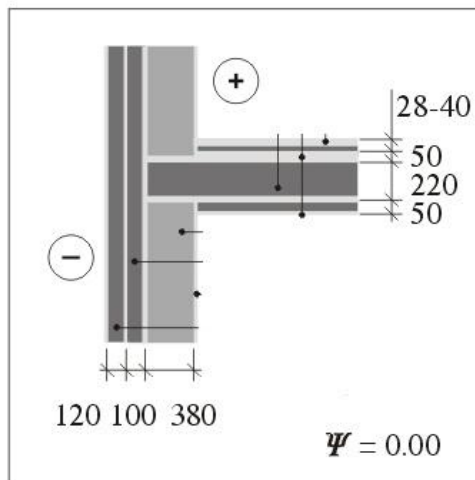
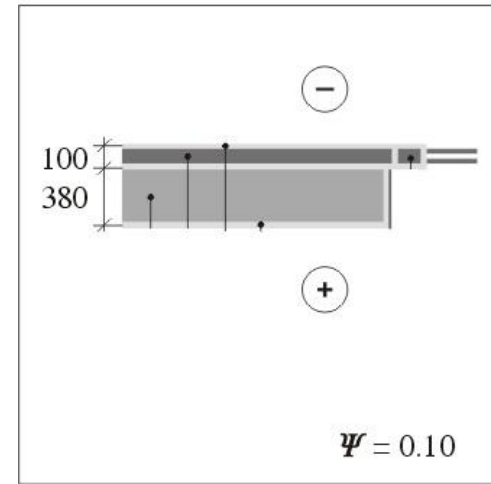
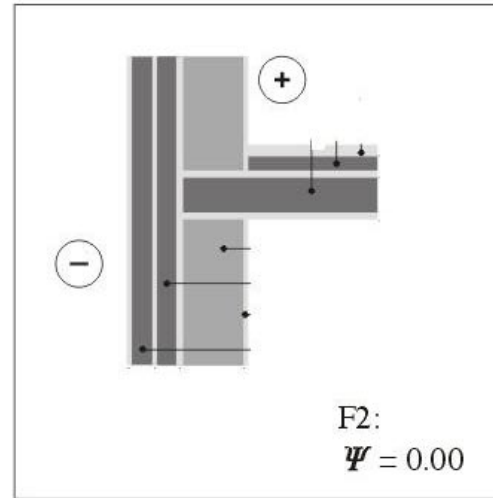
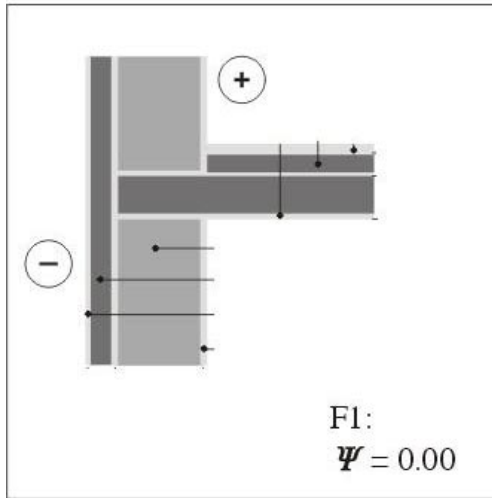


