THERMAL PERFORMANCE CALCULATION

Façade Engineering and Analysis Services Limited.

Analysis undertaken and report prepared on behalf of XXXXX for

XXXXXXXX
XX

DOCUMENT REF :- XXX/TP/XXXXX Rev 01
Document title :- U value analysis of rainscreen backing wall

Date of original issue :- X XXX XXXX
Revised issue date :-

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Revisions

Rev 01	Initial issue of document	X XXX XXXX

This document provides an assessment of the thermal performance only and does not indicate or contain assessments of the façade suitability regarding any other aspects, including but not limited to, structural and fire resistance. These must be assessed by the client and their specialist engineers.

Summary

This document contains 3-dimensional thermal finite element analysis of the backing wall to support the rainscreen to be installed on the XXXXXX project in XXXXX to provide U value information.

The calculation has been undertaken on behalf of XXXXX.

The wall construction is a ventilated rainscreen system supported on vertical rails and helping hand brackets and fixed back to a supporting SFS wall.

By convention, from BR443, the external rainscreen element is ignored in U value calculations but an amendment to the external surface resistance of the insulating material is made to allow for the sheltering effect of the rainscreen cladding and penetrating brackets through the insulation must be allowed for. See analysis notes for further details.

The nominal construction is as shown on drawing XXXXX and has been assumed for modelling purposes to be a sample area of 600mm (SFS module) x 2850mm (storey height)

The build-up consists of 190mm Rockwool DuoSlab mineral wool insulation (λ = 0.035 W/mK) in the cavity behind the rainscreen mounted onto a Tyvek Firecurb breather membrane covered sheathing board on SFS wall construction.

The sheathing board is 15mm CP board and faces a 150mm uninsulated SFS @ 600mm centres with an assumed 2 layers of 15mm plasterboard with a VCL form internal finishes.

Aluminium helping hand brackets are sized as 75mm long for restraint (single) and 150mm for load (double) brackets with 4 single and 1 double in a module height.

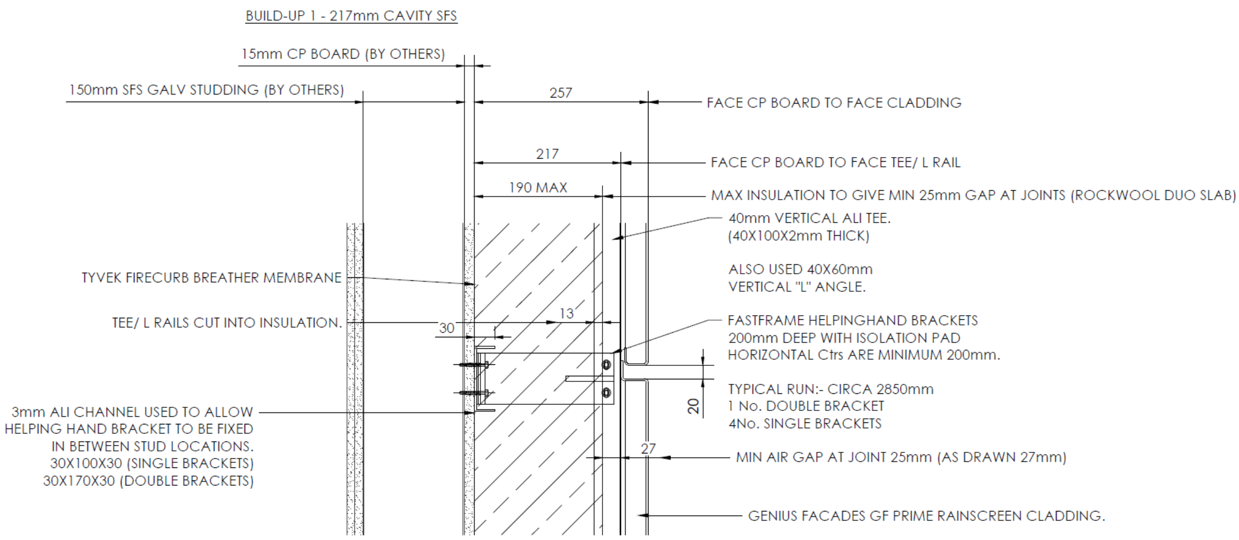
The brackets are fixed to the SFS via a 3mm aluminium channel section (100mm deep at single brackets and 170mm deep at double brackets locations) and a 5mm thick isolating pad has been included between the bracket and the horizontal rail.

Vertical cladding supports penetrate the cavity insulation and are included in this analysis.

Analysis of the examined area shows that the construction achieves a U value of 0.41 W/m^{2}K .

A condensation risk analysis in accordance with BS EN ISO 13788:2002 shows that no condensation will occur in the construction assessed

Wall section detail (extract XXXXX)



Wall U value calculations.

Wall

Based on a 0.6m x 2.850m wall (horizontal bracket centres = 600mm)

Rainscreen backing wall U value

	U value (W/m^2K)	X value (W/K)	Ψ value (W/mK)	Area (m^2)	length (m)	Qty	Q (W/K)
Nom'l U value	0.175			1.710		-	0.299
Load bkt X value		0.115				1	0.115
Load rail Ψ value			0.003		0.600	1	0.002
Wind bkt X value		0.071				4	0.284
Wind rail Ψ value			0.003		0.600	4	0.007
Vert rail Ψ value			0.000		3.000	1	0.000
				1.710			0.707

$$\text{U value} = \frac{0.707}{1.710}$$

U value = 0.41 W/m^2K

The effective U value is calculated from the heat loss from the nominal construction (nom'l U value x area) + heat loss from penetrating brackets (X x number) and rails (Ψ x length). The total heat transfer is divided by the area to give the resulting U value.

3D analysis method

The following thermal analysis was undertaken using "TRISCO ver 15.0.01" 3 dimensional finite elemental analysis software.
This software has been developed by Physibel for 3 dimensional steady state thermal simulation and this produces constant and reliable analysis of constructions measuring heat transfer in rectangular objects.

TRISCO is a thermal analysis program for steady state heat transfer in three-dimensional rectangular objects consisting of different materials and submitted to different boundary conditions. The geometry is described with a list of rectangular blocks, which vertices lie on grid points of a rectangular grid. Materials and surface boundary conditions with different thermal properties are identified using separate colours. Each geometry block is part of either a material or a surface boundary condition region, and has a reference to one of these colours. Node boundary conditions with fixed temperature or power are possible, and can be placed in grid point locations. Also border face boundary conditions in the interface between two colour regions with fixed temperature or heat flux, or (material boundary conditions with fixed temperature or heat power density are possible.

After input of geometry and thermal properties a system of linear equations is calculated based on the energy balance technique, and solved using a fast iterative method. Possible non-linear problems are solved using of different cycles of adjusted linear systems.

These simulations benefit from incorporation of Physibel's RADCON module for additional accuracy in analysis by calculating infrared radiation and convection in a more realistic manner than TRISCO alone.

RADCON is a program add-on module to calculate infrared radiation and convection in a physically more realistic way. The radiation is based on view factors, surface emissivities and surface temperatures. The convection is based on empirical laws.

Material properties such as thermal conductivity (λ values) used in these calculations have been taken from BS EN 12524:2000, BS EN ISO 10077-2:2003 or directly from the Physibel material database.

In addition, specific product thermal conductivity values may be taken from suppliers' own literature in the case of the material not being specifically included in the British Standards.

Equivalent thermal conductivities of ventilated and unventilated air cavities are calculated by the software.

The analyses assume steady state heat flow and therefore any thermal mass effect of any adjacent construction or building component has not been considered.

Analysis output.

Information taken from the resulting software studies and included within the individual analysis includes…..

- Diagrams indicating assigned thermal conductivity values according to appropriate materials and software generated equivalent cavity values if applicable.
- Thermal gradient diagrams indicating temperature across the examined construction.
- Text files showing build-up of material blocks and coordinates used to construct the analysis.
- Text output showing resulting material temperature ranges, U value through the inspected construction and temperature factor indicting internal RH level at which surface condensation could occur.

Note, 3d analysis has been completed for all elements with 3 insulation options but only pictures for the 100mm option included in this compilation to minimise the document size.

From BR443

4.9.5 Rainscreen cladding

Make no allowance in U-value calculations for the effect of the rainscreen cladding itself, because the space behind is fully ventilated. The effect of brackets or rails fixing the cladding to the wall behind needs to be allowed for, if the brackets or rails penetrate an insulation layer or part of an insulation layer.
As the effect of fixing brackets or rails on the U-value of the wall can be large, even when a thermal break pad is included, their contribution to the overall U-value needs to be assessed by a detailed calculation.
The calculation model should omit the cladding but include the fixing rails or brackets to their full length. The external surface resistance should be taken as 0.13 m^2K/W (rather than 0.04 m^2K/W) to allow for the sheltering effect of the cladding (see 4.8.6).
For further information see CAB/CWCT Guide

“centre” U value excluding brackets and condensation risk analysis

Nominal U value is 0.18 W/m²K

A condensation risk analysis in accordance with BS EN ISO 13788:2012 shows that no condensation will occur in the construction assessed.

The rainscreen cladding is such that the cavity beyond is deemed to be “well ventilated” thus the layers are excluded from the results.

Temperature data utilised in the BS EN ISO 13788 calculation is provided by the Met Office from 10 years of historic data. Each temperature being a mean for that month and averaged over 10 years

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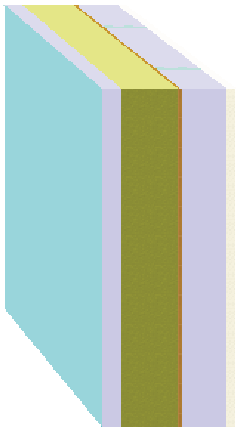
[redacted]

Documentation of the component
Thermal transmittance (U-value) according to Digest 465
Source: **own catalogue - External walls**
Component: [redacted]

OUTSIDE INSIDE



This illustration of inhomogeneous layers is provided only to assist in visualising the arrangement.

Assignment: External wall

		Manufacturer	Name	Thickness [m], number	Lambda [W/(mK)]	Q	R [m²K/W]
		Rse					0.1300
☐	1	BS EN 12524	Aluminium alloys	0.0030	160.000	D	~~0.0000~~
☐	2	BS EN ISO 6946	Well ventilated air layer	0.0670	0.000	D	-
☑	3	Rockwool Ltd	Rainscreen Duo-Slab (>90mm)	0.1900	0.035	E	5.4286
		Fixings	s/s insulation fixing No./m²:	1.5/m²	17.000	E	-
		Fixings	equivalent diameter: 0.004 m / alpha: 0.800				
		Air gaps	Level 1: dU" = 0.01 W/(m²K)				
☑	4	DuPont UK Ltd	Tyvek FireCurb	0.0002	0.500	D	0.0004
☑	5	BS EN 12524	Cement-bonded particleboard	0.0150	0.230	D	0.0652
☑	6	Light steel-frame	consisting of:	0.1500	ø 0.949		0.1581
	6a	BS EN ISO 9646	Unventilated air layer: 150 mm, horiz. heat flow	99.75 %	0.826	E	-
	6b	BS EN 12524	Steel	00.25 %	50.000	D	-
☑	7	BS EN 12524	Polyethylene 0.15 mm	0.0002	0.170	D	0.0009
☑	8	British Gypsum Limited	Gyproc FireLine	0.0150	0.240	D	0.0625
☑	9	British Gypsum Limited	Gyproc FireLine	0.0150	0.240	D	0.0625
		Rsi					0.1300
				0.4553			

☐ was not taken into consideration in the calculation

$R_T = p*R_T' + (1-p)*R_T'' = 6.06$ m²K/W

Correction to U-value for	according to	delta U [W/(m²K)]
Mechanical fasteners	Digest 465	0.0022
Air gaps	BS EN ISO 6946 Annex F	0.0080
		0.0102

$U = 1/R_T + \Sigma\Delta U = 0.18$ W/(m²K)

Q .. The physical values of the building materials has been graded by their level of quality. These 5 levels are the following
A .. A: Data is entered and validated by the manufacturer or supplier. Data is continuously tested by 3rd party.
B .. B: Data is entered and validated by the manufacturer or supplier. Data is certified by 3rd party
C .. C: Data is entered and validated by the manufacturer or supplier.
D .. D: Information is entered by BuildDesk without special agreement with the manufacturer, supplier or others.
E .. E: Information is entered by the user of the BuildDesk software without special agreement with the manufacturer, supplier or others.

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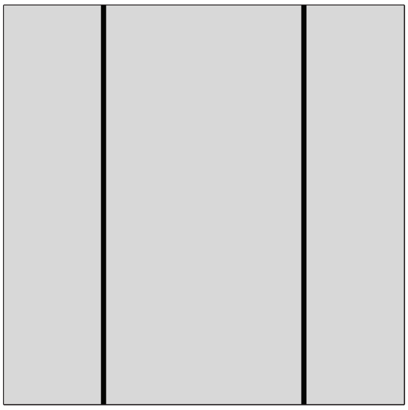
Documentation of the component [redacted]
Thermal transmittance (U-value) according to Digest 465
Source: **own catalogue - External walls**
Component: [redacted]

Steel percentage: 0.25 %



Light steel-frame sections
The portion is given in %.

A	consisting of material layers: 3, 4, 5, 6a, 7, 8, 9	= 99.75%
B	consisting of material layers: 3, 4, 5, 6b, 7, 8, 9	= 0.25%

Upper limit of the thermal transfer resistance R

U_A [W/(m²K)] = $\frac{1}{(\Sigma R_{i,A}) + R_{si} + R_{se}} = \frac{1}{5.80 + 0.13 + 0.13}$ = 0.16

U_B [W/(m²K)] = $\frac{1}{(\Sigma R_{i,B}) + R_{si} + R_{se}} = \frac{1}{5.62 + 0.13 + 0.13}$ = 0.17

$$R_T' = \frac{1}{A * U_A + B * U_B} = 6.06 \text{ m}^2\text{K/W}$$

Lower limit of the thermal transfer resistance R

R_{se} [m²K/W]		= 0.13
R_3'' [m²K/W] = d_3/λ'_3=	0.1900 / 0.035	= 5.43
R_4'' [m²K/W] = d_4/λ_4=	0.0002 / 0.500	= 0.00
R_5'' [m²K/W] = d_5/λ_5=	0.0150 / 0.230	= 0.07
R_6'' [m²K/W] = $d_6/(\lambda_{6a} * A + \lambda_{6b} * B)$ =	0.1500 /(0.826 * 99.75% + 50.000 * 0.25%)	= 0.16
R_7'' [m²K/W] = d_7/λ_7=	0.0002 / 0.170	= 0.00
R_8'' [m²K/W] = d_8/λ_8=	0.0150 / 0.240	= 0.06
R_9'' [m²K/W] = d_9/λ_9=	0.0150 / 0.240	= 0.06
R_{si} [m²K/W]		= 0.13

$$R_T'' = \Sigma R_i'' + R_{si} + R_{se} = 6.04 \text{ m}^2\text{K/W}$$

Kind of frame:	Hybrid frame
Flange width:	known not to exceed 50 mm
Stud spacing s [m]:	0.600
Stud depth d [m]:	0.150
Web thickness t [m]:	0.00150
Steel percentage [%]:	0.25

Weight factor p
Formula: $p = 0,8 * (R_T''/R_T') + 0,32 - 0,2 * (0,6/s) - 0,04 * (d/0,1)$ = **0.857**

$$R_T = p*R_T' + (1-p)*R_T'' = 6.06 \text{ m}^2\text{K/W}$$

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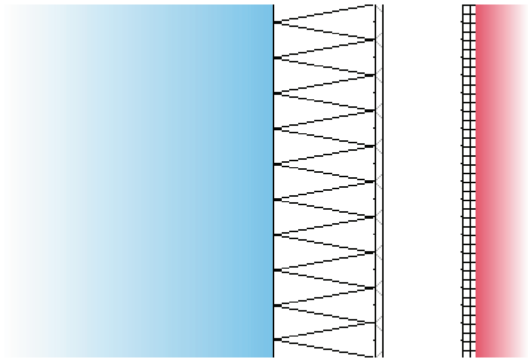
Documentation of the component [redacted]
Calculation according BS EN ISO 13788
Source: **own catalogue - External walls**
Component: [redacted]

OUTSIDE INSIDE



The list of material layers shown below may differ from those in the U-value calculation printout. Only material layers which are used in the Condensation Risk Analysis are listed.

