FACULTY OF MECHANICAL ENGINEERING CTU IN PRAGUE

Environmental Engineering

Heating Load

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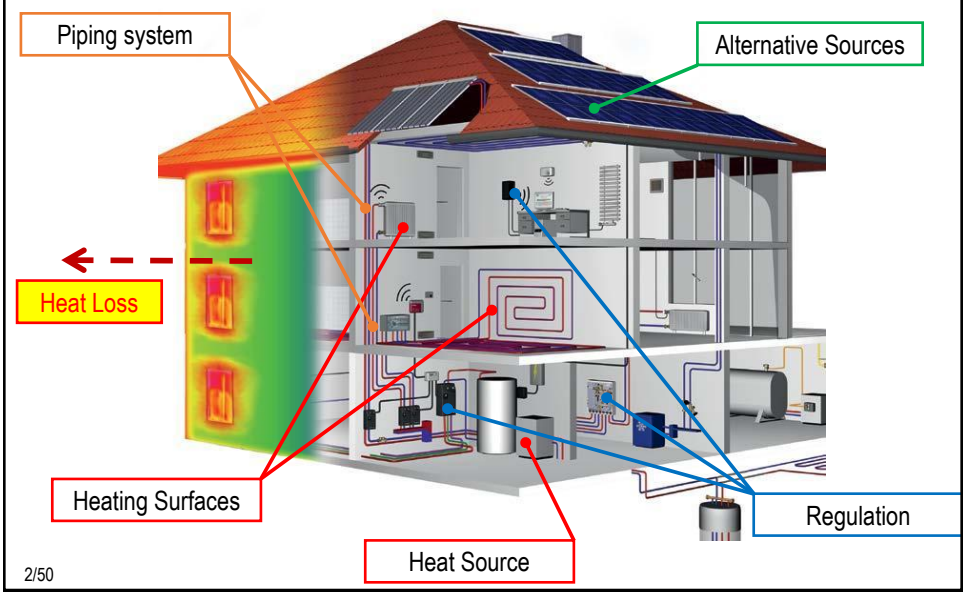
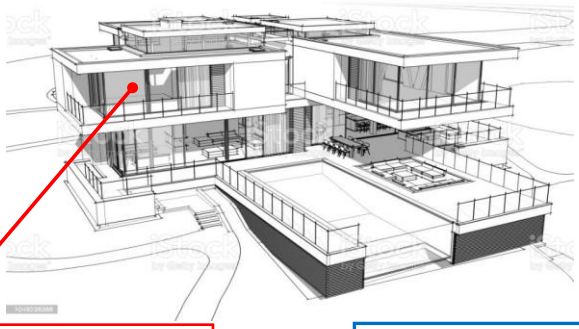
Heating Systems in Buildings



Heating Load – Conditions

Thermal comfort in the interior of the building space.

WINTER CONDITIONS



INSIDE TEMPERATURE
*(typical in bedroom **+20 °C**)*

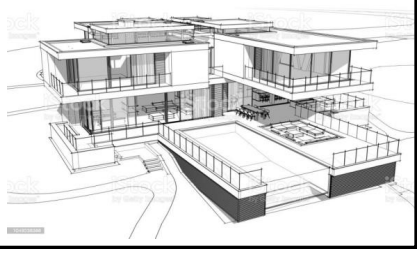
OUTSIDE TEMPERATURE
*(typical in Czechia **-12 °C**)*

3/50

Heating Load – Conditions

Typical Internal Temperatures in Buildings

Sort of Space	$\theta_{int,i}$ [°C]
Kitchen	20
Bathroom	24
Toilet	20
Heated Neighbouring Space (e.g. Entrance Hall, Corridor, etc.)	15



4/50

Heating Load – Conditions

External temperatures (Typical in Czech Republic)

Climatic Area (Locations in Czech Republic)	External Design Temperature θ_e [°C]
Czech Krumlov	-18
Jihlava	-15
Prague	-12

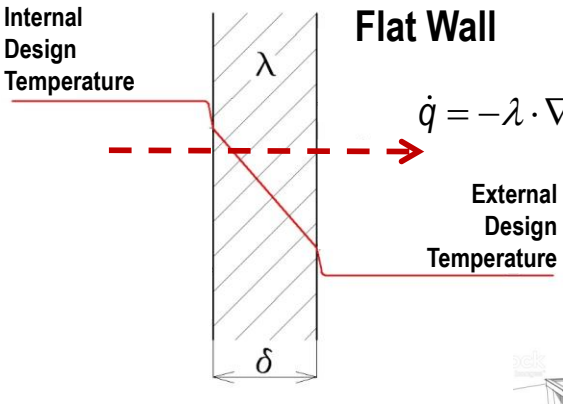
5/50

Heating Load – Conditions

External temperatures

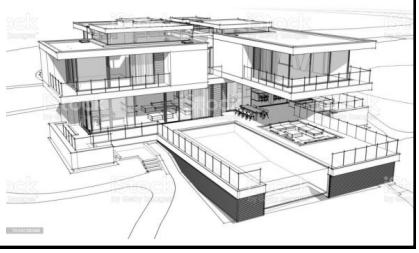
6/50

Basic Concepts of Heat Transfer



Flat Wall

$$\dot{q} = -\lambda \cdot \nabla T$$

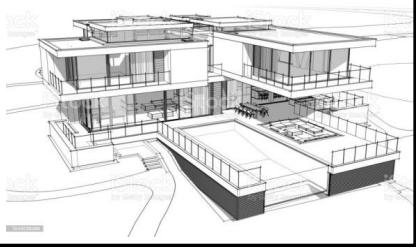


q – Heat Flux [W/m^2]
λ – Thermal Conductivity [W/m·K]