# Negative impact of Thermal Bridge

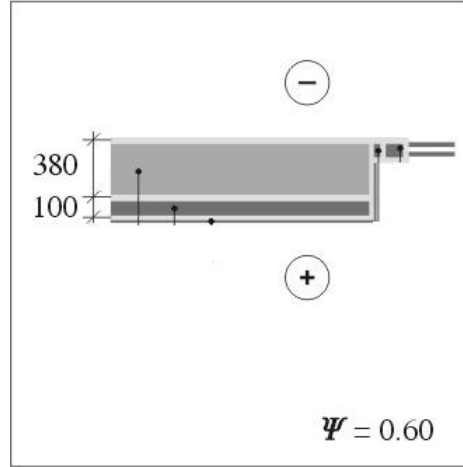
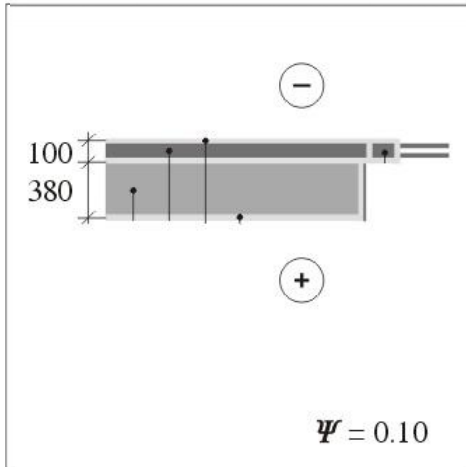
- Additional heat losses



# Correct decision of Thermal Bridge

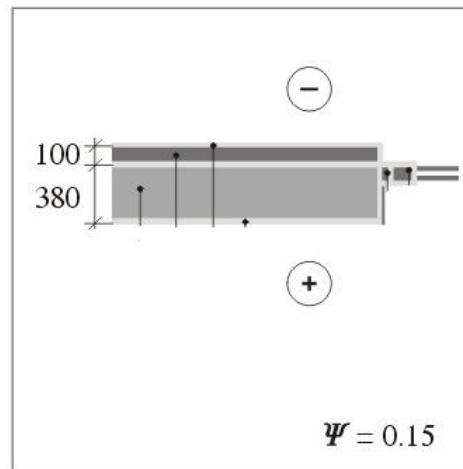
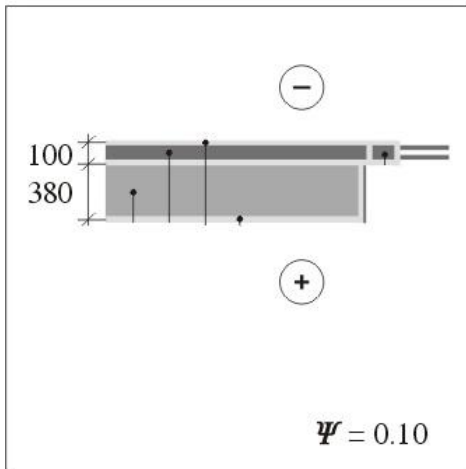


# Window installation



$$\Delta\Psi = 0.50 \text{ W/(mK)}$$

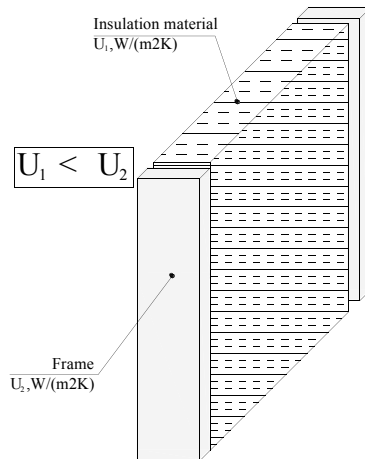
$$Q = U \cdot A \cdot 24 \cdot T_{gd} \cdot 10^{-3} = 0.5 \cdot 4.4 \cdot 24 \cdot 4060 \cdot 10^{-3} = 214 \text{ kWh} = 0.2 \text{ MWh}$$