This calculation of the Condensation risk analysis according to BS EN ISO 13788 has been performed on a construction containing inhomogeneous layers. This calculation is only valid through the selected section. It is advisable that you should also select the alternative position and recalculate the Condensation Risk Analysis for a more complete assessment of the construction. For further information the user is advised to follow the guidance in BS 5250:2021 Management of moisture in buildings

Assignment: External wall

Name	Thickn. [m]	lambda [W/(mK)]	Q	μ [-]	Q	sd [m]	R [m²K/W]
Rainscreen Duo-Slab (>90mm)	0.1900	0.035	E	1.00	E	0.19	5.4286
Tyvek FireCurb	0.0002	0.500	D	8.33	D	0.00	0.0004
Cement-bonded particleboard	0.0150	0.230	D	30.00	D	0.45	0.0652
Unventilated air layer: 150 mm, horiz. heat flow	0.1500	0.826	E	1.00	E	0.15	0.1816
Polyethylene 0.15 mm	0.0002	0.170	D	300000.00	D	45.00	0.0009
Gyproc FireLine	0.0150	0.240	D	10.00	D	0.15	0.0625
Gyproc FireLine	0.0150	0.240	D	10.00	D	0.15	0.0625

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[redacted]

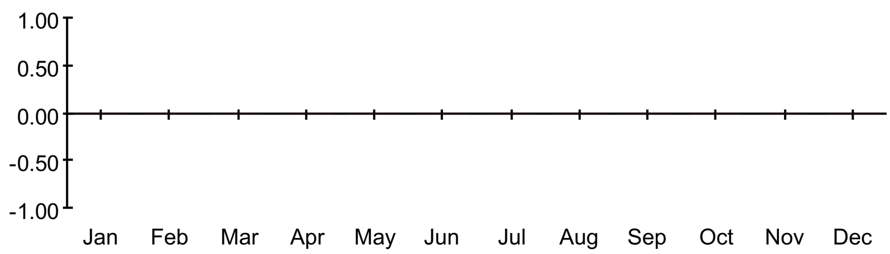
Documentation of the component
Calculation according BS EN ISO 13788
Source: **own catalogue - External walls**
Component: [redacted]

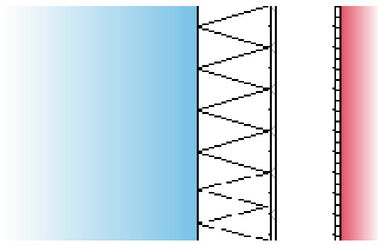
Condensation risk analysis - summary of main results
Calculation according BS EN ISO 13788

Surface temperature to avoid critical surface moisture:
No danger of mould growth is expected.

Interstitial condensation:
No condensation is predicted at any interface in any month.

Interstitial condensation and evaporation per month gc [g/m²]





Component, condensation range

Condensation Risk Analysis calculations according to BS EN ISO 13788 are used as a guide in predicting interstitial condensation. This methodology uses some simplifications of the dynamic processes involved and subsequently does have some limitations. For further information the user is advised to follow the prescriptive guidance in BS 5250:2021 Management of moisture in buildings – Code of practice & BRE Information Paper:IP2/O5 (Feb. 2005) 'Modelling and controlling interstitial condensation

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Documentation of the component [redacted]
Calculation according BS EN ISO 13788
Source: **own catalogue - External walls**
Component: [redacted]

Surface temperature to avoid critical surface humidity Calculation according BS EN ISO 13788

Location: Manchester Airport; Humidity class according BS EN ISO 13788 annex A: legacy; Dwellings with high occupancy; Return period according BS 5250:2021 Once in 10 years (-1°C Ext Temp, +4% Ext RH)

		1	2	3	4	5	6	7	8	9	10	11	12
	Month	Te	phi_e	Ti	phi_i	pe	delta p	pi	ps(Tsi)	Tsi,min	fRsi	Tsi	Tse
		[°C]	---	[°C]	---	[Pa]	[Pa]	[Pa]	[Pa]	[°C]	---	[°C]	[°C]
●	January	3.2	0.870	20.0	0.713	668	998	1666	2083	18.2	0.890	19.3	3.3
	February	3.1	0.840	20.0	0.704	641	1004	1645	2056	17.9	0.878	19.3	3.2
	March	4.8	0.800	20.0	0.681	688	903	1591	1988	17.4	0.830	19.4	4.9
	April	6.8	0.750	20.0	0.652	741	784	1525	1906	16.7	0.754	19.5	6.9
	May	10.3	0.720	20.0	0.632	902	576	1478	1847	16.3	0.614	19.6	10.4
	June	13.1	0.750	20.0	0.659	1130	410	1540	1925	16.9	0.551	19.7	13.1
	July	15.1	0.760	20.0	0.682	1304	291	1595	1993	17.5	0.481	19.8	15.1
	August	14.8	0.780	20.0	0.694	1312	309	1621	2027	17.7	0.561	19.8	14.8
	September	12.3	0.810	20.0	0.691	1158	457	1616	2019	17.7	0.696	19.7	12.4
	October	9.3	0.850	20.0	0.698	995	636	1631	2039	17.8	0.796	19.6	9.4
	November	5.7	0.860	20.0	0.700	787	849	1637	2046	17.9	0.851	19.4	5.8
	December	4.2	0.880	20.0	0.712	725	939	1664	2080	18.1	0.882	19.4	4.3

● The critical month is January with $f_{Rsi,max}$ = 0.890
f_{Rsi} = 0.959

$f_{Rsi} > f_{Rsi,max}$, the component complies.

Nr Explanation
1 External temperature
2 External rel. humidity
3 Internal temperature
4 Internal relative humidity
5 External partial pressure $p_e = \phi_e * p_{sat}(T_e)$; $p_{sat}(T_e)$ according formula E.7 and E.8 of BS EN ISO 13788
6 Partial pressure difference. The security factor of 1.10 according to BS EN ISO 13788, ch.4.2.4 is already included.
7 Internal partial pressure $p_i = \phi_i * p_{sat}(T_i)$; $p_{sat}(T_i)$ according formula E.7 and E.8 of BS EN ISO 13788
8 Minimum saturation pressure on the surface obtained by $p_{sat}(T_{si}) = p_i / \phi_{si}$,
where ϕ_{si} = 0.8 (critical surface humidity)
9 Minimum surface temperature as function of $p_{sat}(T_{si})$, formula E.9 and E.10 of BS EN ISO 13788
10 Design temperature factor according 3.1.2 of BS EN ISO 13788
11 Internal surface temperature, obtained from $T_{si} = T_i - R_{si} * U * (T_i - T_e)$
12 External surface temperature, obtained from $T_{se} = T_e + R_{se} * U * (T_i - T_e)$

Documentation of the component [redacted]
Calculation according BS EN ISO 13788
Source: **own catalogue - External walls**
Component: [redacted]

Interstitial condensation - main results
Calculation according BS EN ISO 13788

No condensation is predicted at any interface in any month.

Climatic conditions
Location: Manchester Airport; Humidity class according BS EN ISO 13788 annex A: legacy; Dwellings with high occupancy; Return period according BS 5250:2021 Once in 10 years (-1°C Ext Temp, +4% Ext RH)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Internal temperature [°C]	Ti	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Internal rel. humidity [%]	phi_i	71.3	70.4	68.1	65.2	63.2	65.9	68.2	69.4	69.1	69.8	70.0	71.2
External temperature [°C]	Te	3.2	3.1	4.8	6.8	10.3	13.1	15.1	14.8	12.3	9.3	5.7	4.2
External rel. humidity [%]	phi_e	87.0	84.0	80.0	75.0	72.0	75.0	76.0	78.0	81.0	85.0	86.0	88.0

Double Bracket

X value analysis.

- Material thermal conductivity diagram.
- Temperature gradient diagrams.
- FEA input data sheet.
- FEA output data sheet.

Finite element analysis undertaken using TRISCO version 15.0.01 software.

Summary.

A sample area of 600mm x 600mm was examined, and the X value of the bracket was found to be **0.115 W/K**

X value calculation

With bracket

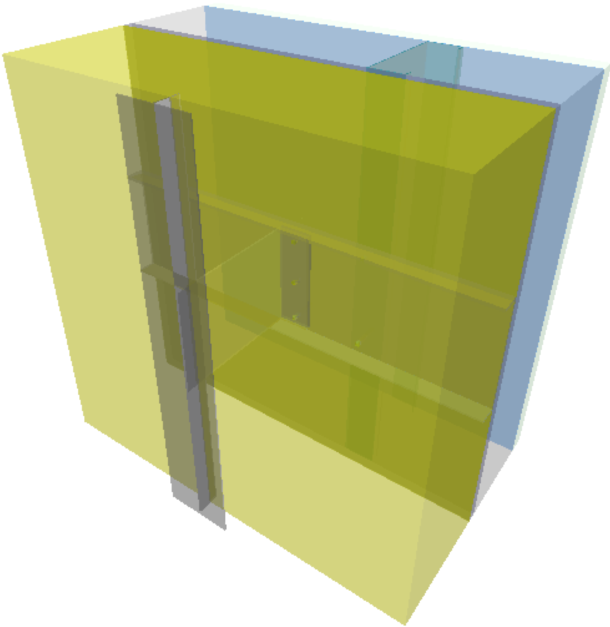
Q =	3.552	W
Δt =	20	K
A =	0.360	m^2
$Q/\Delta t$ =	0.178	W/K

Without bracket

Q =	1.244	W
Δt =	20	K
A =	0.360	m^2
$Q/\Delta t$ =	0.062	W/K

$X = (Q_{bkt}/\Delta T) - (Q_{nobkt}/\Delta T)$

X = 0.115 W/K



Material Thermal Conductivity Diagram.

