Saint-Gobain Construction Products Rus LLC

Thermo-technical calculation

SP 50.13330.2012

"Thermal protection of buildings"

VIRMAK

2020

Initial data

Type of construction: Sandwich wall

Territory: Krasnodar Region, Krasnodar

t_{ext} Design external air temperature: (reliability of 0.92, SP 131.13330.2012 t.3.1)	- 16 °C
t_{ht} Design average air temperature of heating season: (with daily average temperature t ≤ 8°C, SP 131.13330.2012 t.3.1)	2.5 °C
z_{ht} Duration of heating season: (with daily average temperature t ≤ 8°C, SP 131.13330.2012 t.3.1)	145 days
Humidity area	dry

Intended use of building and room

Building: residential unit

Room: habitable room

Coefficient a: (SP 50.13330.2012, t.3)	0.00035
Coefficient b: (SP 50.13330.2012, t.3)	1.4
a_{int} - Internal film heat-transfer coefficient: (as per SP 50.13330.2012, t.4)	8.7
Rate temperature drop between temperature of internal air and temperature of internal surface of enclosing structure: (as per SP 50.13330.2012, t.5)	4°C
a_{ext} - External film heat-transfer coefficient: (as per SP 50.13330.2012, t.6)	12
t_{int} Temperature of staying: (as per GOST 30494-2011)	20°C
ϕ - Relative humidity: (as per GOST 30494-2011, SP 131.13330.2012, t.3.1)	no more than 60%
Moist room conditions: (SP 50.13330.2012, t.1)	regular
Enclosing structures operation practices: (SP 50.13330.2012, t.2)	A
Coefficient of structure uniformity r: (as per GOST R 54851-2011)	0.8
Dependency ratio of enclosing structure position n: (SP 50.13330.2012, f.5.3)	1

Makeup of structure

No.	Layer	Thickness, mm	Note
1	Cement bonded particleboard	12	λ = 58 W/(m °C)
2	Thermal insulating layer ISOVER Sandwich LIFE	110	λ = 0.04 W/(m °C) μ = 0.3 mg/ m·h·Pa
3	Cement bonded particleboard	12	λ = 58 W/(m °C)

Heating season degree-day (HSDD):
(SP. 50.13330.2012 f.5.2)

$$HSDD=\left(t_{int}-t_{ht}\right)\times z_{ht}=\left(20-2.5\right)\times 145=2537.5\frac{°C\times days}{year}$$

Normalized heat transfer resistance:
(SP 50.13330.2012)

$$R_{0}^{norm}=\left(a\times HSDD+b\right)\times n=\left(0.00035\times 2537.5+1.4\right)\times 1=2.288\frac{m^{2}\times °C}{W}$$

Calculation of heat transfer resistance

CBPB, homogeneous layer, δ=12 mm, λ =58 W/(m °C)

Heat transfer resistance:

$$R_{1}=\frac{\delta}{\lambda}=\frac{12\times 10^{-3}}{58}=0\frac{m^{2}\times °C}{W}$$

CBPB, homogeneous layer, δ=12 mm, λ =58 W/(m °C)

Heat transfer resistance:

$$R_{2}=\frac{\delta}{\lambda}=\frac{12\times 10^{-3}}{58}=0\frac{m^{2}\times °C}{W}$$

Calculation of an approximate heat transfer resistance of insulant

$$R_{ins}=\frac{R_{0}^{norm}}{r}-R_{1}-R_{2}-\frac{1}{\alpha_{int}}-\frac{1}{\alpha_{ext}}=$$

$$\frac{2.288}{0.8}-0-0-\frac{1}{8.7}-\frac{1}{12}=2.662\frac{m^{2}\times °C}{W}$$