Basic Concepts of Heat Transfer

Typical values coefficient of thermal conductivity

Material	λ [W/m·K]
Brick	0,8
Concrete	1,2
Wood	0,3
Heat Insulation (e.g. Mineral Wool)	0,035



Basic Concepts of Heat Transfer

U – factor (thermal transmittance of opaque building elements)

$$U = \frac{1}{R_{si} + \sum_{n=1}^{m} R_n + R_{se}} = \frac{1}{R_{si} + \sum_{n=1}^{m} \frac{\delta_n}{\lambda_n} + R_{se}}$$

R_{int} - internal heat transmission resistance [m²·K/W]
R_{ext} - external heat transmission resistance [m²·K/W]

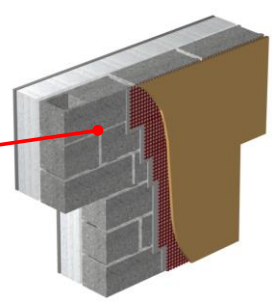
Heat Transmission Resistance [m²·K/W]	Direction of Heat Flow		
	Upwards	Horizontally	Downwards
R_{int}	0,10	0,13	0,17
R_{ext}	0,04	0,04	0,04

9/50

Basic Concepts of Heat Transfer

Example 1:

Materials of Wall	Thickness δ [mm]	Thermal Conductivity λ [W/m·K]
External Plaster	25	0,95
Solid Brick	400	0,86
Internal Plaster	15	0,98



$$U = \frac{1}{R_{si} + \sum_{n=1}^{m} \frac{\delta_n}{\lambda_n} + R_{se}} = \frac{1}{0,13 + \frac{0,025}{0,95} + \frac{0,4}{0,86} + \frac{0,015}{0,98} + 0,04} = 1,48 \left[\frac{W}{m^2 \cdot K} \right]$$

10/50

Basic Concepts of Heat Transfer

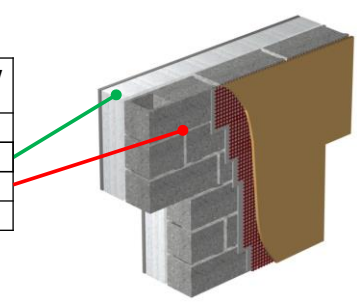
Thermal protection of buildings

Construction		Overall Coefficient of Thermal Transmittance U [W/m²·K]		
		Required	Recommended	Recommended for Passive Houses
Exterior Wall	Light	0,30	0,25	0,18 to 0,12
	Heavy		0,20	
Roof > 45°		0,30	0,20	0,18 to 0,12
Roof < 45°		0,24	0,16	0,15 to 0,10
Ceiling and Floor over Outdoor Area		0,24	0,16	0,15 to 0,10

Basic Concepts of Heat Transfer

Example 2:

Materials of Wall	Thickness δ [mm]	Thermal Conductivity λ [W/m·K]
External Plaster	25	0,95
Mineral Wool	X	0,035
Solid Brick	400	0,86
Internal Plaster	15	0,98



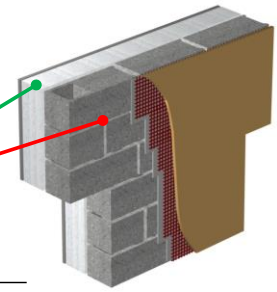
$$U = 1,48 \left[\frac{W}{m^2 \cdot K} \right]$$

$$U_{RECOMMENDED} \leq 0,25 \left[\frac{W}{m^2 \cdot K} \right]$$

Basic Concepts of Heat Transfer

Example 2:

Materials of Wall	Thickness δ [mm]	Thermal Conductivity λ [W/m·K]
External Plaster	25	0,95
Mineral Wool	X	0,035
Solid Brick	400	0,86
Internal Plaster	15	0,98



$$U \le U_{RECOMMENDED} \Rightarrow U_{RECOMMENDED} \ge \frac{1}{R_{si} + \sum_{n=1}^{m} \frac{\delta_n}{\lambda_n} + R_{se}}$$

$$0,25 \ge \frac{1}{0,13 + \frac{0,025}{0,95} + \frac{\delta_{MINERAL\ WOOL}}{0,035} + \frac{0,4}{0,86} + \frac{0,015}{0,98} + 0,04}$$

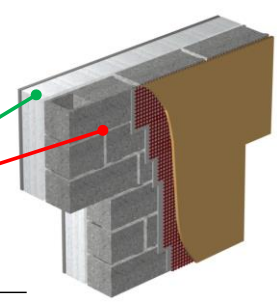
$$\delta_{MINERAL\ WOOL} \ge 0,116\,[m] \Rightarrow REAL\ THICKNESS\ 120\,[\mathrm{mm}]$$

13/50

Basic Concepts of Heat Transfer

Example 2:

Materials of Wall	Thickness δ [mm]	Thermal Conductivity λ [W/m·K]
External Plaster	25	0,95
Mineral Wool	X	0,035
Solid Brick	400	0,86
Internal Plaster	15	0,98



$$U \le U_{RECOMMENDED} \Rightarrow U_{RECOMMENDED} \ge \frac{1}{R_{si} + \sum_{n=1}^{m} \frac{\delta_n}{\lambda_n} + R_{se}}$$