Wall section = 600mm x 600mm
Q = 3.552W

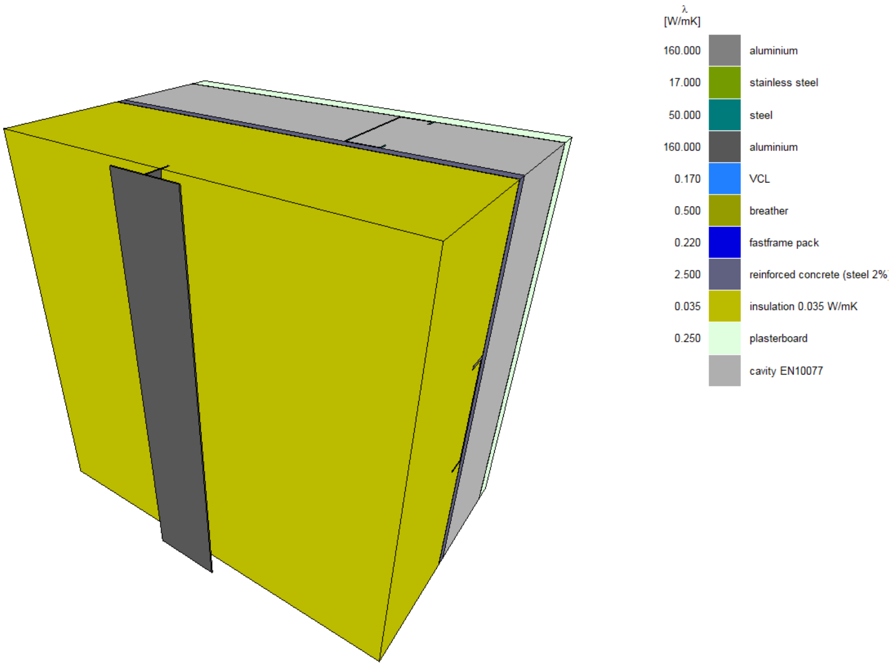


Figure 11 External material thermal conductivity diagram

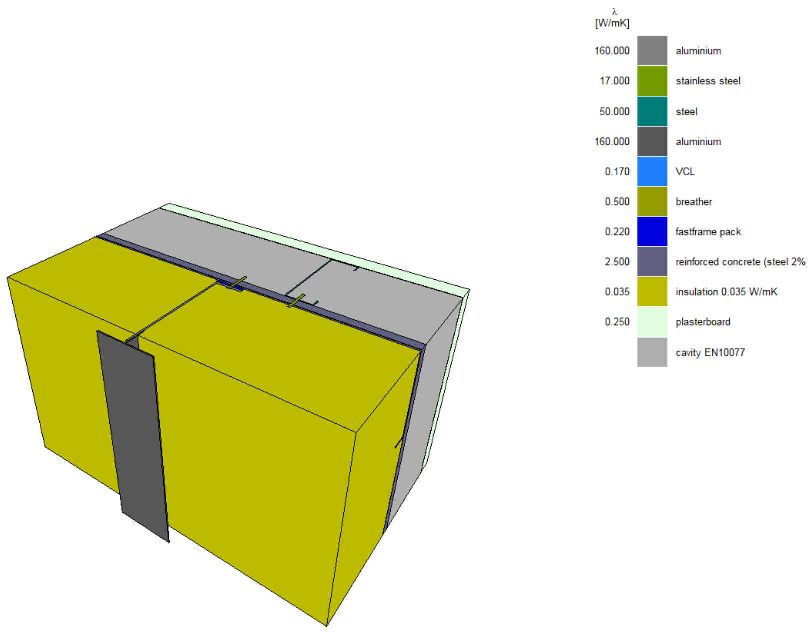


Figure 12 Cut through bracket thermal conductivity diagram

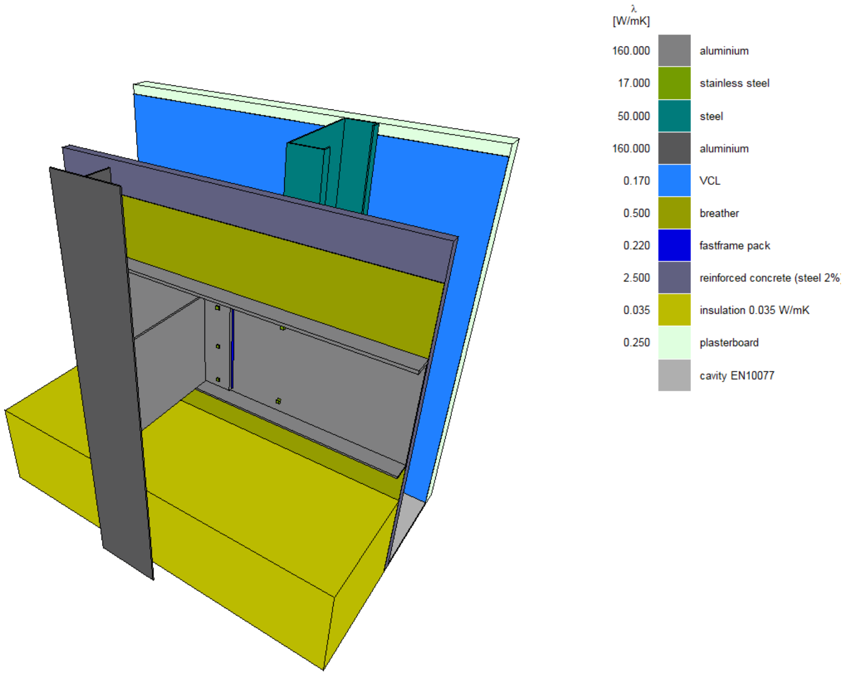


Figure 13 Thermal conductivity diagram –materials cut back for clarity

Temperature Gradient Diagrams

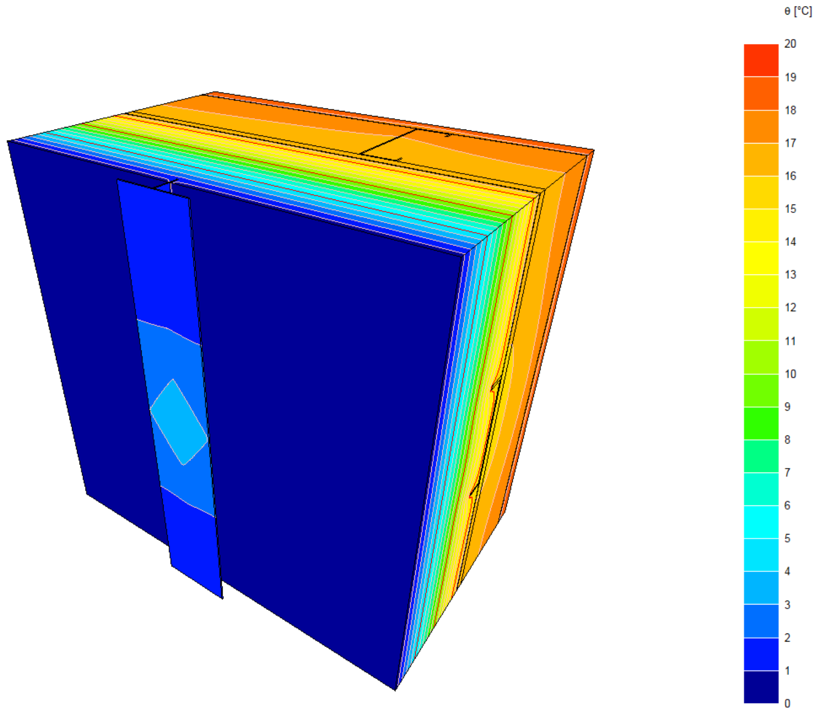


Figure 14 External temperature gradient diagram

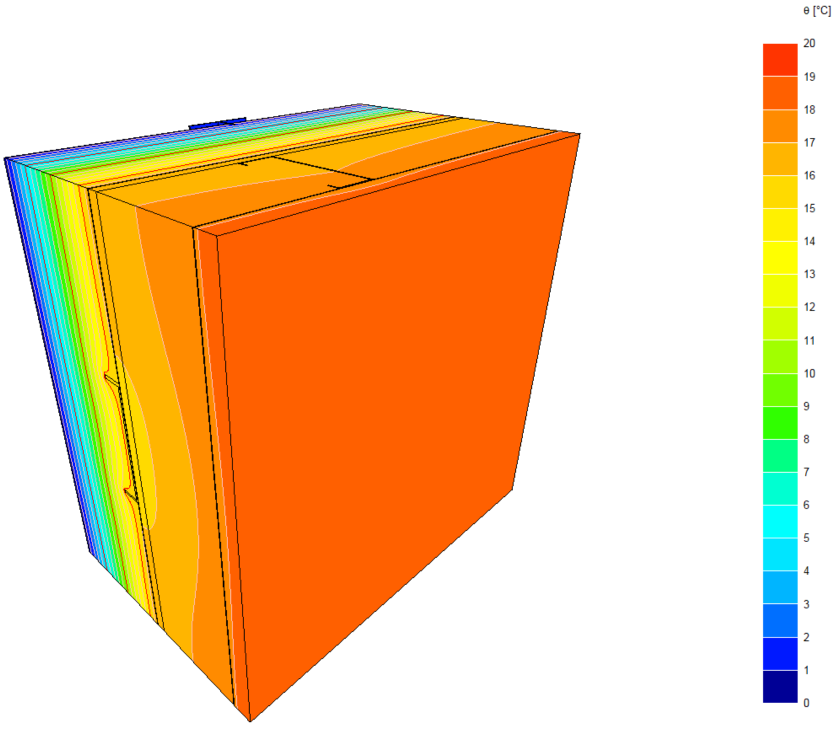


Figure 15 Internal temperature gradient diagram

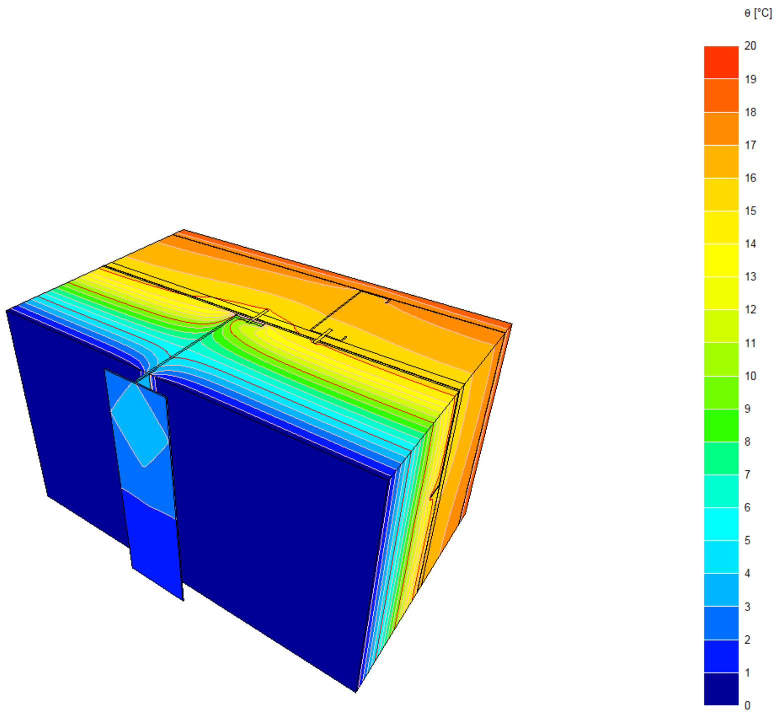


Figure 16 External temperature gradient diagram cut through bracket

TRISCO - Input Data

TRISCO data file: 01 load.trc

COLOURS

Col.	Type	Subtype	Phys. flow	Geom. flow	Name	eps1 / eps2 [- / -]
8	MATERIAL				aluminium	
11	MATERIAL				stainless_steel	
13	MATERIAL				steel	
24	MATERIAL				aluminium	
42	MATERIAL				VCL	
43	MATERIAL				breather	
98	MATERIAL				fastframe_pack	
136	MATERIAL				reinforced_concrete_(stee	
151	MATERIAL				insulation_0.035_W/mK_	
161	MATERIAL				plasterboard	
174	BC_SIMPL	HI_NORML	HOR		interior	
185	BC_SIMPL	NIHIL			highly_ventilated_cavity,	
200	EQUIMAT	CAVITY	HOR	Yx	cavity_non-vent_physical_	0.90 / 0.90

Col.	lambda [W/mK]	eps [-]	t [°C]	h [W/m²K]	q [W/m²]	ta [°C]	hc [W/m²K]	Pc [W/m]	tr [°C]	Standard
8	160.000									
11	17.000									
13	50.000									
24	160.000									
42	0.170									
43	0.500									
98	0.220									
136	2.500									
151	0.035									
161	0.250									
174			20.0	7.70	0					EN10077
185			0.0	7.70	0					NIHIL
200	0.836									EN10077

CALCULATION PARAMETERS

Iteration cycles = 5
Maximum number of iterations (within each iteration cycle) = 10000
Maximum temperature difference (within each iteration cycle) = 0.0001°C
Maximum temperature difference (between iteration cycles) = 0.001°C
Heat flow divergence for total object = 0.001 %
Heat flow divergence for worst node = 1 %
Automatic recalculation of thermal values
Default temperature difference across airspace = 10°C

TRISCO - Calculation Results

TRISCO data file: 01 load.trc

Number of nodes = 1361400
Heat flow divergence for total object = 0.000407319 %
Heat flow divergence for worst node = 0.990744 %

Q = 3.552 W
ti = 20.0000°C
te = 0.0000°C
A1 = 0.36 m²
Xmin=0 Xmax=126 Ymin=34 Ymax=34 Zmin=0 Zmax=123

Col.	Type	Name	tmin [°C]	X	Y	Z	tmax [°C]	X	Y	Z
8	MATERIAL	aluminium	3.0615	57	3	46	15.4793	126	48	46
11	MATERIAL	stainless_steel	10.0354	62	45	62	15.5882	85	58	47
13	MATERIAL	steel	15.2823	85	53	62	17.3283	92	85	123
24	MATERIAL	aluminium	1.1985	46	1	0	4.0303	57	10	62
42	MATERIAL	VCL	16.8447	80	85	62	17.8715	0	86	0
43	MATERIAL	breather	14.0103	62	48	61	16.5976	0	49	0
98	MATERIAL	fastframe_pack	9.6498	56	46	65	14.4960	67	47	77
136	MATERIAL	reinforced_concrete_(stee	14.0620	62	49	61	16.6206	0	53	0
151	MATERIAL	insulation_0.035_W/mK_	0.3684	83	7	61	16.5915	0	48	0
161	MATERIAL	plasterboard	16.9357	81	86	62	18.8905	0	92	0
174	BC_SIMPL	interior	18.4540	83	92	62	18.8905	0	92	0
185	BC_SIMPL	highly_ventilated_cavity,	0.3684	83	7	61	3.8013	56	7	62
200	EQUIMAT	cavity_non-vent_physical_	14.3908	61	53	61	17.8219	0	85	0

Col.	Type	Name	ta [°C]	Flow in [W]	Flow out [W]
174	BC_SIMPL	interior		3.5522	0.0000
185	BC_SIMPL	highly_ventilated_cavity,		0.0000	3.5523

Double bracket – centre area for deduction to ascertain X value of bracket

Material Thermal Conductivity Diagram.