Calculation of an approximate thickness of insulant layer from condition:

$$R_{ins}=\frac{\delta_{ins}}{\lambda_{ins}}=2.662\frac{m^{2}\times °C}{W}$$

where λ_{ins} = 0.04 W/(m °C)

$$\delta_{ins}=R_{ins}\times\lambda_{ins}=2.662\times 0.04=106.48\ mm$$

Due to the multiplicity of materials, the thickness of thermal insulating layer is taken to be equal to δ_{thick} = 110 mm. Then the reduced total thermal resistance:

$$R_{rd}=r\times\left(\frac{1}{\alpha_{int}}+\frac{1}{\alpha_{ext}}+\frac{\delta_{thick}}{\lambda_{ins}}+R_1+R_2\right)=$$

$$0.8\times\left(\frac{1}{8.7}+\frac{1}{12}+\frac{110\times10^{-3}}{0.04}+0+0\right)=2.359\,\frac{m^2\times{}^\circ C}{W}$$

The condition $R_{0norm} \leq R_{rd}$ is fulfilled: 2.288 ≤ 2.359.

Sanitary requirements

Calculation of temperature drop between temperature of internal air and temperature of internal surface of enclosing structure:

$$\Delta t_{dr}=\frac{n\times\left(t_{int}-t_{ext}\right)}{R_{thick}\times\alpha_{int}}=\frac{1\times\left(20+16\right)}{2.359\times8.7}=1.75^\circ C$$

The condition $\Delta t_{rated} \geq \Delta t_{dr}$ is fulfilled: 4≥1.75

The temperature of internal surface – Ti, °C of enclosing structure (not including heat-conducting factor) shall be calculated according to the formula:

$$T_i=t_{int}-\Delta t_{dr}=20-1.75=18.25^\circ C$$

The condition $Ti \geq t_{cond}$ is fulfilled : 18.25 ≥ 12

where t_{cond} stands for condensing point temperature.

$$\gamma\left(t_{int},\phi\right)=\frac{17.27\times t_{int}}{237.7+t_{int}}+\log\left(\phi\times0.01\right)=\frac{17.27\times20}{237.7+20}+\log\left(60\times0.01\right)=0.83$$

$$t_{cond}=\frac{237.7\times\gamma\left(t_{int},\phi\right)}{17.27-\gamma\left(t_{int},\phi\right)}=12^\circ C$$