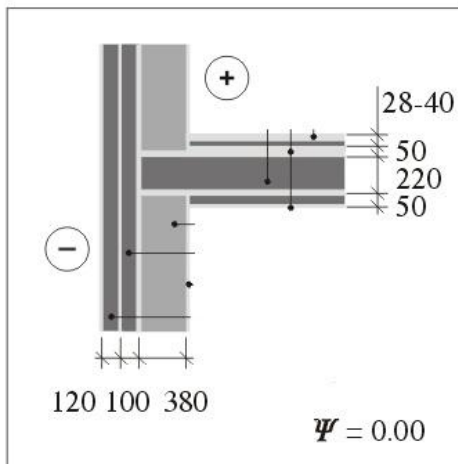
$$\Delta\Psi = 0.05 \text{ W/(mK)}$$

$$Q = U \cdot A \cdot 24 \cdot T_{gd} \cdot 10^{-3} = 0.05 \cdot 4.4 \cdot 24 \cdot 4060 \cdot 10^{-3} = 21 \text{ kWh} = 0.02 \text{ MWh}$$

# How to calculate Thermal Bridge?!



LVS EN ISO 6946 - Building components and building elements -- Thermal resistance and thermal transmittance -- Calculation method.



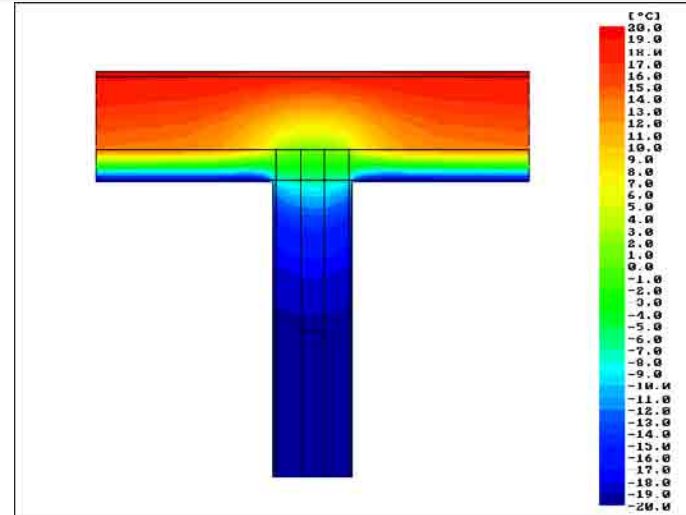
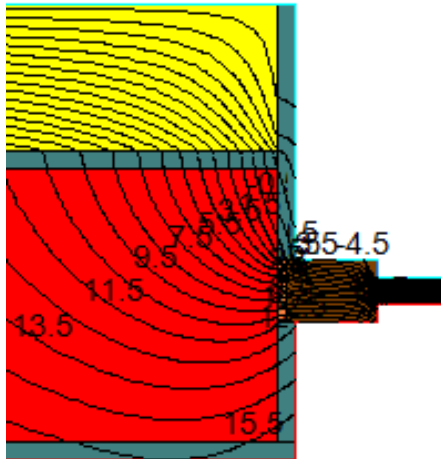
LVS EN ISO 10211-1 - Thermal bridges in building construction -- Heat flows and surface temperatures -- Part 1: General calculation methods.

LVS EN ISO 10211-2 - Thermal bridges in building construction -- Calculation of heat flows and surface temperatures -- Part 2: Linear thermal bridges.

# How to calculate Thermal Bridge?!

## SOFTWARE:

- ✓ EUROKOBRA;
- ✓ THERM<sup>®</sup> 5.2.



Group: M2AA\_A - Detail: MBG4XB20  
p. 01-04

### KOBRA RESULTS

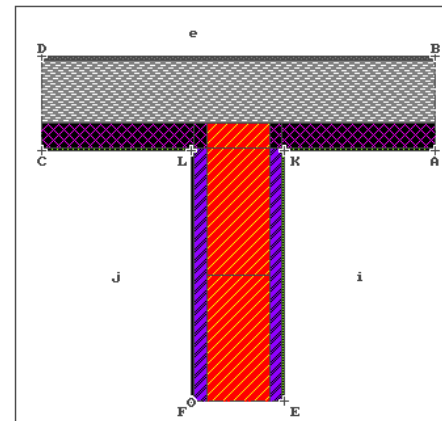
Rsi = 0.20 m<sup>2</sup>K/W hi = 5.0 W/m<sup>2</sup>K  
 θi = -20.0 °C θe = 20.0 °C