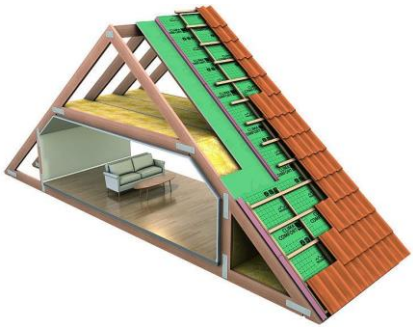
$$U = \frac{1}{0,13 + \frac{0,025}{0,95} + \frac{0,12}{0,035} + \frac{0,4}{0,86} + \frac{0,015}{0,98} + 0,04} = 0,24\left[\frac{W}{m^2 \cdot K}\right]$$

14/50

Basic Concepts of Heat Transfer

Example 3:

Materials of Roof	Thickness δ [mm]	Thermal Conductivity λ [W/m·K]
OSB Board	22	0,13
Mineral Wool	200	0,035
Vapor Barrier Insulation	25	0,2
Plasterboard	12,5	0,21
Internal Plaster	10	0,98



$$U_{RECOMMENDED} = 0,20\left[\frac{W}{m^2 \cdot K}\right]$$

$$U = \frac{1}{R_{si} + \sum_{n=1}^{m} \frac{\delta_n}{\lambda_n} + R_{se}} = ...$$

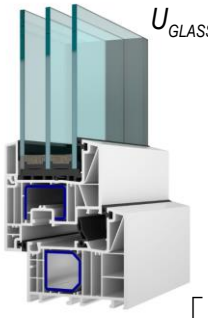
15/50

Basic Concepts of Heat Transfer

U – factor (thermal transmittance of translucent building elements)

$$U_{WINDOW} \neq U_{GLASS}$$

$$U_{GLASS} = 0,5\left[\frac{W}{m^2 \cdot K}\right]$$



$$U_{WINDOW} = \frac{\sum A_{GLASS} \cdot U_{skla} + \sum A_{FRAME} \cdot U_{FRAME} + \sum l_{GLAS} \cdot \psi_{GLASS}}{\sum A_{GLASS} + \sum A_{FRAME}}$$

$$U_{FRAME} = 1,8\left[\frac{W}{m^2 \cdot K}\right]$$

$$U_{WINDOW} = 1,06\left[\frac{W}{m^2 \cdot K}\right]$$

16/50

Heat Load According to EN 12831-1

EN 12831-1:2017

**Energy performance of buildings —
Method for calculation of the design heat load — Part 1:
Space heating load**

This European Standard covers methods for the calculation of the design heat load for single rooms, building entities and buildings, where the design heat load is defined as the heat supply (power) needed to maintain the required internal design temperature under design external conditions.

The total design **heat load** is calculated from all **transmission heat losses** to the exterior (direct and indirect), the **ventilation heat loss** of the building and, if any, an additional heating-up power.

17/50

Heat Load According to EN 12831-1

Design Heat load (total) for Heated Space (i)

$$\Phi_{HL,i} = \Phi_{T,i} + \Phi_{V,i} + \Phi_{hu,i} - \Phi_{gain,i}$$

$\Phi_{HL,i}$ - Total Design Heat Load of the Heated Space

$\Phi_{T,i}$ - Design Transmission Heat Loss of the Heated Space

$\Phi_{V,i}$ - Design Ventilation Heat Loss for the Heated Space

$\Phi_{hu,i}$ - Optional Additional Heating-up Power for the Heated Space (internal) in Case of Intermittent Heating

$\Phi_{gain,i}$ - Optional Permanent Heat Gains for the Heated Space

18/50

Heat Load According to EN 12831-1

Design *Transmission* Heat Losses of a Heated Space (i)

$$\Phi_{T,i} = \left(H_{T,ie} + H_{T,ia} + H_{T,iae} + H_{T,iaBE} + H_{T,ig}\right) \cdot \left(\theta_{int,i} - \theta_e\right)$$

$$\Phi_{T,i} \approx \left(H_{T,ie} + \sum H_{T,ia(...)} + H_{T,ig}\right) \cdot \left(\theta_{int,i} - \theta_e\right)$$

$H_{T,ie}$ - Heat Transfer Coefficient from the Heated Space (i) to the Exterior (e) [W/K]

$H_{T,ia}$ - Heat Transfer Coefficient from the Heated Space (i) to an Adjacent Heated Space (a) [W/K]

$H_{T,iae}$ - Heat Transfer Coefficient from the Heated Space (i) to the Exterior (e) Through an Adjacent Unheated Space [W/K]

$\theta_{int,i}$ - internal design temperature [°C]

θ_e - external design temperature [°C]

19/50

Heat Load According to EN 12831-1

Heat Transfer Coefficient Directly to Exterior

$$H_{T,ie} = \sum_k \left[A_k \cdot \left(U_k + \Delta U_{TB}\right) \cdot f_{U,k} \cdot f_{ie,k}\right]$$

A_k – Surface Area of the Building Element [m^2]

U_k – Thermal Transmittance Coefficient of the Building Element [W/m^2·K]

ΔU_{TB} – Blanket Additional Thermal Transmittance for Thermal Bridges [W/m^2·K]

f_{Uk} – Correction Factor for the Influence of Building Part Qualities and Meteorological Conditions not Taken Into Account in the Calculation of the Respective U-Values (for Central Europe, i.e. CZ, **f_{Uk} = 1** [-]

$f_{ie,k}$ – Temperature Adjustment Factor (**for $H_{T,ie}$ Equals 1**) [-]

20/50

Heat Load According to EN 12831-1

Heat Transfer Coefficient Directly to Exterior

$$H_{T,ie} = \sum_k \left[A_k \cdot \left(U_k + \Delta U_{TB} \right) \cdot f_{U,k} \cdot f_{ie,k} \right]$$