Wall section = 600mm x 600mm
Q = 1.244 W

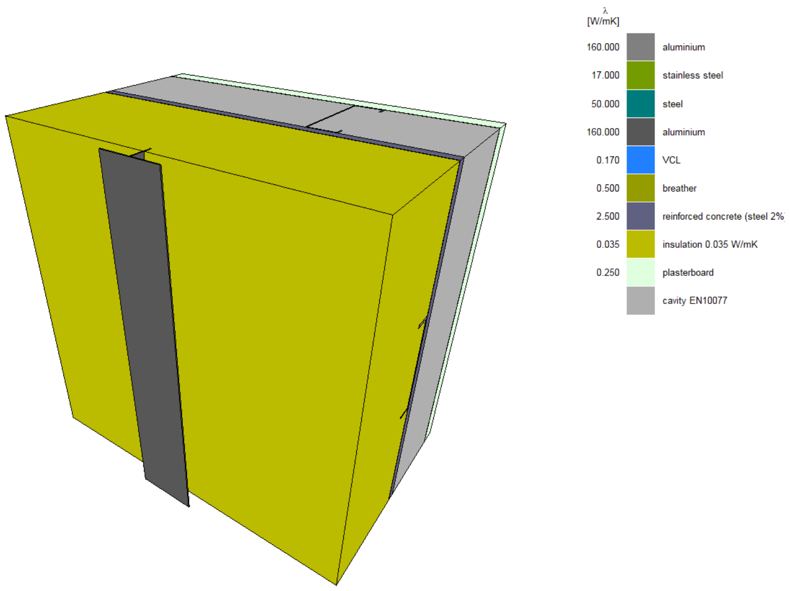


Figure 17 External material thermal conductivity diagram

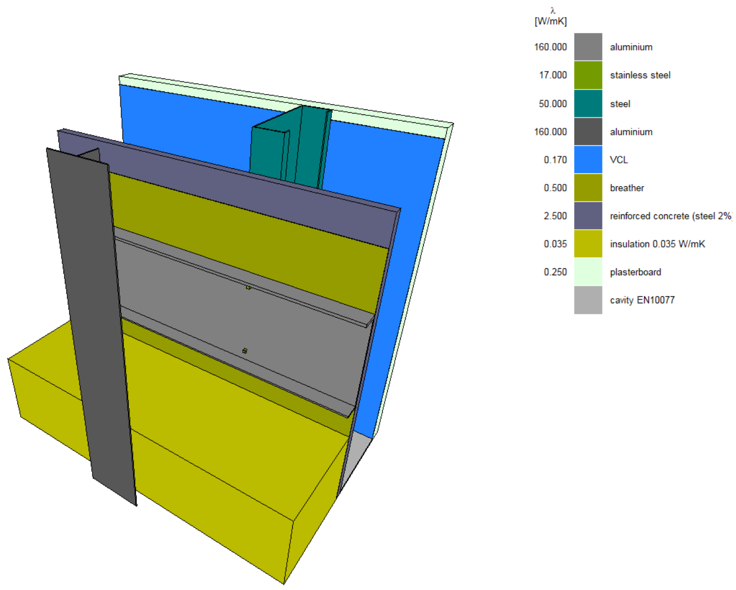


Figure 18 Thermal conductivity diagram –materials cut back for clarity

Temperature Gradient Diagrams

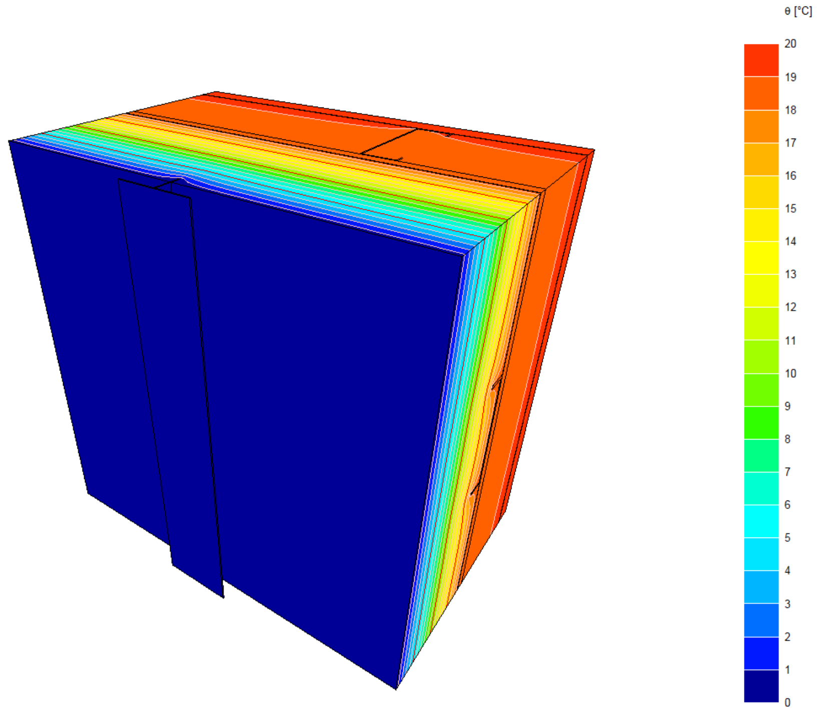


Figure 19 External temperature gradient diagram

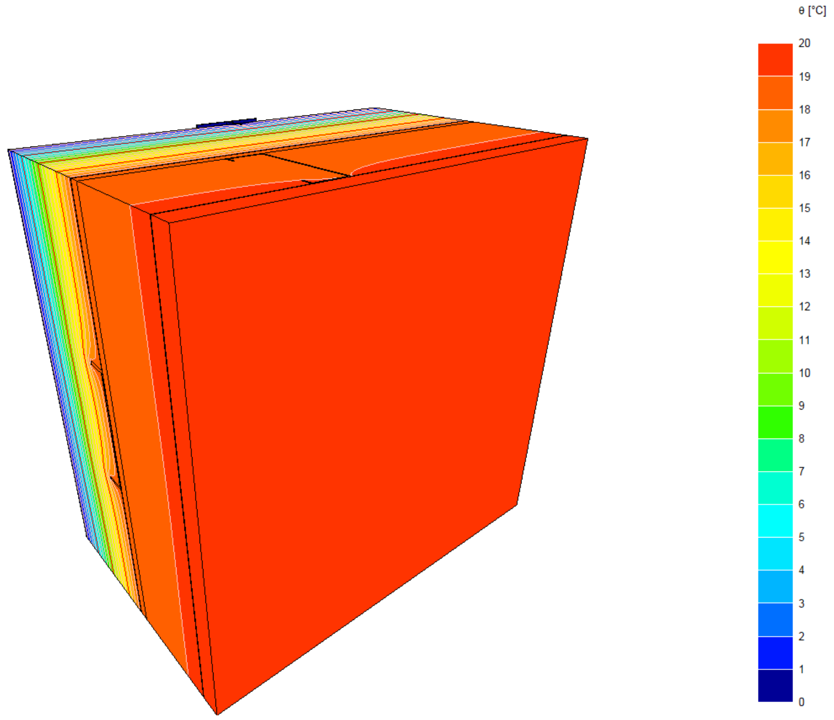


Figure 20 Internal temperature gradient diagram

TRISCO – Input Data

TRISCO data file: 02 load no bracket.trc

COLOURS

Col.	Type	Subtype	Phys. flow	Geom. flow	Name	eps1 / eps2 [- / -]
8	MATERIAL				aluminium	
11	MATERIAL				stainless_steel	
13	MATERIAL				steel	
24	MATERIAL				aluminium	
42	MATERIAL				VCL	
43	MATERIAL				breather	
136	MATERIAL				reinforced_concrete_(stee	
151	MATERIAL				insulation_0.035_W/mK_	
161	MATERIAL				plasterboard	
174	BC_SIMPL	HI_NORML	HOR		interior	
185	BC_SIMPL	NIHIL			highly_ventilated_cavity,	
200	EQUIMAT	CAVITY	HOR	Yx	cavity_non-vent_physical_	0.90 / 0.90

Col.	lambda [W/mK]	eps [-]	t [°C]	h [W/m²K]	q [W/m²]	ta [°C]	hc [W/m²K]	Pc [W/m]	tr [°C]	Standard
8	160.000									
11	17.000									
13	50.000									
24	160.000									
42	0.170									
43	0.500									
136	2.500									
151	0.035									
161	0.250									
174			20.0	7.70	0					EN10077
185			0.0	7.70	0					NIHIL
200	0.786									EN10077

CALCULATION PARAMETERS

Iteration cycles = 5
Maximum number of iterations (within each iteration cycle) = 10000
Maximum temperature difference (within each iteration cycle) = 0.0001°C
Maximum temperature difference (between iteration cycles) = 0.001°C
Heat flow divergence for total object = 0.001 %
Heat flow divergence for worst node = 1 %
Automatic recalculation of thermal values
Default temperature difference across airspace = 10°C

TRISCO - Calculation Results

TRISCO data file: 02 load no bracket.trc

Number of nodes = 1361272
Heat flow divergence for total object = 6.54042e-05 %
Heat flow divergence for worst node = 0.94624 %

Uwall = (Q/(ti-te))/A1 = 0.173 W/(m².K)
Q = 1.244 W
ti = 20.0000°C
te = 0.0000°C
A1 = 0.36 m²
Xmin=0 Xmax=126 Ymin=34 Ymax=34 Zmin=0 Zmax=123

Col.	Type	Name	tmin [°C]	X	Y	Z	tmax [°C]	X	Y	Z
8	MATERIAL	aluminium	18.4367	0	40	43	18.4983	85	48	60
11	MATERIAL	stainless_steel	18.4880	86	46	74	18.5958	85	58	48
13	MATERIAL	steel	18.5411	92	53	63	19.0207	92	85	123
24	MATERIAL	aluminium	0.0636	46	1	0	0.0818	58	10	64
42	MATERIAL	VCL	18.9673	80	85	62	19.1726	0	86	123
43	MATERIAL	breather	18.4473	0	48	43	18.6105	83	49	123
136	MATERIAL	reinforced_concrete_(stee	18.4598	0	49	76	18.6446	81	53	123
151	MATERIAL	insulation_0.035_W/mK_	0.0758	58	7	0	18.6038	83	48	123
161	MATERIAL	plasterboard	18.9973	81	86	62	19.5699	0	92	123
174	BC_SIMPL	interior	19.4932	84	92	62	19.5699	0	92	123
185	BC_SIMPL	highly_ventilated_cavity,	0.0636	46	1	0	0.4553	126	7	68
200	EQUIMAT	cavity_non-vent_physical_	18.4831	0	53	70	19.1531	0	85	123

Col.	Type	Name	ta [°C]	Flow in [W]	Flow out [W]
174	BC_SIMPL	interior		1.2442	0.0000
185	BC_SIMPL	highly_ventilated_cavity,		0.0000	1.2442

Single Bracket

X value analysis.

- Material thermal conductivity diagram.
- Temperature gradient diagrams.
- FEA input data sheet.
- FEA output data sheet.

Finite element analysis undertaken using TRISCO version 15.0.01 software.

Summary.

A sample area of 600mm x 600mm was examined, and the X value of the bracket was found to be **0.071 W/K**

X value calculation

With bracket

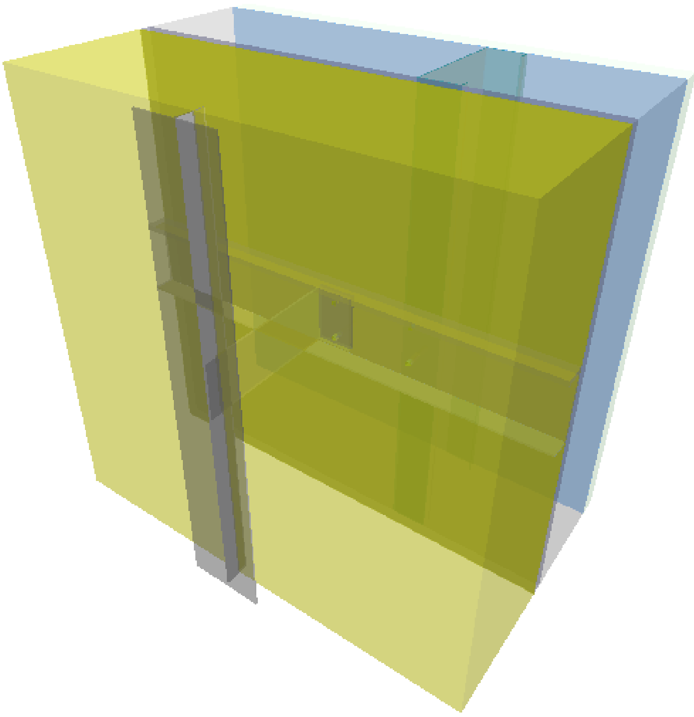
Q =	2.667	W
Δt =	20	K
A =	0.360	m^2
Q/Δt =	0.133	W/K

Without bracket

Q =	1.241	W
Δt =	20	K
A =	0.360	m^2
Q/Δt =	0.062	W/K

X = $(Q_{bkt}/\Delta T) - (Q_{nobkt}/\Delta T)$

X = 0.071 W/K



Material Thermal Conductivity Diagram.