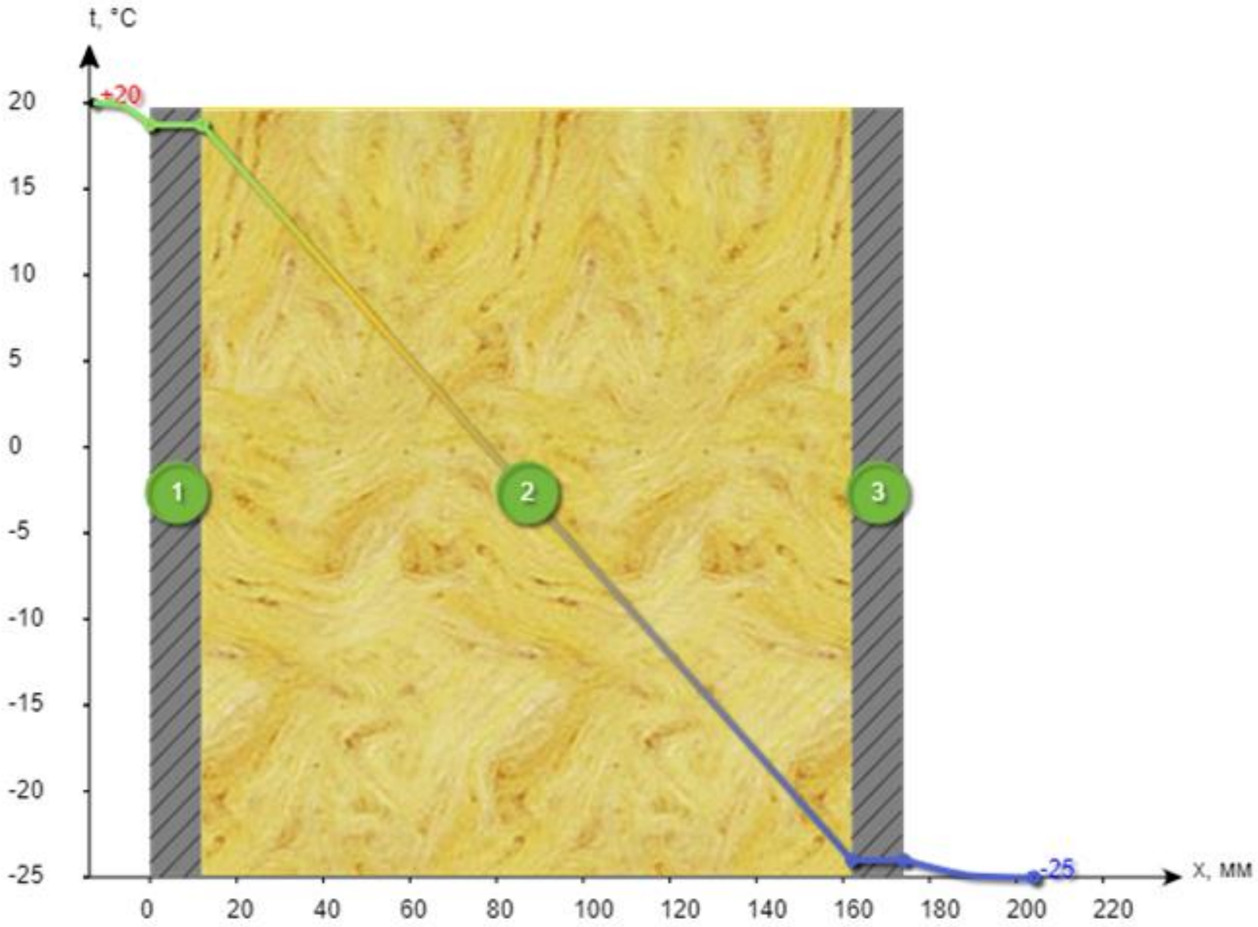
Heating pattern in structural section

The temperature t_x, °C of enclosing structure in plane corresponding to the layer x boundary, shall be calculated according to the formula:

$$t_x\left(x\right)=t_{int}-\frac{\left(t_{int}-t_{ext}\right)\times R_x\left(x\right)}{R_{rd}}$$

$$R_x(x)=\frac{1}{\alpha_{int}}+\sum_{i=1}^{x}R_i$$

where x stands for the number of layer, x=0 stands for the internal space, R_i stands for heat transfer resistance of layer with number I, in the direction from internal space.



Point 1: t_{int} = 20°C – temperature inside the room

Point 2: $t_x(0)$ = 18.66°C – temperature at the internal boundary of layer No.1 – *"CBPB"*

$$R_x(0)=\frac{1}{\alpha_{int}}+\sum_{i=1}^{0}R_i=\frac{1}{8.7}=0.11\frac{m^2\times{}^\circ C}{W}$$

$$t_x(0)=t_{int}-\frac{\left(t_{int}-t_{ext}\right)\times R_x(0)\times r}{R_{rd}}=20-\frac{(20+16)\times 0.11\times 0.8}{2.359}=18.66{}^\circ C$$

Point 3: $t_x(1)$ = 18.66°C – temperature at boundary of layer No.1 *"CBPB"* and layer No.2 *ISOVER Sandwich Life*

$$R_x(1)=\frac{1}{\alpha_{int}}+\sum_{i=1}^{1}R_i=\frac{1}{8.7}+0=0.11\frac{m^2\times{}^\circ C}{W}$$

$$t_x(1) = t_{int} - \frac{(t_{int} - t_{ext}) \times R_x(1) \times r}{R_{rd}} = 20 - \frac{(20+16) \times 0.11 \times 0.8}{2.359} = 18.66°C$$

Point 4: $t_x(2)$ = -14.92°C – temperature at boundary of layer No.2 *ISOVER Sandwich Life* and layer No.3 "CBPB"

$$R_x(2) = \frac{1}{\alpha_{int}} + \sum_{i=1}^{2} R_i = \frac{1}{8.7} + 0 + 2.75 = 2.86 \frac{m^2 \times °C}{W}$$

$$t_x(2) = t_{int} - \frac{(t_{int} - t_{ext}) \times R_x(2) \times r}{R_{rd}} = 20 - \frac{(20+16) \times 2.86 \times 0.8}{2.359} = -14.92°C$$