Selection Criteria	Additional Thermal Transmittance ΔU_{TB} [W/(m²·K)]
New buildings with a high level of heat insulation and attested minimization of thermal bridges that exceeds generally recognized rules of practice	0,02
New buildings in compliance with generally recognized rules of practice regarding the minimization of thermal bridges	0,05
Buildings with mainly internal heat insulation broken by solid ceilings	0,15
All other buildings	0,10

21/50

Heat Load According to EN 12831-1

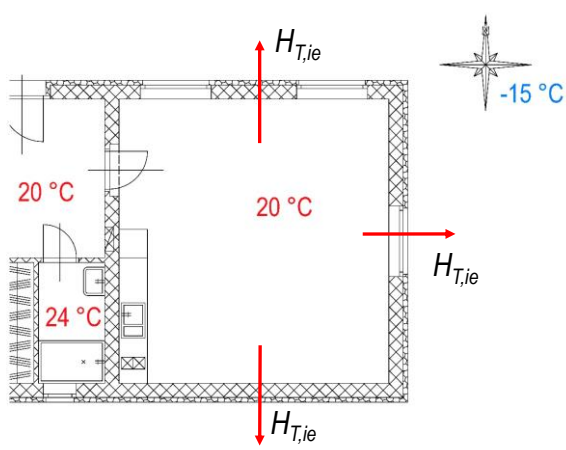
Heat Transfer Coefficient Directly to Exterior

$$H_{T,ie} = \sum_k \left[A_k \cdot \left(U_k + \Delta U_{TB} \right) \cdot f_{U,k} \cdot f_{ie,k} \right]$$

ΔU_{TB} = 0,05 – new building

Example 4:

U_{wall} = 0,20 [W/m²·K]
U_{window} = 0,80 [W/m²·K]
U_{roof} = 0,18 [W/m²·K]

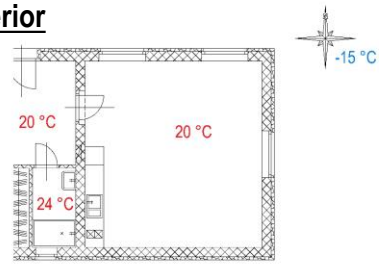


22/50

Heat Load According to EN 12831-1

Heat Transfer Coefficient Directly to Exterior

$$H_{T,ie} = \sum_k \left[A_k \cdot \left(U_k + \Delta U_{TB} \right) \cdot f_{U,k} \cdot f_{ie,k} \right]$$



Example 4:

U_{wall}	= 0,20 [W/m²·K]	A_{wall}	= 54,0 [m²]
U_{window}	= 0,80 [W/m²·K]	A_{window}	= 9,0 [m²]
U_{roof}	= 0,18 [W/m²·K]	A_{roof}	= 36,0 [m²]

$$H_{T,ie} = \ldots$$

23/50

Heat Load According to EN 12831-1

Heat Transfer Coefficient to Adjacent Spaces

$$H_{T,ia(\ldots),k} = \sum_k (A_k \cdot U_k \cdot f_{ia(\ldots),k})$$

$$f_{ia(\ldots),k} = \frac{\theta_{\text{int},i} - \theta_{ia(\ldots)}}{\theta_{\text{int},i} - \theta_e}$$

$f_{ia(\ldots)}$ – temperature adjustment factor

$\theta_{int,i}$ - Internal Design Temperature of the Considered Heated Space (i)

$\theta_{ia(\ldots)}$ - Temperature of the Adjacent Space ia (…)

θ_e - External Design Temperature

24/50

Heat Load According to EN 12831-1

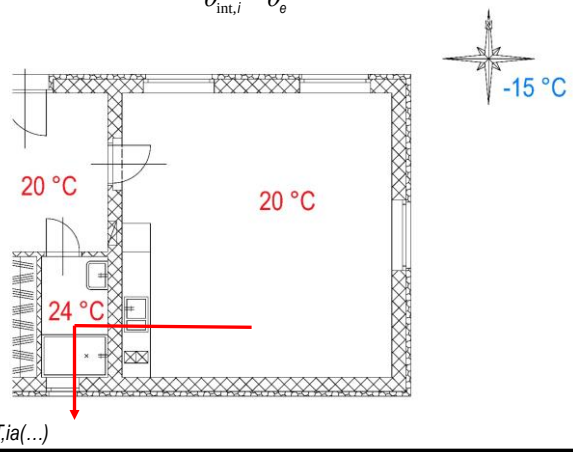
Heat Transfer Coefficient to Adjacent Spaces

$$H_{T,ia(\ldots),k} = \sum_k (A_k \cdot U_k \cdot f_{ia(\ldots),k})$$

$$f_{ia(\ldots),k} = \frac{\theta_{\mathrm{int},i} - \theta_{ia(\ldots)}}{\theta_{\mathrm{int},i} - \theta_e}$$

Example 5:

$U_{internal\ wall}$ = 0,90 [W/m²·K]
$A_{internal\ wall}$ = 10,5 [m²]