Wall section = 600mm x 600mm
Q = 2.667W

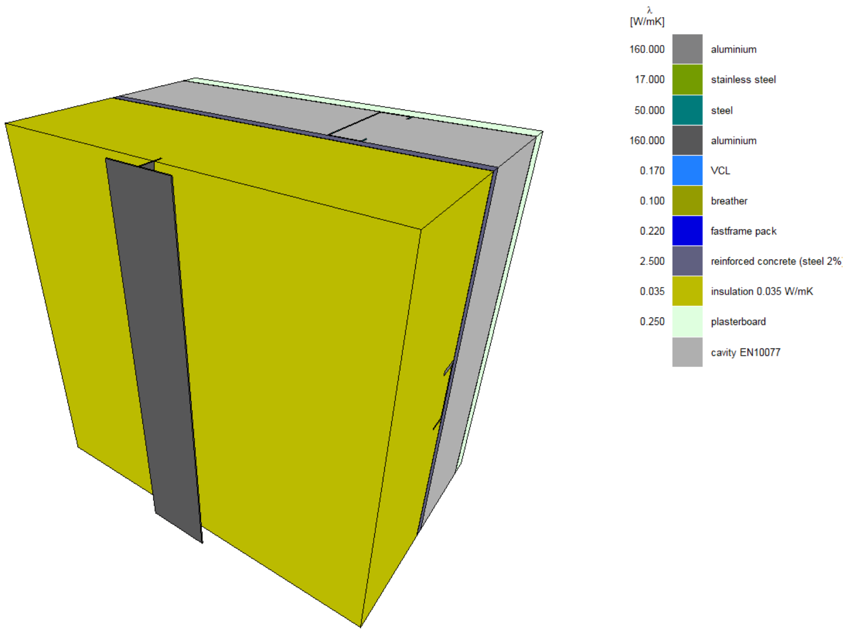


Figure 21 External material thermal conductivity diagram

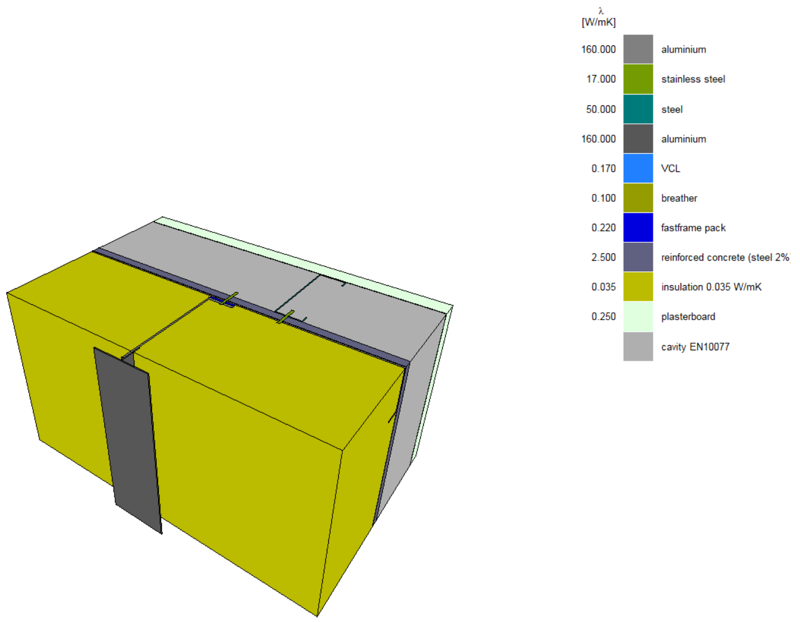


Figure 22 Cut through bracket thermal conductivity diagram

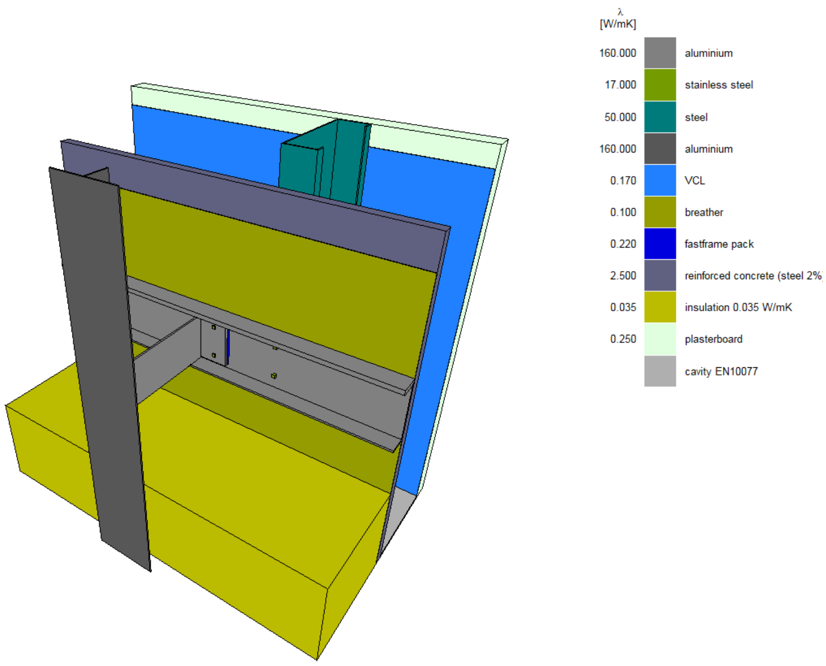


Figure 23 Thermal conductivity diagram –materials cut back for clarity

Temperature Gradient Diagrams

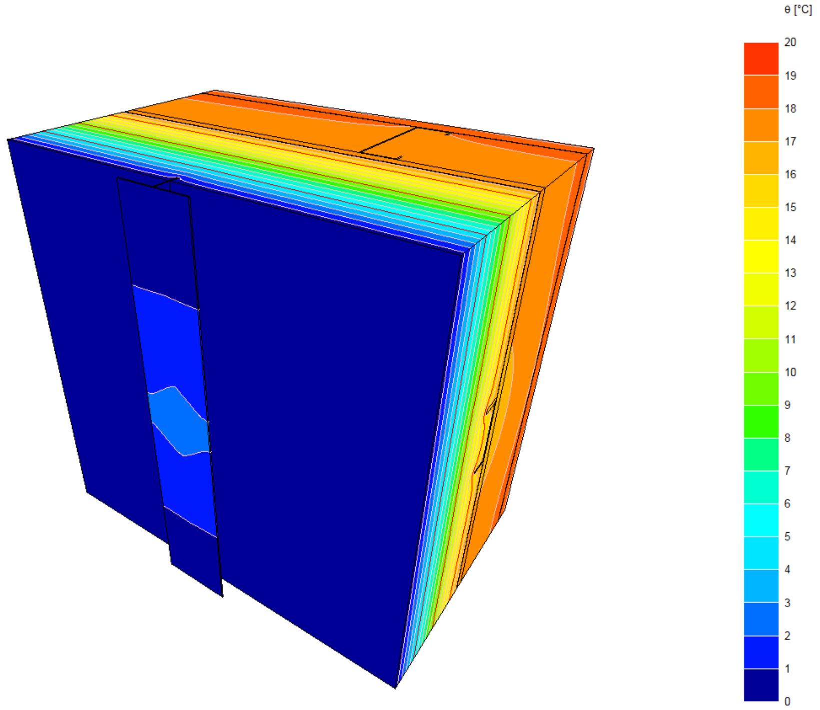


Figure 24 External temperature gradient diagram

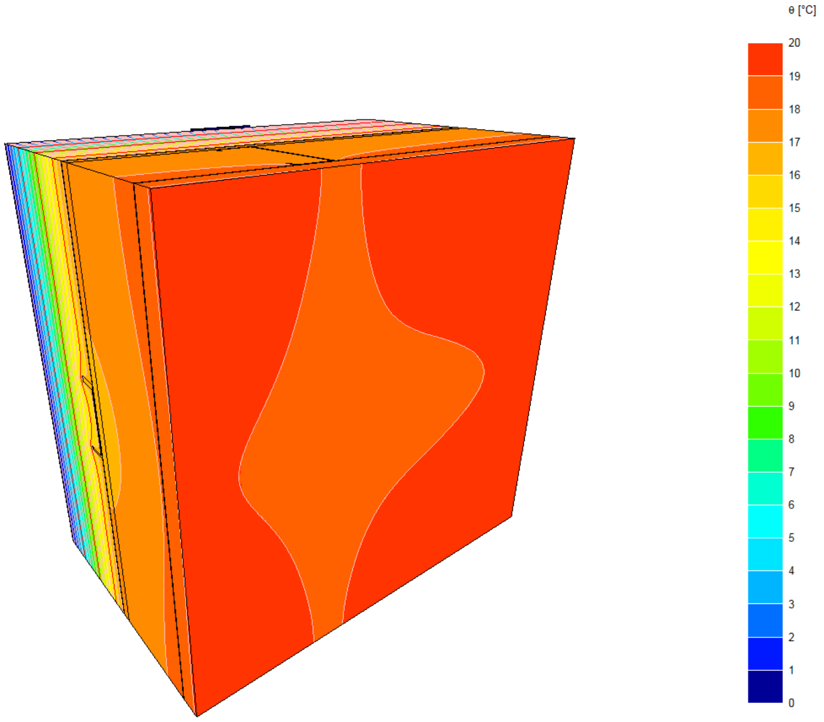


Figure 25 Internal temperature gradient diagram

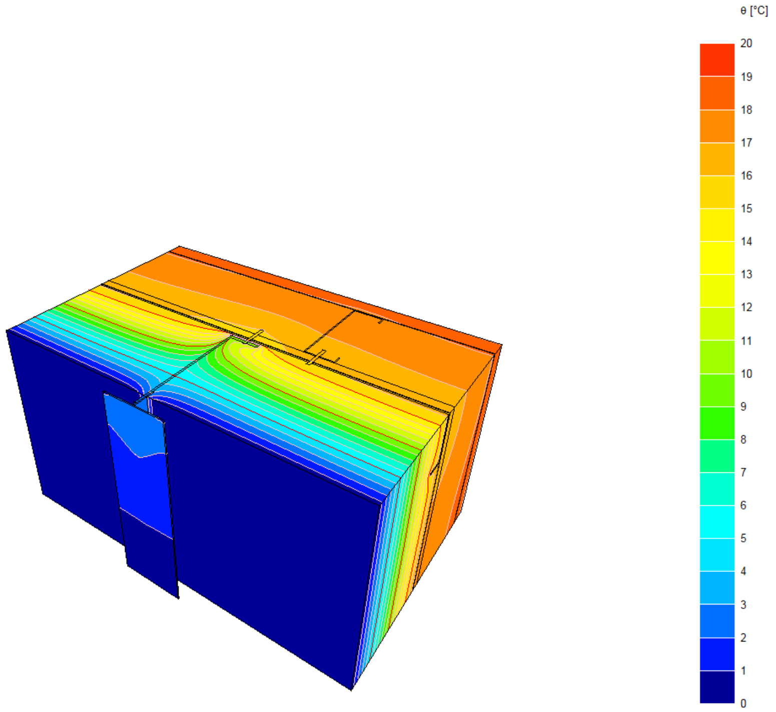


Figure 26 External temperature gradient diagram cut through bracket

TRISCO - Input Data

TRISCO data file: 03 res.trc

COLOURS

Col.	Type	Subtype	Phys. flow	Geom. flow	Name	eps1 / eps2 [- / -]
8	MATERIAL				aluminium	
11	MATERIAL				stainless_steel	
13	MATERIAL				steel	
24	MATERIAL				aluminium	
42	MATERIAL				VCL	
43	MATERIAL				breather	
98	MATERIAL				fastframe_pack	
136	MATERIAL				reinforced_concrete_(stee	
151	MATERIAL				insulation_0.035_W/mK_	
161	MATERIAL				plasterboard	
174	BC_SIMPL	HI_NORML	HOR		interior	
185	BC_SIMPL	NIHIL			highly_ventilated_cavity,	
200	EQUIMAT	CAVITY	HOR	Yx	cavity_non-vent_physical_	0.90 / 0.90

Col.	lambda [W/mK]	eps [-]	t [°C]	h [W/m²K]	q [W/m²]	ta [°C]	hc [W/m²K]	Pc [W/m]	tr [°C]	Standard
8	160.000									
11	17.000									
13	50.000									
24	160.000									
42	0.170									
43	0.100									
98	0.220									
136	2.500									
151	0.035									
161	0.250									
174			20.0	7.70	0					EN10077
185			0.0	7.70	0					NIHIL
200	0.831									EN10077

CALCULATION PARAMETERS

Iteration cycles = 5
Maximum number of iterations (within each iteration cycle) = 10000
Maximum temperature difference (within each iteration cycle) = 0.0001°C
Maximum temperature difference (between iteration cycles) = 0.001°C
Heat flow divergence for total object = 0.001 %
Heat flow divergence for worst node = 1 %
Automatic recalculation of thermal values
Default temperature difference across airspace = 10°C

TRISCO - Calculation Results

TRISCO data file: 03 res.trc

Number of nodes = 1339380
Heat flow divergence for total object = 0.000338536 %
Heat flow divergence for worst node = 0.656343 %

Q = 2.667 W
ti = 20.0000°C
te = 0.0000°C
A1 = 0.36 m²
Xmin=0 Xmax=126 Ymin=34 Ymax=34 Zmin=0 Zmax=121

Col.	Type	Name	tmin [°C]	X	Y	Z	tmax [°C]	X	Y	Z
8	MATERIAL	aluminium	2.3796	57	3	53	16.2126	126	48	55
11	MATERIAL	stainless_steel	10.7310	62	45	56	16.5495	85	58	55
13	MATERIAL	steel	16.3617	87	53	61	17.9962	92	85	121
24	MATERIAL	aluminium	0.7395	46	1	0	3.1949	57	10	61
42	MATERIAL	VCL	17.6457	80	85	60	18.3812	0	86	0
43	MATERIAL	breather	14.9832	62	48	56	17.3572	0	49	0
98	MATERIAL	fastframe_pack	10.2474	56	46	60	15.3683	67	47	68
136	MATERIAL	reinforced_concrete_(stee	15.0883	62	49	56	17.3835	80	53	121
151	MATERIAL	insulation_0.035_W/mK_	0.3459	60	7	0	17.3255	0	48	0
161	MATERIAL	plasterboard	17.7137	81	86	60	19.1566	0	92	0
174	BC_SIMPL	interior	18.8466	83	92	60	19.1566	0	92	0
185	BC_SIMPL	highly_ventilated_cavity,	0.3459	60	7	0	2.9110	56	7	61
200	EQUIMAT	cavity_non-vent_physical_	15.5849	62	53	57	18.3435	0	85	0

Col.	Type	Name	ta [°C]	Flow in [W]	Flow out [W]
174	BC_SIMPL	interior		2.6668	0.0000
185	BC_SIMPL	highly_ventilated_cavity,		0.0000	2.6668

Single bracket – centre area for deduction to ascertain X value of bracket

Material Thermal Conductivity Diagram.