### CONDENSATION RISK EVALUATION

Belgium: use hi = 5 W/m<sup>2</sup>K  
 K: f(0.20) = 0.89 θ = -15.7 °C  
 OK : minimal risk (C80)  
 L: f(0.20) = 0.50 θ = 0.0 °C  
 not OK : high risk (C00)  
 O: f(0.20) = 0.99 θ = -19.7 °C

### HEAT LOSS EVALUATION

use hi = 8 W/m<sup>2</sup>K for best accuracy  
 U-values [W/m<sup>2</sup>K]  
 A-B: 0.31 C-D: 0.31 E-F: 0.30  
 Total heat loss Q(B-D) = 26.5 W/m  
 Coupling coefficient Lie = -0.7 W/mK  
 psi-e = Lie - U(AB)\*BD  
 = -1.14 W/mK negligible (C1)  
 psi-i = Lie - U(AB)\*AK - U(CD)\*CL  
 = -1.03 W/mK negligible (C1)  
 Um = Lie/AC = -1.10 W/m<sup>2</sup>K



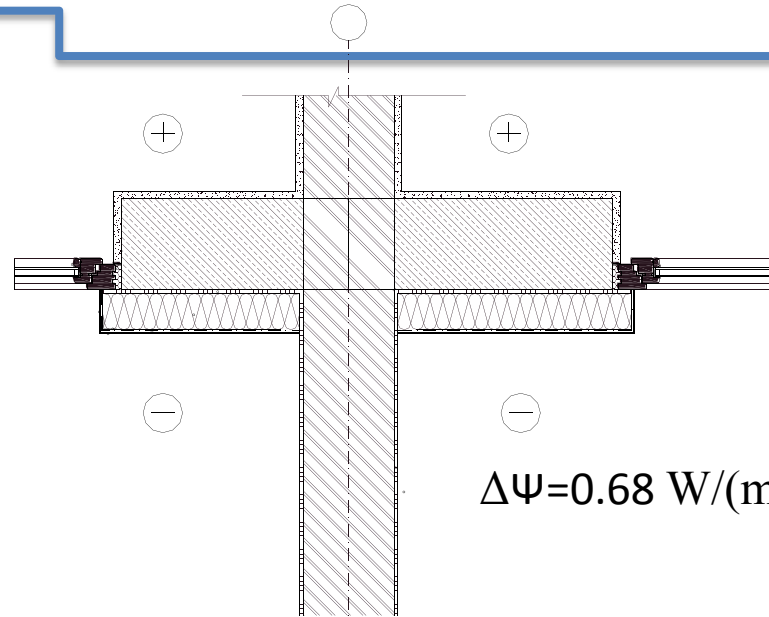
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# Example 1 – without insulation



Group: \_1 - Detail: \_1\_02  
p.44-02



$$\Delta\Psi = 0.68 \text{ W/(mK)}$$

Group: \_1 - Detail: \_1\_02  
p.44-02

## KOBRA RESULTS

Rsi = 0.13 m<sup>2</sup>K/W    hi = 7.7 W/m<sup>2</sup>K  
 ei = 20.0 °C        ee = 0.0 °C

## CONDENSATION RISK EVALUATION

Belgium: use hi = 5 W/m<sup>2</sup>K  
 K: f(0.13) = 0.86    θ = 17.2 °C  
 OK : minimal risk (C80)  
 L: f(0.13) = 0.85    θ = 17.0 °C  
 OK : minimal risk (C80)  
 O: f(0.13) = 0.85    θ = 17.0 °C  
 OK : minimal risk (C80)