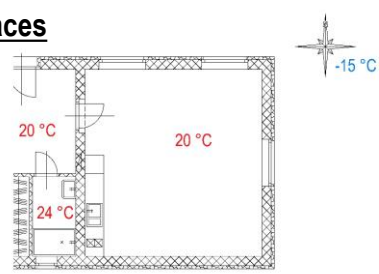


25/50

Heat Load According to EN 12831-1

Heat Transfer Coefficient to Adjacent Spaces

$$H_{T,ia(\ldots),k} = \sum_k (A_k \cdot U_k \cdot f_{ia(\ldots),k})$$



Example 5:

$$f_{ia(\ldots),k} = \frac{\theta_{\mathrm{int},i} - \theta_{ia(\ldots)}}{\theta_{\mathrm{int},i} - \theta_e} = \ldots$$

$$H_{\mathrm{T,ia(\ldots),k}} = \ldots$$

26/50

Heat Load According to EN 12831-1

Heat Transfer Coefficient Directly to Exterior

$$H_{T,ia(...),k} = \sum_k (A_k \cdot U_k \cdot f_{ia(...),k})$$

$$f_{ia(...),k} = \frac{\theta_{\text{int},i} - \theta_{ia(...)}}{\theta_{\text{int},i} - \theta_e} = ...$$

Type of unheated space		Temperature of the Adjacent Space $\theta_{ia(...)}$ [°C] by External Design Temperature θ_e [°C]		
		-12	*-15*	*-18*
Lofts	Not tight roofing	-6	-9	*-12*
	Tight roofing			
	- without thermal insulation	-3	-6	*-9*
	- with thermal insulation	0	0	*-3*
Adjoining rooms	Mainly with heated space for example corridors	+15		
	Mainly with exterior space and connected with door	-3	-6	-9

27/50

Heat Load According to EN 12831-1

Heat Transfer Coefficient to the Ground

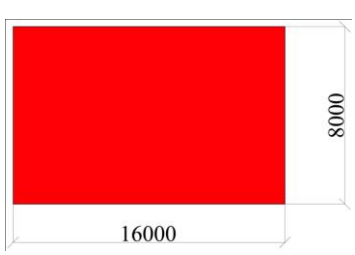
B' - geometric parameter of the floor slab [m]

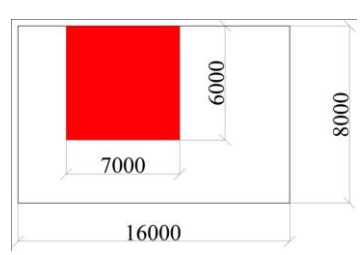
$$B' = \frac{A_g}{0,5 \cdot P}$$

A_G - area of the floor slab [m²]
P - exposed periphery of the floor slab [m]

$$B' = \frac{A_g}{0,5 \cdot P} = \frac{16 \cdot 8}{0,5 \cdot 2 \cdot (16+8)} = 5,33\,[\text{m}]$$

$$B' = \frac{A_g}{0,5 \cdot P} = \frac{6 \cdot 7}{0,5 \cdot 7} = 12\,[\text{m}]$$





28/50

Heat Load According to EN 12831-1

Heat Transfer Coefficient to the Ground

In Detail Only => EN ISO 13 370

Type of Ground	Thermal Conductivity λ_g [W/m·K]
Clay	1,5
Sand and Gravel	2,0
Rock	3,5

29/50

Heat Load According to EN 12831-1

Heat Transfer Coefficient to the Ground

EN ISO 13 370

Type of Ground	Thermal Conductivity λ_g [W/m·K]
Clay	1,5

30/50

Heat Load According to EN 12831-1

Heat Transfer Coefficient to the Ground

EN ISO 13 370

Type of Ground	Thermal Conductivity λ_g [W/m·K]
Sand and Gravel	2,0

31/50

Heat Load According to EN 12831-1

Heat Transfer Coefficient to the Ground

EN ISO 13 370

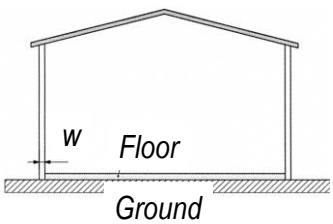
Type of Ground	Thermal Conductivity λ_g [W/m·K]
Rock	3,5

32/50

Heat Load According to EN 12831-1

EN ISO 13 370

Thermal transmittance coefficient of ground (heat transfer coefficient)



$$d_t = w + \lambda_{ground} \cdot (R_{si} + R_f + R_{se})$$

$$d_t < B' \Rightarrow U_g = \frac{2 \cdot \lambda_{ground}}{\pi \cdot B' + d_t} \cdot \ln\left(\frac{\pi \cdot B'}{d_t} + 1\right)$$

$$d_t \geq B' \Rightarrow U_g = \frac{\lambda_{ground}}{0,457 \cdot B' + d_t}$$

w – Total Thickness of Perimeter Walls Containing All the Vertical Layers [m]
d_t – Total Equivalent Floor Thickness [m]
R_{si} – Internal Heat Transmission Resistance (R_{si} = 0,17 – downwards) [m²·K/W]
R_f – Floor Heat Transmission Resistance [m²·K/W]
R_{se} – External Heat Transmission Resistance (R_{se} = 0,04 – downwards) [m²·K/W]

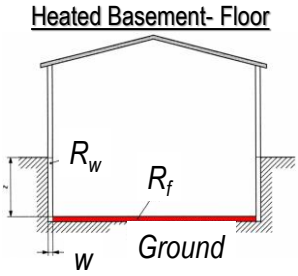
33/50

Výpočet součinitele prostupu tepla

EN ISO 13 370

Thermal transmittance coefficient of ground (heat transfer coefficient)