Wall section = 600mm x 600mm
Q = 1.241 W

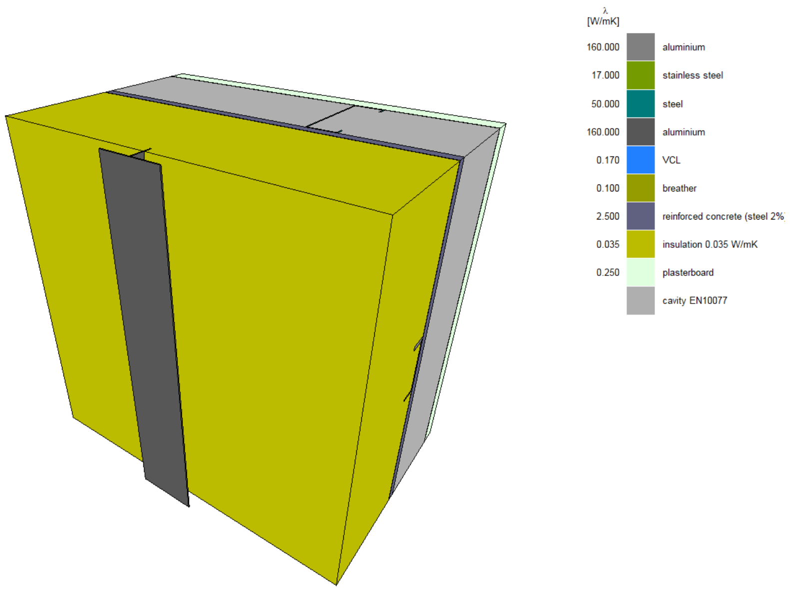


Figure 27 External material thermal conductivity diagram

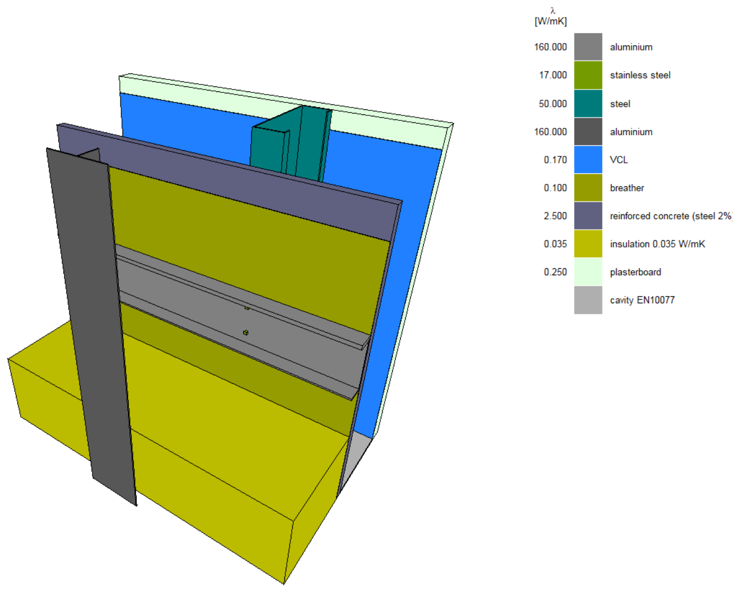


Figure 28 Thermal conductivity diagram –materials cut back for clarity

Temperature Gradient Diagrams

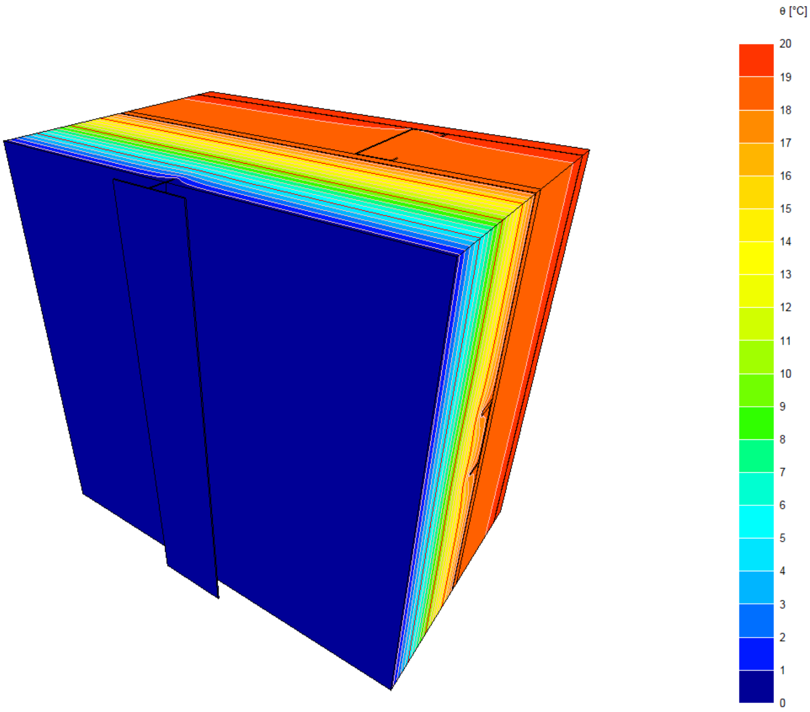


Figure 29 External temperature gradient diagram

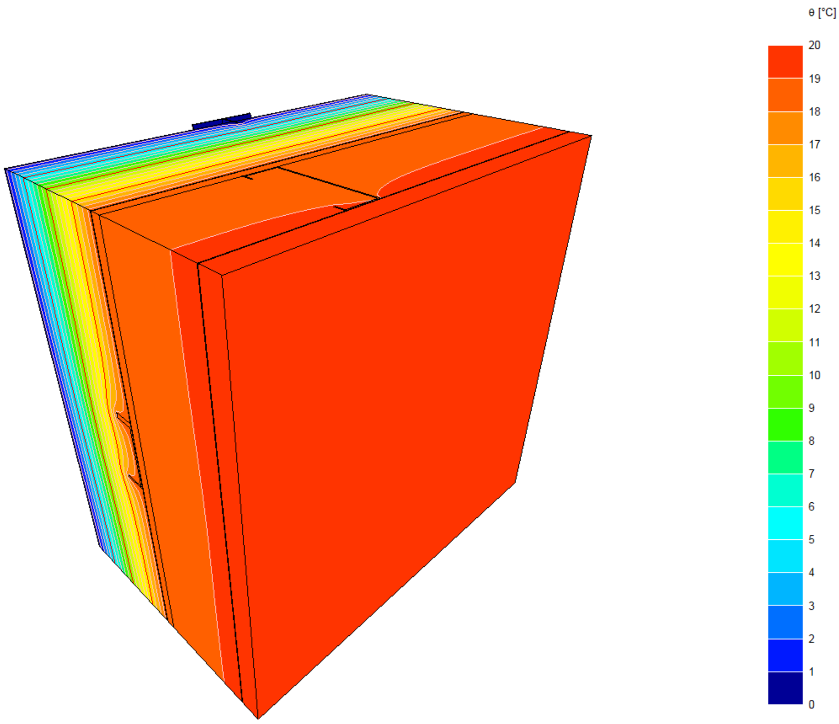


Figure 30 Internal temperature gradient diagram

TRISCO – Input Data

TRISCO data file: 04 res no bracket.trc

COLOURS

Col.	Type	Subtype	Phys. flow	Geom. flow	Name	eps1 / eps2 [- / -]
8	MATERIAL				aluminium	
11	MATERIAL				stainless_steel	
13	MATERIAL				steel	
24	MATERIAL				aluminium	
42	MATERIAL				VCL	
43	MATERIAL				breather	
136	MATERIAL				reinforced_concrete_(stee	
151	MATERIAL				insulation_0.035_W/mK_	
161	MATERIAL				plasterboard	
174	BC_SIMPL	HI_NORML	HOR		interior	
185	BC_SIMPL	NIHIL			highly_ventilated_cavity,	
200	EQUIMAT	CAVITY	HOR	Yx	cavity_non-vent_physical_	0.90 / 0.90

Col.	lambda [W/mK]	eps [-]	t [°C]	h [W/m²K]	q [W/m²]	ta [°C]	hc [W/m²K]	Pc [W/m]	tr [°C]	Standard
8	160.000									
11	17.000									
13	50.000									
24	160.000									
42	0.170									
43	0.100									
136	2.500									
151	0.035									
161	0.250									
174			20.0	7.70	0					EN10077
185			0.0	7.70	0					NIHIL
200	0.787									EN10077

CALCULATION PARAMETERS

Iteration cycles = 5
Maximum number of iterations (within each iteration cycle) = 10000
Maximum temperature difference (within each iteration cycle) = 0.0001°C
Maximum temperature difference (between iteration cycles) = 0.001°C
Heat flow divergence for total object = 0.001 %
Heat flow divergence for worst node = 1 %
Automatic recalculation of thermal values
Default temperature difference across airspace = 10°C

TRISCO - Calculation Results

TRISCO data file: 04 res no bracket.trc

Number of nodes = 1339316
Heat flow divergence for total object = 0.000298259 %
Heat flow divergence for worst node = 0.945368 %

Q = 1.241 W
ti = 20.0000°C
te = 0.0000°C
A1 = 0.36 m²
Xmin=0 Xmax=126 Ymin=34 Ymax=34 Zmin=0 Zmax=121

Col.	Type	Name	tmin [°C]	X	Y	Z	tmax [°C]	X	Y	Z
8	MATERIAL	aluminium	18.3816	0	40	50	18.4432	86	48	56
11	MATERIAL	stainless_steel	18.4343	85	46	65	18.5939	85	58	55
13	MATERIAL	steel	18.5406	92	53	61	19.0254	92	85	121
24	MATERIAL	aluminium	0.0633	46	1	0	0.0819	58	10	61
42	MATERIAL	VCL	18.9739	80	85	60	19.1726	15	86	121
43	MATERIAL	breather	18.3917	0	48	50	18.6164	83	49	121
136	MATERIAL	reinforced_concrete_(stee	18.4411	0	49	61	18.6504	81	53	121
151	MATERIAL	insulation_0.035_W/mK_	0.0755	58	7	0	18.5825	83	48	121
161	MATERIAL	plasterboard	19.0037	81	86	60	19.5699	11	92	121
174	BC_SIMPL	interior	19.4963	84	92	60	19.5699	11	92	121
185	BC_SIMPL	highly_ventilated_cavity,	0.0633	46	1	0	0.4597	126	7	61
200	EQUIMAT	cavity_non-vent_physical_	18.4661	0	53	60	19.1531	15	85	121

Col.	Type	Name	ta [°C]	Flow in [W]	Flow out [W]
174	BC_SIMPL	interior		1.2405	0.0000
185	BC_SIMPL	highly_ventilated_cavity,		0.0000	1.2405

Vertical rail Ψ value

- Material thermal conductivity diagram.
- Temperature gradient diagrams.
- FEA input data sheet.
- FEA output data sheet.

Finite element analysis undertaken using TRISCO version 15.0.01 software.

Summary.

A sample area of 600mm x 600mm was examined, and the ψ value of the vertical rail was found to be **0.000 W/mK**

Additional Ψ value of vertical rail is negligible.

Ψ value calculation

With rail

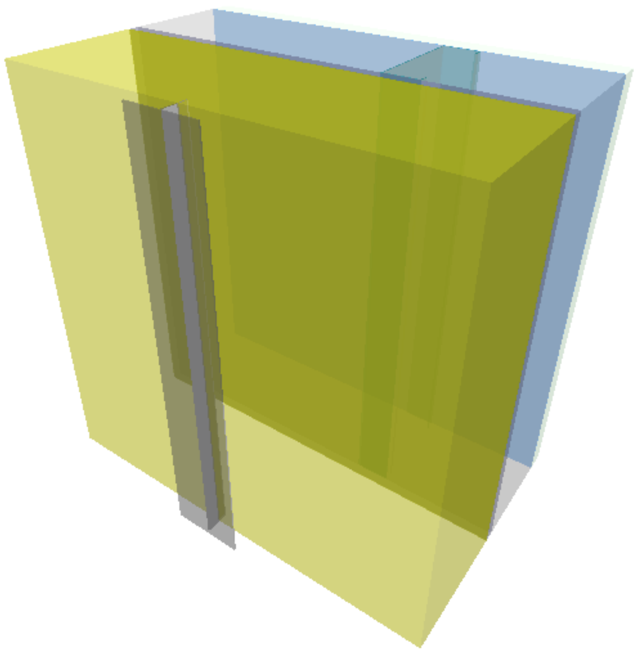
Q =	1.208	W
Δt =	20	K
l =	0.600	m
Q/Δt =	0.060	W/K

Without rail

Q =	1.202	W
Δt =	20	K
l =	0.600	m
Q/Δt =	0.060	W/K

$\psi = ((Q_{rail}/\Delta T) - (Q_{norail}/\Delta T))/l$

ψ = 0.000 W/K



Material Thermal Conductivity Diagram.

Wall section = 600mm x 600mm
Q = 1.208W

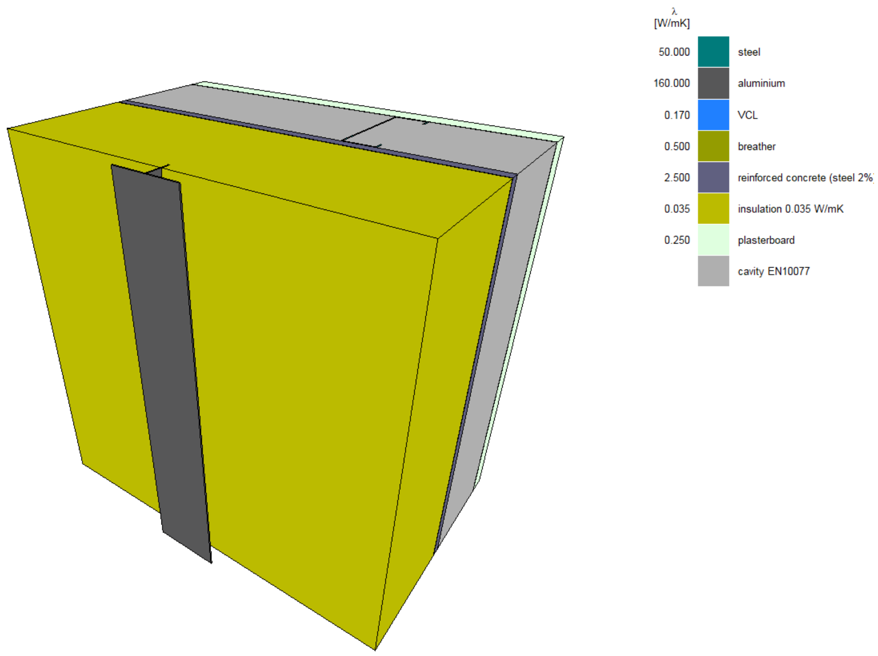


Figure 31 External material thermal conductivity diagram

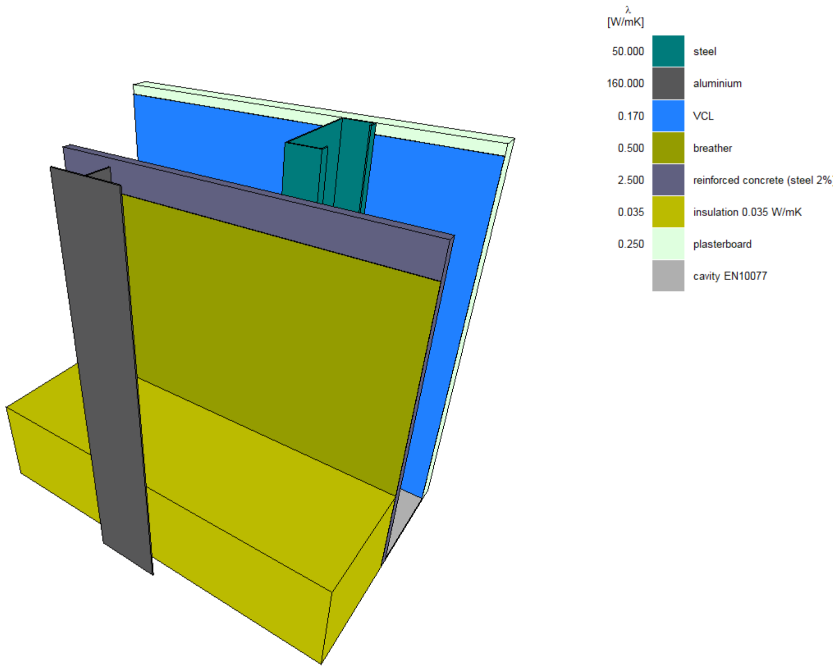


Figure 32 Thermal conductivity diagram –materials cut back for clarity

Temperature Gradient Diagrams

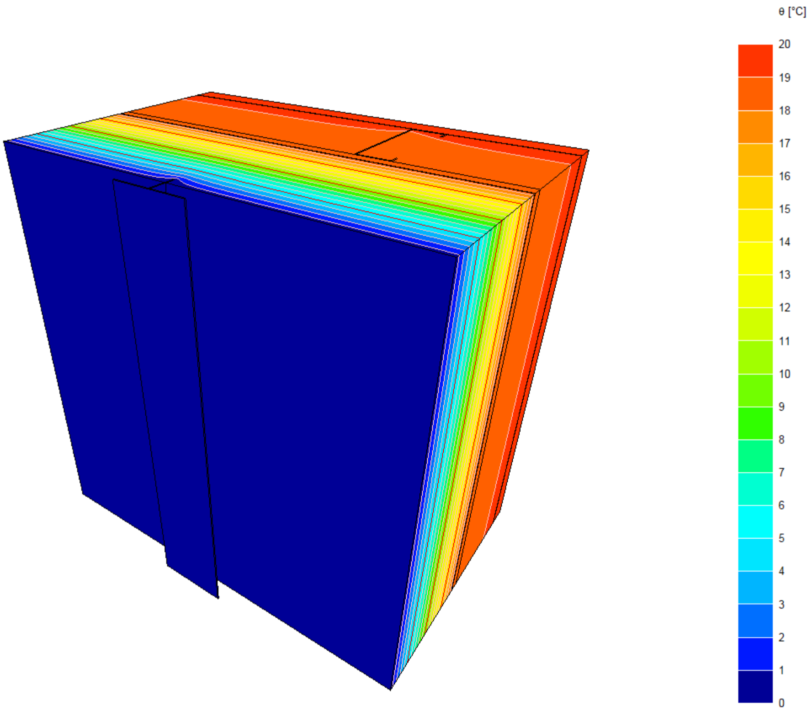


Figure 33 External temperature gradient diagram

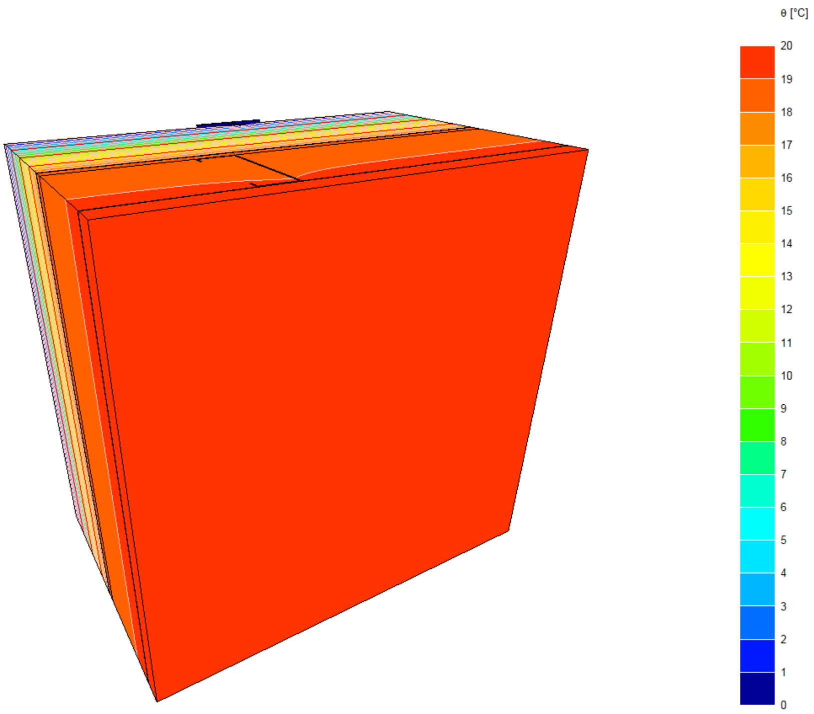


Figure 34 Internal temperature gradient diagram

TRISCO – Input Data

TRISCO data file: 05 vert.trc

COLOURS

Col.	Type	Subtype	Phys. flow	Geom. flow	Name	eps1 / eps2 [- / -]
13	MATERIAL				steel	
24	MATERIAL				aluminium	
42	MATERIAL				VCL	
97	MATERIAL				y_wall	
151	MATERIAL				insulation_0.035_W/mK_	
161	MATERIAL				gyproc_fireline	
174	BC_SIMPL	HI_NORML	HOR		interior	
185	BC_SIMPL	NIHIL			highly_ventilated_cavity,	