## HEAT LOSS EVALUATION

use hi = 8 W/m<sup>2</sup>K for best accuracy  
 U-values [W/m<sup>2</sup>K]  
 A-B: 0.24    C-D: 0.24    E-F: 2.30  
 Total heat loss Q(B-D) = 24.1 W/m  
 Coupling coefficient Lie = 1.2 W/mK  
 psi-e = Lie - U(AB)\*BD  
 = 0.68 W/mK    very high (C4)  
 psi-i = Lie - U(AB)\*AK - U(CD)\*CL  
 = 0.73 W/mK    very high (C4)

## KOBRA RESULTS

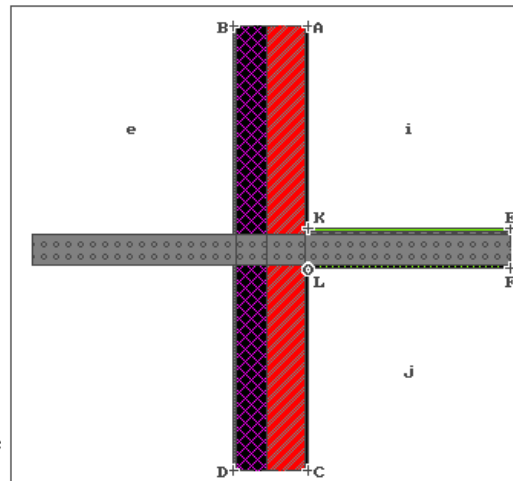
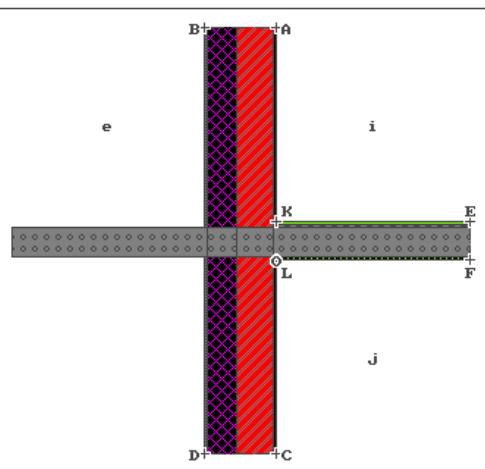
Rsi = 0.13 m<sup>2</sup>K/W    hi = 7.7 W/m<sup>2</sup>K  
 ei = 20.0 °C        ee = -20.0 °C