Point 5: $t_x(3)$ = -14.92°C – temperature at the outside boundary of layer No. 3 - *"CBPB"*

$$R_x(3) = \frac{1}{\alpha_{int}} + \sum_{i=1}^{3} R_i = \frac{1}{8.7} = 2.86 \frac{m^2 \times °C}{W}$$

$$t_x(3) = t_{int} - \frac{(t_{int} - t_{ext}) \times R_x(3) \times r}{R_{rd}} = 20 - \frac{(20+16) \times 2.86 \times 0.8}{2.359} = -14.92°C$$

Point 6: t_{ext} = -16°C - outside temperature

Determination of the plane of a maximum moistening (condensation)

This is a calculation procedure based on the use of method of dimensionless characteristics.

The value of f_i ($t_{max.m.}$), an indicative of the temperature in the plane of maximum moistening, shall be calculated for each layer of multilayer structure.

No. of layer	Layer of structure	Rni=δi/μi	μi/λi
Internal surface of enclosing structure		Rint,vp = 0.0266	0
1	CBPB	0	0
2	ISOVER Sandwich Life	0.11 / 0.3 = 0.367	0.3 / 0.04 = 7.5
3	CBPB	0	0
Outside surface of enclosing structure		Rext,vp = 0.0133	0
Rint,vp and Rext,vp – resistance to moisture exchange respectively of internal and outside surfaces of enclosing structure, (m2·h·Pa / mg). *Note:* 1. Resistance to vapour permeability of close air spaces in enclosing structures shall be taken as equal to zero regardless the position and thickness of these spaces. 2. Layers of structure, located between an air space, ventilated with outside air, and outside surface of enclosing structure shall not be taken into calculation.			

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$$f_i\left(t_{max.moist.}\right)=\frac{5330\times R_{0,dr}\times\left(t_i-t_{ext.bel.zero}\right)\times\mu_i}{R_{0con}\times\left(e_{int}-e_{ext.bel.zero}\right)\times\lambda_i}$$

$$R_{0,dr}=\sum_i\frac{\delta_i}{\mu_i}=0.0266+0+0.367+0+0.0133=0.4069\frac{m^2\times h\times Pa}{mg}$$

E_{sat} - partial pressure of saturated steam, Pa, at the air temperature from -40 to + 45 °C is determined according to the formula:

$$E(t)=1.84\times10^{11}\times\exp\left(\frac{-5330}{273+t}\right)$$

For the temperature t_{sat} = 20 °C:

$$E_{sat}=E(20)=1.84\times10^{11}\times\exp\left(\frac{-5330}{273+20}\right)=2314.79\text{ Pa}$$

e_{int} - partial pressure of saturated steam of internal air, Pa, at the designed temperature and relative humidity in room is determined according to the formula:

$$e_{int}=\left(\frac{\phi_{int}}{100}\right)\times E_{sat}=\left(\frac{60}{100}\right)\times2314.79=1388.87\text{ Pa}$$

$e_{ext.bel.zero}$ - partial pressure of saturated steam of external air for the period of months with below zero monthly average temperature is determined according to SP 131.13330:

$$e_{ext.bel.zero} = 100 \times 4.9 = 490 \text{ Pa}$$

$t_{ext.bel.zero}$ – average temperature of external air for the period of months with below zero monthly average temperature is determined according to SP 131.13330:

$$t_{ext.bel.zero} = -0.2 = -0.2 \text{ °C}$$

μi/λi – the ratio of heat-transfer coefficients, W/(m2 x °C), and steam permeability, mg/(m x h x Pa), of material of corresponding layer, or 0 if the coefficients are not set.