Col.	lambda [W/mK]	eps [-]	t [°C]	h [W/m²K]	q [W/m²]	ta [°C]	hc [W/m²K]	Pc [W/m]	tr [°C]	Standard
13	50.000									
24	160.000									
42	0.170									
97	0.120									
151	0.035									
161	0.240									
174			20.0	7.70	0					EN10077
185			0.0	7.70	0					NIHIL

CALCULATION PARAMETERS

Iteration cycles = 5
Maximum number of iterations (within each iteration cycle) = 10000
Maximum temperature difference (within each iteration cycle) = 0.0001°C
Maximum temperature difference (between iteration cycles) = 0.001°C
Heat flow divergence for total object = 0.001 %
Heat flow divergence for worst node = 1 %
Automatic recalculation of thermal values
Default temperature difference across airspace = 10°C

TRISCO - Calculation Results

TRISCO data file: 05 vert.trc

Number of nodes = 1361272
Heat flow divergence for total object = 0.000512238 %
Heat flow divergence for worst node = 0.987327 %

Q = 1.208 W
ti = 20.0000°C
te = 0.0000°C
A1 = 0.36 m²
Xmin=0 Xmax=126 Ymin=34 Ymax=34 Zmin=0 Zmax=123

Col.	Type	Name	tmin [°C]	X	Y	Z	tmax [°C]	X	Y	Z
13	MATERIAL	steel	18.6509	92	53	113	19.0509	92	85	0
24	MATERIAL	aluminium	0.0621	46	1	0	0.0787	58	10	97
42	MATERIAL	VCL	19.0178	80	85	0	19.1908	126	86	0
43	MATERIAL	breather	18.5071	0	48	114	18.6443	83	49	0
136	MATERIAL	reinforced_concrete_(stee	18.5138	0	49	96	18.6787	81	53	0
151	MATERIAL	insulation_0.035_W/mK_	0.0742	58	7	0	18.6374	83	48	0
161	MATERIAL	plasterboard	19.0462	81	86	0	19.5791	126	92	0
174	BC_SIMPL	interior	19.5173	84	92	0	19.5791	126	92	0
185	BC_SIMPL	highly_ventilated_cavity,	0.0621	46	1	0	0.4334	126	7	68
200	EQUIMAT	cavity_non-vent_physical_	18.5337	0	53	101	19.1718	126	85	24

Col.	Type	Name	ta [°C]	Flow in [W]	Flow out [W]
174	BC_SIMPL	interior		1.2075	0.0000
185	BC_SIMPL	highly_ventilated_cavity,		0.0000	1.2076

Double bracket location horizontal rail Ψ value

- Material thermal conductivity diagram.
- Temperature gradient diagrams.
- FEA input data sheet.
- FEA output data sheet.

Finite element analysis undertaken using TRISCO version 15.0.01 software.

Summary.

A sample area of 600mm x 600mm was examined, and the ψ value of the horizontal rail was found to be **0.003 W/mK**

Ψ value calculation

With rail

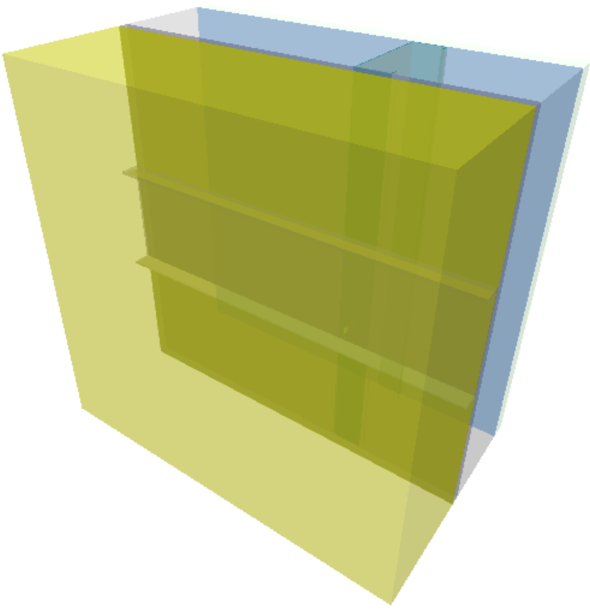
Q =	1.238	W
Δt =	20	K
l =	0.600	m
Q/Δt =	0.062	W/K

Without rail

Q =	1.202	W
Δt =	20	K
l =	0.600	m
Q/Δt =	0.060	W/K

ψ = $((Q_{rail}/\Delta T) - (Q_{norail}/\Delta T))/l$

ψ = 0.003 W/K



Material Thermal Conductivity Diagram.

Wall section = 600mm x 600mm
Q = 1.238W

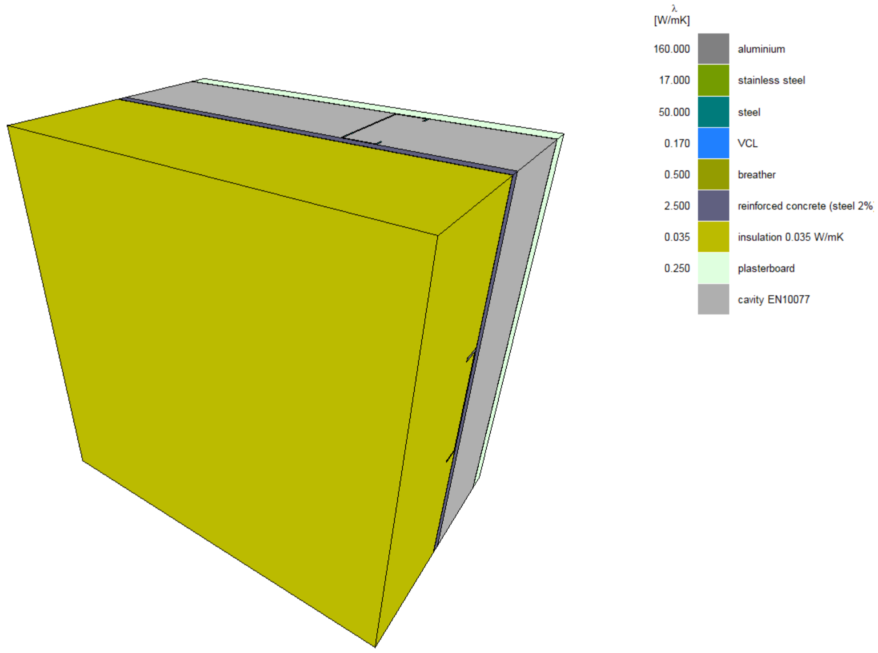


Figure 41 External material thermal conductivity diagram

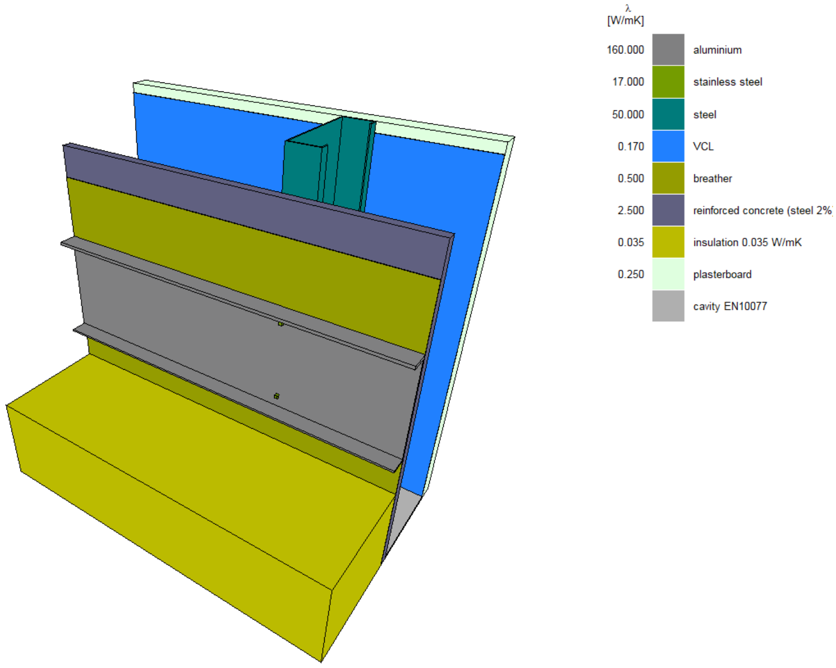


Figure 42 Thermal conductivity diagram –materials cut back for clarity

Temperature Gradient Diagrams

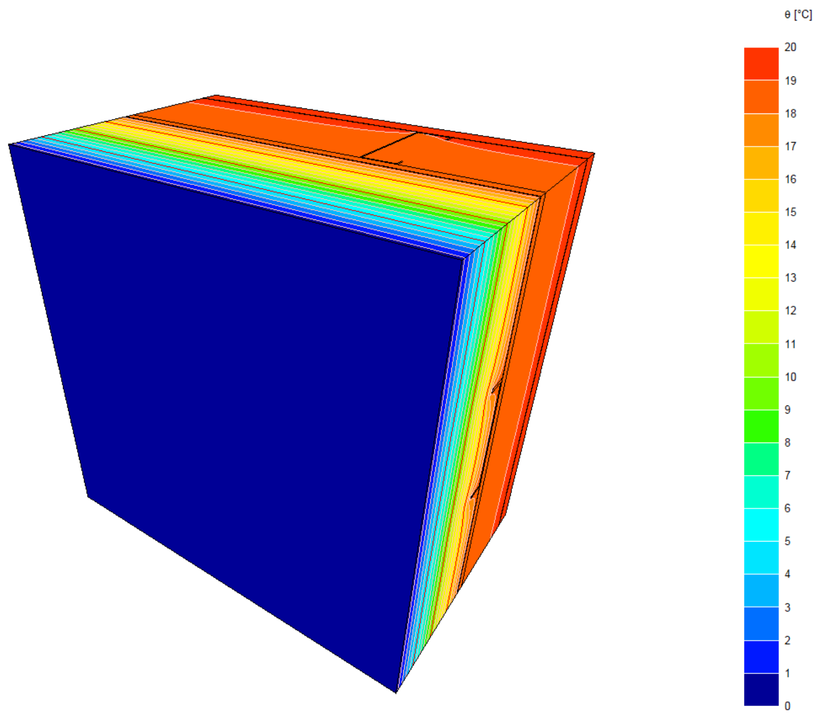


Figure 43 External temperature gradient diagram

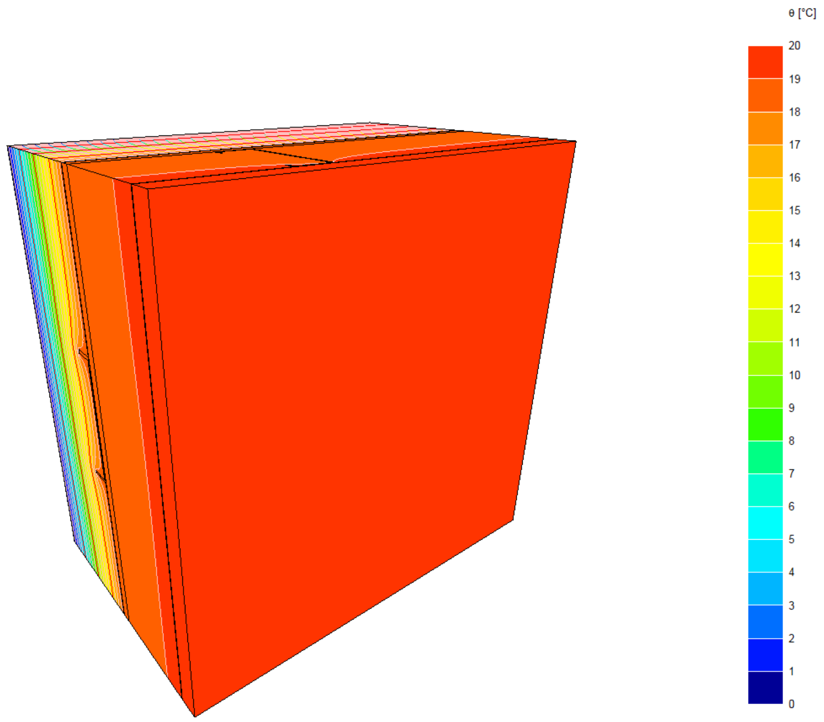


Figure 44 Internal temperature gradient diagram

TRISCO – Input Data

TRISCO data file: 06 load horiz.

COLOURS

Col.	Type	Subtype	Phys. flow	Geom. flow	Name	eps1 / eps2 [- / -]
8	MATERIAL				aluminium	
11	MATERIAL				stainless_steel	
13	MATERIAL				steel	
42	MATERIAL				VCL	
43	MATERIAL				breather	
136	MATERIAL				reinforced_concrete_(stee	
151	MATERIAL				insulation_0.035_W/mK_	
161	MATERIAL				plasterboard	
174	BC_SIMPL	HI_NORML	HOR		interior	
185	BC_SIMPL	NIHIL			highly_ventilated_cavity,	
200	EQUIMAT	CAVITY	HOR	Yx	cavity_non-vent_physical_	0.90 / 0.90

Col.	lambda [W/mK]	eps [-]	t [°C]	h [W/m²K]	q [W/m²]	ta [°C]	hc [W/m²K]	Pc [W/m]	tr [°C]	Standard
8	160.000									
11	17.000									
13	50.000									
42	0.170									
43	0.500									
136	2.500									
151	0.035									
161	0.250									
174			20.0	7.70	0					EN10077
185			0.0	7.70	0					NIHIL
200	0.786									EN10077

CALCULATION PARAMETERS
Iteration cycles = 5
Maximum number of iterations (within each iteration cycle) = 10000
Maximum temperature difference (within each iteration cycle) = 0.0001°C
Maximum temperature difference (between iteration cycles) = 0.001°C
Heat flow divergence for total object = 0.001 %
Heat flow divergence for worst node = 1 %
Automatic recalculation of thermal values
Default temperature difference across airspace = 10°C

TRISCO - Calculation Results

TRISCO data file: 06 load horiz.trc

Number of nodes = 1354328
Heat flow divergence for total object = 0.000974509 %
Heat flow divergence for worst node = 0.524848 %

Q = 1.238 W
ti = 20.0000°C
te = 0.0000°C
A1 = 0.36 m²
Xmin=0 Xmax=126 Ymin=34 Ymax=34 Zmin=0 Zmax=123

Col.	Type	Name	tmin [°C]	X	Y	Z	tmax [°C]	X	Y	Z
8	MATERIAL	aluminium	18.4441	0	40	43	18.5055	85	48	60
11	MATERIAL	stainless_steel	18.4952	86	46	74	18.6026	85	58	48
13	MATERIAL	steel	18.5480	92	53	63	19.0254	92	85	123
42	MATERIAL	VCL	18.9723	80	85	62	19.1765	0	86	123
43	MATERIAL	breather	18.4546	0	48	43	18.6174	83	49	123
136	MATERIAL	reinforced_concrete_(stee	18.4671	0	49	76	18.6513	81	53	123
151	MATERIAL	insulation_0.035_W/mK_	0.4362	0	7	0	18.6107	83	48	123
161	MATERIAL	plasterboard	19.0022	81	86	62	19.5719	0	92	123
174	BC_SIMPL	interior	19.4956	84	92	62	19.5719	0	92	123
185	BC_SIMPL	highly_ventilated_cavity,	0.4362	0	7	0	0.4559	89	7	69
200	EQUIMAT	cavity_non-vent_physical_	18.4904	0	53	53	19.1571	0	85	123

Col.	Type	Name	ta [°C]	Flow in [W]	Flow out [W]
174	BC_SIMPL	interior		1.2381	0.0000
185	BC_SIMPL	highly_ventilated_cavity,		0.0000	1.2381

Single bracket location horizontal rail Ψ value

- Material thermal conductivity diagram.
- Temperature gradient diagrams.
- FEA input data sheet.
- FEA output data sheet.