## CONDENSATION RISK EVALUATION

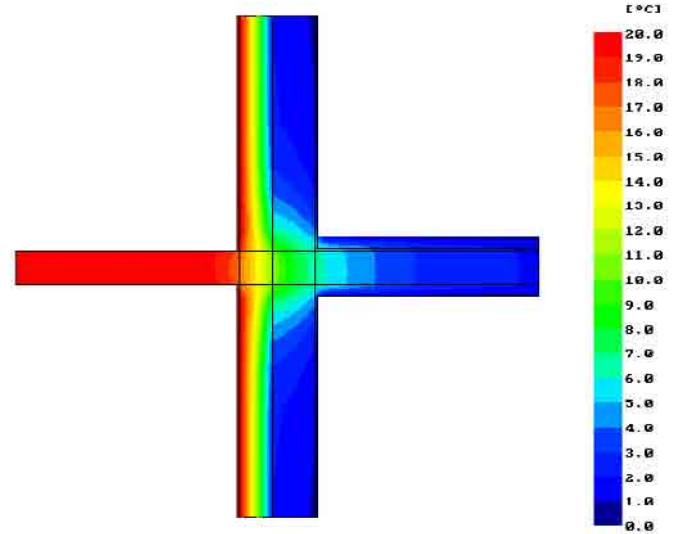
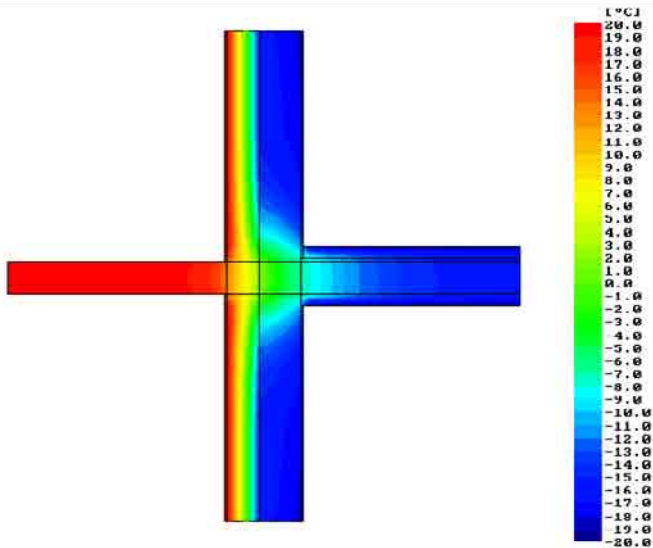
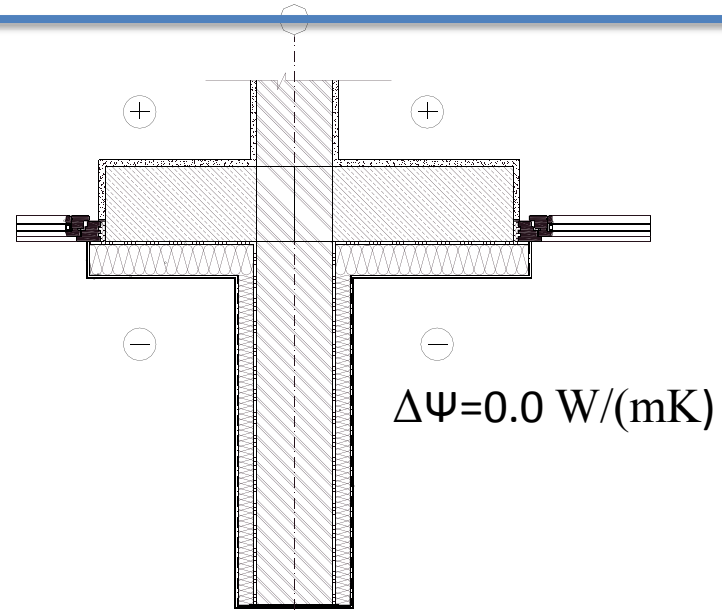
Belgium: use hi = 5 W/m<sup>2</sup>K  
 K: f(0.13) = 0.86    θ = 14.5 °C  
 OK : minimal risk (C80)  
 L: f(0.13) = 0.85    θ = 14.0 °C  
 OK : minimal risk (C80)  
 O: f(0.13) = 0.85    θ = 14.0 °C  
 OK : minimal risk (C80)

## HEAT LOSS EVALUATION

use hi = 8 W/m<sup>2</sup>K for best accuracy  
 U-values [W/m<sup>2</sup>K]  
 A-B: 0.24    C-D: 0.24    E-F: 2.30  
 Total heat loss Q(B-D) = 48.1 W/m  
 Coupling coefficient Lie = 1.2 W/mK  
 psi-e = Lie - U(AB)\*BD  
 = 0.68 W/mK    very high (C4)  
 psi-i = Lie - U(AB)\*AK - U(CD)\*CL  
 = 0.73 W/mK    very high (C4)



# Example 1<sup>a</sup> – with insulation



# Example 2

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# Conclusions

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- ✓ Thermal conductivity,  $\lambda$ W/mK and Correction coefficient  $\Delta\lambda_w$  W/(m × K);
- ✓ Heat transfer coefficients, “U-value”, W/ (m<sup>2</sup> x K) and correction value;
- ✓ Thermal Bridge.

### *Session III. Building physics*

#### **Insulation of buildings:**

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- avoiding thermal bridges.

*Thank you for your attention*

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