$$f_i\left(t_{max.moist.}\right)=\frac{5330\times R_{0,rd}\times\left(t_i-t_{ext.bel.zero}\right)\times\mu_i}{R_{0con}\times\left(e_{int}-e_{ext.bel.zero}\right)\times\lambda_i}=\frac{5330\times0.4069\times(20+0.2)\times\mu_i}{2.949\times(1388.87-490)\times\lambda_i}=16.53\times\left(\frac{\mu_i}{\lambda_i}\right)$$

$$f_1\left(t_{max.moist.}\right)=16.53\times 0=0$$

$$f_2\left(t_{max.moist.}\right)=16.53\times 7.5=123.98$$

$$f_3\left(t_{max.moist.}\right)=16.53\times 0=0$$

According to SP 50.13330 table 11, when $f_i(t_{max.moist})$ is not negative, than $t_{max.moist}$ can be calculated according to formula:

$$t_{max.moist.}=\frac{\left(a\times b+c\times f\left(t_{max.moist}\right)^{d}\right)}{\left(b+f\left(t_{max.moist}\right)^{d}\right)}$$

$$a=96.6680675349$$
$$b=4.89349504771$$
$$c=-66.4983819958$$
$$d=0.406903783624$$

$$t_{max.moist.1}=\frac{\left(a\times b+c\times 0^{d}\right)}{\left(b+0^{d}\right)}=96.668$$

$$t_{max.moist.2}=\frac{\left(a\times b+c\times 123.98^{d}\right)}{\left(b+123.98^{d}\right)}=0.027$$

$$t_{max.moist.3}=\frac{\left(a\times b+c\times 0^{d}\right)}{\left(b+0^{d}\right)}=96.668$$

Calculation of temperature at boundaries of layers

$$\tau_{t.layer\,k}=t_i-\left(\frac{t_i-t_{ext.bel.zero}}{R_{0con}}\right)\times\left(\frac{1}{\alpha_{int}}+\sum_{i=1}^{k}R_i\right)$$

where R_i — heat transfer resistance of the layer I (or 0 if this layer is not included in thermo-technical calculation), k – number of layer for which the temperature is calculated.

$$\tau_{t.layer\,0}=20-\left(\frac{20+0.2}{2.949}\right)\times\left(\frac{1}{8.7}\right)=19.21°C$$

$$T_{t.layer\,1} = 20 - \left(\frac{20+0.2}{2.949}\right) \times \left(\frac{1}{8.7} + 0\right) = 19.21°C$$

$$T_{t.layer\,2} = 20 - \left(\frac{20+0.2}{2.949}\right) \times \left(\frac{1}{8.7} + 0 + 2.75\right) = 0.38°C$$

$$T_{t.layer3} = 20 - \left(\frac{20+0.2}{2.949}\right) \times \left(\frac{1}{8.7} + 0 + 2.75 + 0\right) = 0.38°C$$

Summary table $t_{max.moist.}$ and $T_{t.layer\,k}$

This is the table that includes the value of $t_{max.moist.}$ for each layer and temperatures at boundaries of layers (at average temperature of external air in a period of below zero monthly average temperatures):

No. of layer	Layer of the structure	$T_{t.layer\,k}$, °C	$t_{max.moist.}$, °C
0	CBPB	19.21	96.668
1		19.21	
1	ISOVER Sandwich Life	19.21	0.027
2		0.38	
2	CBPB	0.38	96.668
3		0.38	

Determination of the maximum moistening plane

As you can see in the table, there is not a single layer with a temperature of $t_{max.\,moist.}$ within the limits of$\tau_{t.layer}$. Also, there are no pairs of adjacent layers where the condition $t_{max.\,moist.} > \max(\tau_{t.layer})$ for the colder layer and the condition $t_{max.\,moist.} > \max(\tau_{t.layer})$ for the warmer layer are satisfied.

In this case, the plane of maximum moistening is taken on the external surface of the structure. Protection from excessive moistening is not required.
The structural components does not require additional measures to protect against excessive moistening.

Conclusion

The structure is designed to meet the requirements of SP 50.13330.2012 "Thermal protection of buildings" and SP 131.13330.2012 "Construction Climatology".

The thickness of the thermal insulation layer of ISOVER Sandwich Life is 110

mm. According to the calculation:

- The structural components meet the requirements for thermal protection.
- The structural components meet the sanitary and hygienic requirements.
- The structural components does not require additional measures to protect against excessive moistening.

Where to buy

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