Heated Basement- Floor



$$d_t = w + \lambda_{ground} \cdot (R_{si} + R_f + R_{se})$$

$$(d_t + 0,5 \cdot z) < B' \Rightarrow U_g = \frac{2 \cdot \lambda_{ground}}{\pi \cdot B' + d_t + 0,5 \cdot z} \cdot \ln\left(\frac{\pi \cdot B'}{d_t + 0,5 \cdot z} + 1\right)$$

$$(d_t + 0,5 \cdot z) \geq B' \Rightarrow U_g = \frac{\lambda_{ground}}{0,457 \cdot B' + d_t + 0,5 \cdot z}$$

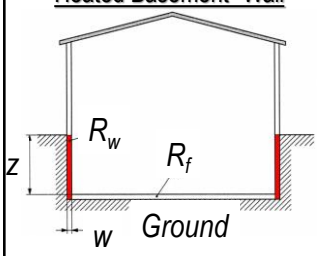
34/50

Výpočet součinitele prostupu tepla

EN ISO 13 370

Thermal transmittance coefficient of ground (heat transfer coefficient)

Heated Basement- Wall



$$d_t = w + \lambda_{ground} \cdot \left(R^t_{si} + R_f + R_{se}\right) \Rightarrow R^t_{si} = 0{,}17$$

$$d_w = \lambda_{ground} \cdot \left(R^w_{si} + R_w + R_{se}\right) \Rightarrow R^w_{si} = 0{,}13$$

$$d_w \geq d_t \Rightarrow U_{wall} = \frac{2 \cdot \lambda_{ground}}{\pi \cdot z} \cdot \left(1 + \frac{0{,}5 \cdot d_t}{d_t + z}\right) \ln\left(\frac{z}{d_w} + 1\right)$$

$$d_w < d_t \Rightarrow U_{wall} = \frac{2 \cdot \lambda_{ground}}{\pi \cdot z} \cdot \left(1 + \frac{0{,}5 \cdot d_t}{d_w + z}\right) \ln\left(\frac{z}{d_w} + 1\right)$$

35/50

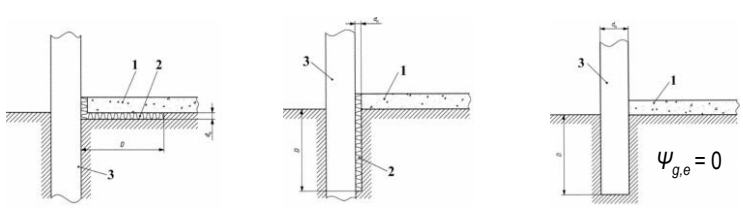
Heat Load According to EN 12831-1

Heat Transfer Coefficient to the Ground

EN ISO 13 370

$$H_{T,g} = \left[A_{floor} \cdot \left(U_g + \frac{2 \cdot \Psi_{g,e}}{B'}\right) + O_g \cdot \left(\Psi_g + \Psi_{g,e}\right)\right] \cdot G_w$$

Ψ_g - Linear Heat Transfer Coefficient (wall/floor connection) [W/m·K]
$\Psi_{g,e}$ - Linear Heat Transfer Coefficient („more“ floor edge insulation) [W/m·K]
O_g - Total Floor Perimeter [m]
G_w - Correction Factor Taking Account the Influence of Ground Water [-]



36/50

Heat Load According to EN 12831-1

Heat Transfer Coefficient to the Ground **EN ISO 13 370**

$$H_{T,g} = \left[A_{floor} \cdot \left(U_g + \frac{2 \cdot \Psi_{g,e}}{B'} \right) + O_g \cdot \left(\Psi_g + \Psi_{g,e} \right) \right] \cdot G_w$$

Ψ_g - Linear Heat Transfer Coefficient (wall/floor connection) [W/m·K]
$\Psi_{g,e}$ - Linear Heat Transfer Coefficient („more“ floor edge insulation) [W/m·K]
O_g - Total Floor Perimeter [m]
G_w - Correction Factor Taking Account the Influence of GroundWater [-]

G_w = 1,0 (dry)

G_w = 1,15 (wet, h < 1 m)

37/50

Heat Load According to EN 12831-1

Heat Transfer Coefficient to the Ground **EN ISO 13 370**

$$H_{T,g} = \left[A_{floor} \cdot \left(U_g + \cancel{\frac{2 \cdot \Psi_{g,e}}{B'}} \right) + O_g \cdot \left(\Psi_g + \cancel{\Psi_{g,e}} \right) \right] \cdot G_w$$

Ψ_g - Linear Heat Transfer Coefficient (wall/floor connection) [W/m·K]
$\Psi_{g,e}$ - Linear Heat Transfer Coefficient („more“ floor edge insulation) [W/m·K]
O_g - Total Floor Perimeter [m]
G_w - Correction Factor Taking Account the Influence of Ground Water [-]

(Typical Floor)
$\Psi_{g,e} = 0$

$$H_{T,g} = \left[A_{floor} \cdot \left(U_g \right) + O_g \cdot \left(\Psi_g \right) \right] \cdot G_w$$

Typical Values for Ψ_g = (0,05 to 0,15)

38/50

Heat Load According to EN 12831-1

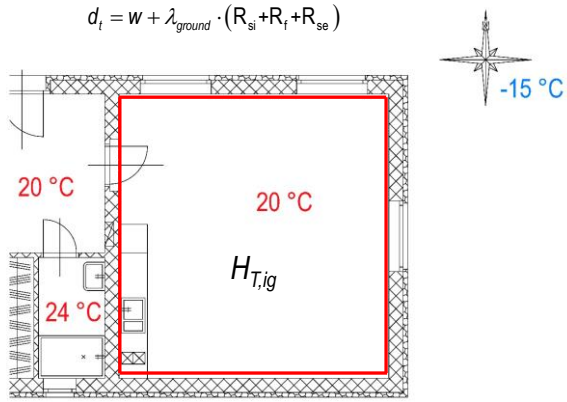
Heat Transfer Coefficient to the Ground

$$H_{T,g} = \left[A_{floor} \cdot \left(U_g \right) + O_g \cdot \left(\Psi_g \right) \right] \cdot G_w$$

$$d_t = w + \lambda_{ground} \cdot \left(R_{si} + R_f + R_{se} \right)$$

Example 6:

A_{floor} = 6 x 6 = 36 [m²]

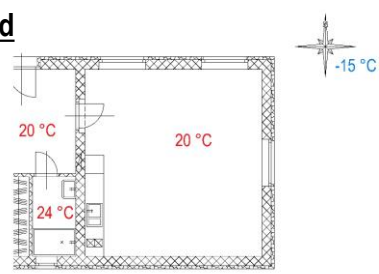


39/50

Heat Load According to EN 12831-1

Heat Transfer Coefficient to the Ground

$$H_{T,g} = \left[A_{floor} \cdot \left(U_g \right) + O_g \cdot \left(\Psi_g \right) \right] \cdot G_w$$



Example 6:

A_{floor} = 6 x 6 = 36 [m²]
w = 0,4 [m]
λ_g = 1,5 (Clay) [W/m·K]
R_f = 4 [m²K/W]

$$B' = \frac{A_g}{0,5 \cdot P} = \ldots$$

$$d_t = w + \lambda_{ground} \cdot \left(R_{si} + R_f + R_{se} \right) = \ldots$$

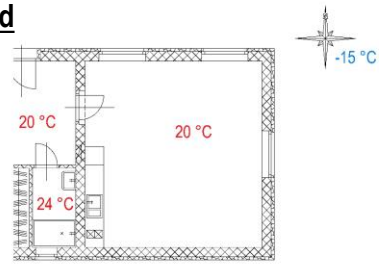
$$d_t < B' \Rightarrow U_g = \frac{2 \cdot \lambda_{ground}}{\pi \cdot B' + d_t} \cdot \ln\left(\frac{\pi \cdot B'}{d_t} + 1 \right) = \ldots \qquad d_t \geq B' \Rightarrow U_g = \frac{\lambda_{ground}}{0,457 \cdot B' + d_t} = \ldots$$

40/50

Heat Load According to EN 12831-1

Heat Transfer Coefficient to the Ground

$$H_{T,g} = \left[A_{floor} \cdot \left(U_g \right) + O_g \cdot \left(\Psi_g \right) \right] \cdot G_w$$



Example 6:

A_{floor} = 6 x 6 = 36 [m^2]
w = 0,4 [m]
λ_g = 1,5 (Clay) [W/m·K]
R_f = 4 [m^{2}K/W]
G_w = 1 [-]

$$H_{T,g} = \ldots$$

41/50

Heat Load According to EN 12831-1

Design Ventilation Heat Loss of Heated Space

$$\Phi_{V,i} = \rho \cdot c_p \cdot q_{V,\min,i} \cdot \left(\theta_{\text{int},i} - \theta_e \right)$$

$$q_{V,\min,i} = n_{\min,i} \cdot V_i$$

$q_{v,min,i}$ - Minimum Air Volume Flow of the Room [m^3/h]
$n_{min,i}$ - Minimum Air Change Rate of the room [h^{-1}]
V_i - Internal volume (Air Volume) of the Room [m^3]

Room type	n_{min} [h^{-1}]
Permanent dwelling areas; e.g. living rooms, offices	0,3 - 0,5
Kitchens, bathrooms, toilets, etc. (with windows)	0,5
Secondary rooms, internal rooms	0,0 – 0,3

42/50

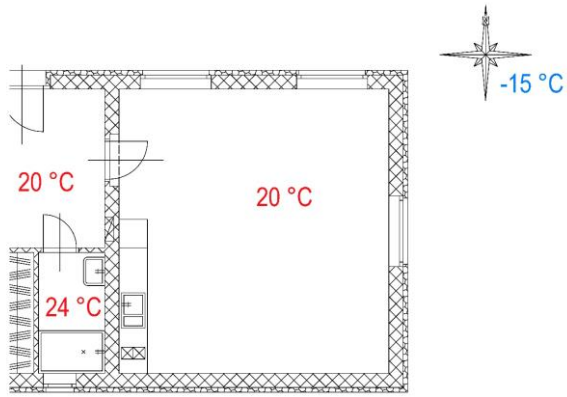
Heat Load According to EN 12831-1

Design Ventilation Heat Loss of Heated Space

$$\Phi_{V,i} = \rho \cdot c_p \cdot q_{V,\min,i} \cdot \left(\theta_{\text{int},i} - \theta_e\right)$$

Example 7:

6 x 6 x 3 m
Living room with kitchen

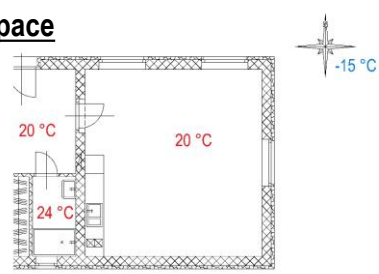


43/50

Heat Load According to EN 12831-1

Design Ventilation Heat Loss of Heated Space

$$\Phi_{V,i} = \rho \cdot c_p \cdot q_{V,\min,i} \cdot \left(\theta_{\text{int},i} - \theta_e\right)$$



Example 7:

6 x 6 x 3 m
Living room with kitchen

ρ_{air} = 1,2 [kg/m^3]
c_{air} = 1010 [J/kg·K]

$$q_{V,\min,i} = n_{\min,i} \cdot V_i = \ldots$$ **!!! m^3/h !!!**

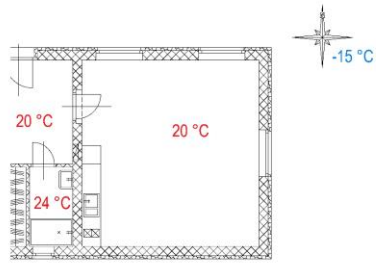
$$\Phi_{V,i} = \rho \cdot c_p \cdot q_{V,\min,i} \cdot \left(\theta_{\text{int},i} - \theta_e\right) = \ldots$$

!!! needs to be recalculated to m^3/s !!!

44/50

Heat Load According to EN 12831-1

Example 4 to 7:



$$H_{T,ie} = \ldots$$

$$H_{T,ia(\ldots),k} = \ldots$$

$$H_{T,g} = \ldots$$

$$\Phi_{T,i} = \left(H_{T,ie} + \sum H_{T,ia(\ldots)} + H_{T,ig} \right) \cdot \left(\theta_{int,i} - \theta_e \right) = \ldots$$

$$\Phi_{V,i} = \ldots$$

Total Design Heat Load Our Room is?

$$\Phi_{HL,i} = \ldots$$

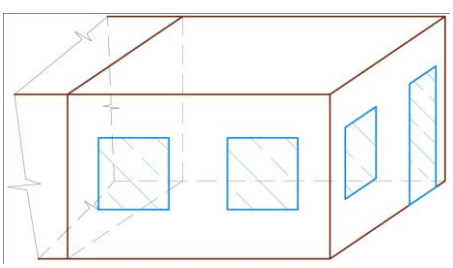
45/50

Heat Load According to EN 12831-1

Final Example:

Calculate the total design heat load (according to the picture). It is a **living room**.

U_{wall} = 0,18 [W/m²·K], U_{window} = U_{door} = 1,10 [W/m²·K], U_{roof} = 0,15 [W/m²·K], U_{floor}= 0,20 [W/m²·K]).



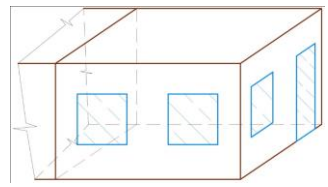
Wall length L_1 = 8 m, L_2 = 6 m,
Wall height H = 3 m,
Windows dimensions 1,5 x 1 m,
Door dimensions 2 x 0,9 m,

$\theta_{int,v}$ = 20 °C, θ_e = -15 °C,
θ_i = 10 °C (adjacent heated space),

46/50

Heat Load According to EN 12831-1

Sulution: ΔU_{TB} = 0,05 W/m²·K



Directly to Exterior

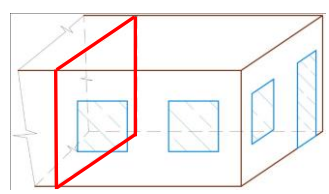
$$H_{T,ie} = \sum_k \left[A_k \cdot \left(U_k + \Delta U_{TB} \right) \cdot f_{U,k} \cdot f_{ie,k} \right]$$

Building elements	$U_k + \Delta U_{TB}$ [W/m²·K]	Area A_k [m²]	$A_k \cdot (U_k + \Delta U_{TB})$ [W/K]
Walls			
Roof			
Windows			
Door			
		Total	30,9

47/50

Heat Load According to EN 12831-1

Solution:



Adjacent Spaces

$$f_{ia(...),k} = \frac{\theta_{\text{int},i} - \theta_{ia(...)}}{\theta_{\text{int},i} - \theta_e} = \ldots$$

$$U_{\text{inner wall}} = 1,3 \left[\text{W/m}^2 \cdot \text{K} \right]$$

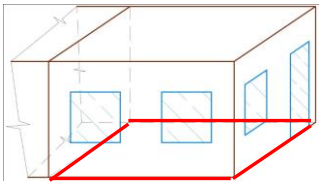
$$H_{T,ia(...),k} = \sum_k (A_k \cdot U_k \cdot f_{ia(...),k}) = \ldots$$

48/50

Heat Load According to EN 12831-1

Solution:

Ground



$$H_{T,g} = \left[A_{floor} \cdot \left(U_g \right) + O_g \cdot \left(\Psi_g \right) \right] \cdot G_w = \ldots$$

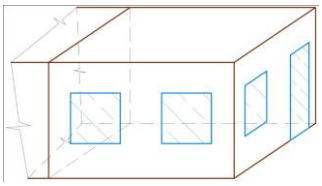
Ψ_g = 0,05
G_w = 1 (floor is not below grounwater level)

49/50

Heat Load According to EN 12831-1

Solution:

Ventilation Heat Loss



$$q_{V,\min,i} = n_{\min,i} \cdot V_i = \ldots$$

$$\Phi_{V,i} = \rho \cdot c_p \cdot q_{V,\min,i} \cdot \left(\theta_{\text{int},i} - \theta_e \right) = \ldots$$

50/50

Heat Load According to EN 12831-1

Solution:

$$\Phi_i = \Phi_{T,i} + \Phi_{V,i}$$

$$\Phi_i = \left[(\ldots + \ldots + \ldots) \cdot \left(20 - (-15) \right) \right] + \ldots$$

$$\Phi_i = \ldots \left[\mathrm{W} \right]$$

51/50

FACULTY OF MECHANICAL ENGINEERING CTU IN PRAGUE

THANK YOU FOR YOUR ATTENTION

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52/50