Finite element analysis undertaken using TRISCO version 15.0.01 software.

Summary.

A sample area of 600mm x 600mm was examined, and the ψ value of the horizontal rail was found to be **0.003 W/mK**

Ψ value calculation

With rail

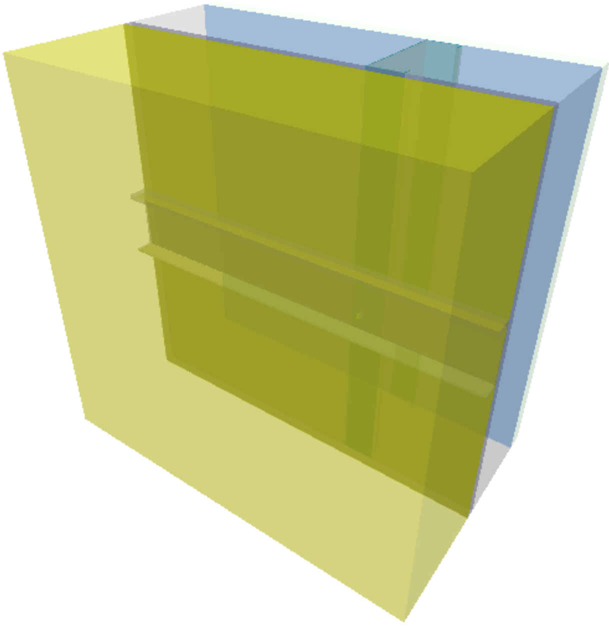
Q =	1.234	W
Δt =	20	K
l =	0.600	m
Q/Δt =	0.062	W/K

Without rail

Q =	1.202	W
Δt =	20	K
l =	0.600	m
Q/Δt =	0.060	W/K

$\psi = ((Q_{rail}/\Delta T) - (Q_{norail}/\Delta T))/l$

$\psi =$ 0.003 W/K



Material Thermal Conductivity Diagram.

Wall section = 600mm x 600mm
Q = 1.234W

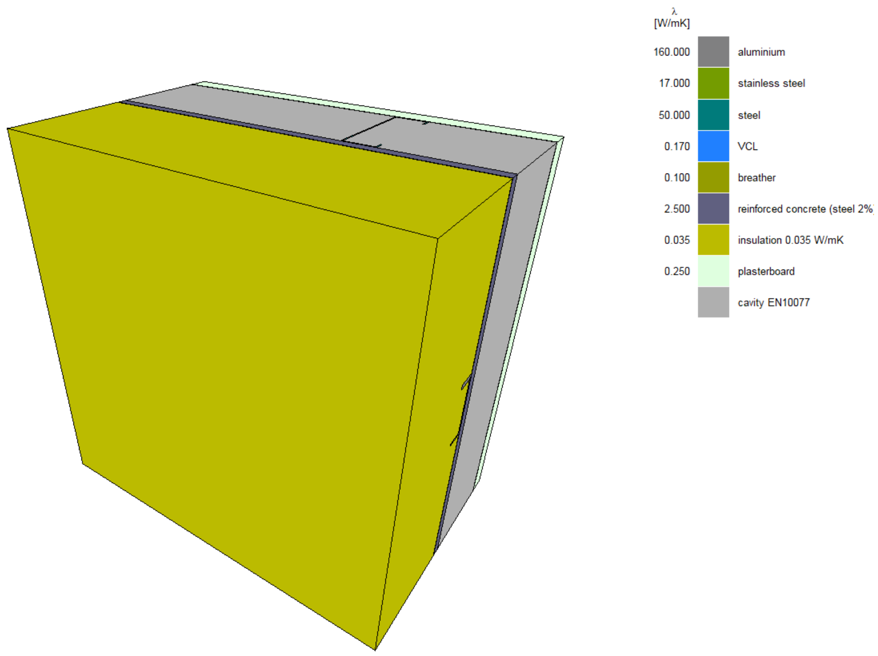


Figure 51 External material thermal conductivity diagram

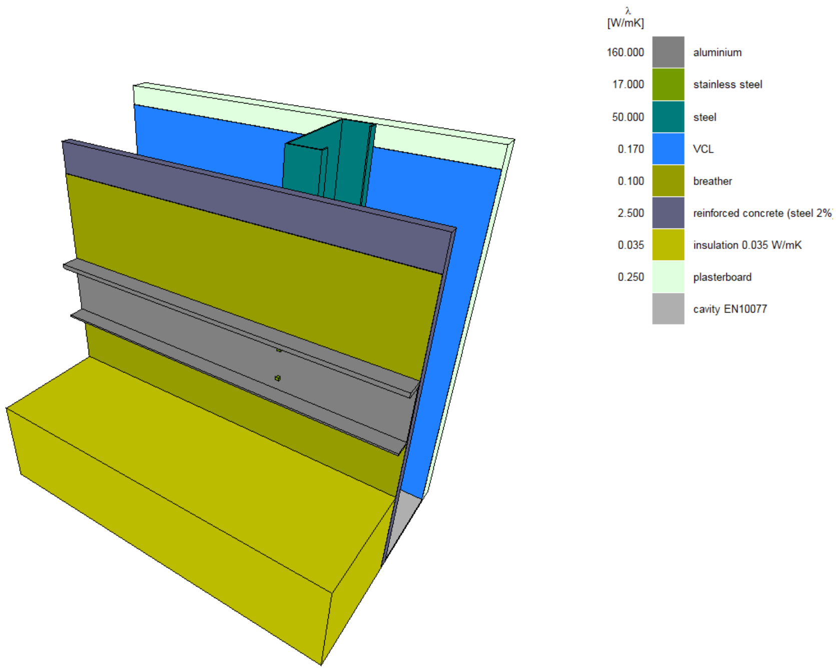


Figure 52 Thermal conductivity diagram –materials cut back for clarity

Temperature Gradient Diagrams

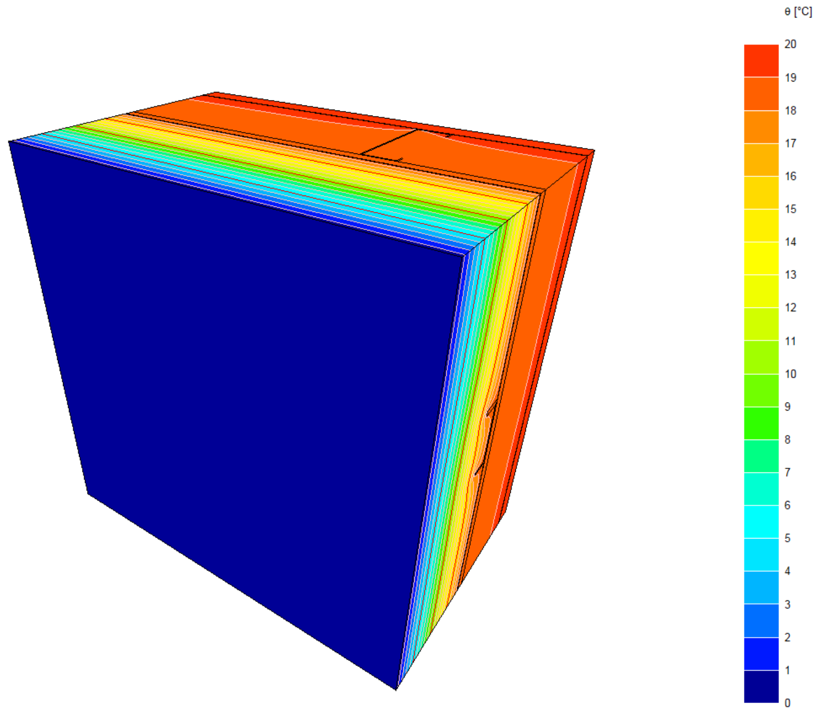


Figure 53 External temperature gradient diagram

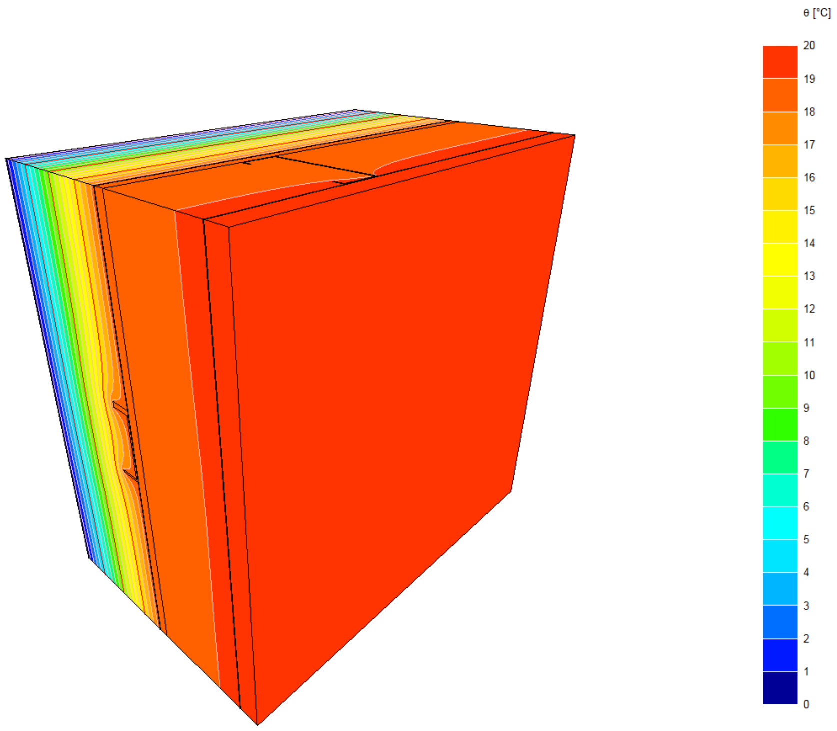


Figure 54 Internal temperature gradient diagram

TRISCO – Input Data

TRISCO data file: 07 res horiz.trc

COLOURS

Col.	Type	Subtype	Phys. flow	Geom. flow	Name	eps1 / eps2 [- / -]
8	MATERIAL				aluminium	
11	MATERIAL				stainless_steel	
13	MATERIAL				steel	
42	MATERIAL				VCL	
43	MATERIAL				breather	
136	MATERIAL				reinforced_concrete_(stee	
151	MATERIAL				insulation_0.035_W/mK_	
161	MATERIAL				plasterboard	
174	BC_SIMPL	HI_NORML	HOR		interior	
185	BC_SIMPL	NIHIL			highly_ventilated_cavity,	
200	EQUIMAT	CAVITY	HOR	Yx	cavity_non-vent_physical_	0.90 / 0.90

Col.	lambda [W/mK]	eps [-]	t [°C]	h [W/m²K]	q [W/m²]	ta [°C]	hc [W/m²K]	Pc [W/m]	tr [°C]	Standard
8	160.000									
11	17.000									
13	50.000									
42	0.170									
43	0.100									
136	2.500									
151	0.035									
161	0.250									
174			20.0	7.70	0					EN10077
185			0.0	7.70	0					NIHIL
200	0.787									EN10077

CALCULATION PARAMETERS

Iteration cycles = 5
Maximum number of iterations (within each iteration cycle) = 10000
Maximum temperature difference (within each iteration cycle) = 0.0001°C
Maximum temperature difference (between iteration cycles) = 0.001°C
Heat flow divergence for total object = 0.001 %
Heat flow divergence for worst node = 1 %
Automatic recalculation of thermal values
Default temperature difference across airspace = 10°C

TRISCO - Calculation Results

TRISCO data file: 07 res horiz.trc

Number of nodes = 1332484
Heat flow divergence for total object = 0.000999852 %
Heat flow divergence for worst node = 0.164467 %

Q = 1.234 W
ti = 20.0000°C
te = 0.0000°C
A1 = 0.36 m²
Xmin=0 Xmax=126 Ymin=34 Ymax=34 Zmin=0 Zmax=121

Col.	Type	Name	tmin [°C]	X	Y	Z	tmax [°C]	X	Y	Z
8	MATERIAL	aluminium	18.3892	0	40	50	18.4507	86	48	56
11	MATERIAL	stainless_steel	18.4418	85	46	65	18.6007	85	58	55
13	MATERIAL	steel	18.5476	92	53	61	19.0301	92	85	121
42	MATERIAL	VCL	18.9789	80	85	60	19.1765	21	86	121
43	MATERIAL	breather	18.3993	0	48	50	18.6232	83	49	121
136	MATERIAL	reinforced_concrete_(stee	18.4485	0	49	60	18.6571	81	53	121
151	MATERIAL	insulation_0.035_W/mK_	0.4342	0	7	0	18.5895	83	48	121
161	MATERIAL	plasterboard	19.0085	81	86	60	19.5719	18	92	121
174	BC_SIMPL	interior	19.4987	84	92	60	19.5719	18	92	121
185	BC_SIMPL	highly_ventilated_cavity,	0.4342	0	7	0	0.4603	88	7	61
200	EQUIMAT	cavity_non-vent_physical_	18.4734	0	53	60	19.1572	22	85	121

Col.	Type	Name	ta [°C]	Flow in [W]	Flow out [W]
174	BC_SIMPL	interior		1.2345	0.0000
185	BC_SIMPL	highly_ventilated_cavity,		0.0000	1.2345

Centre area for deduction to ascertain Ψ value of rails

Material Thermal Conductivity Diagram.

Wall section = 600mm x 600mm
Q = 1.202W

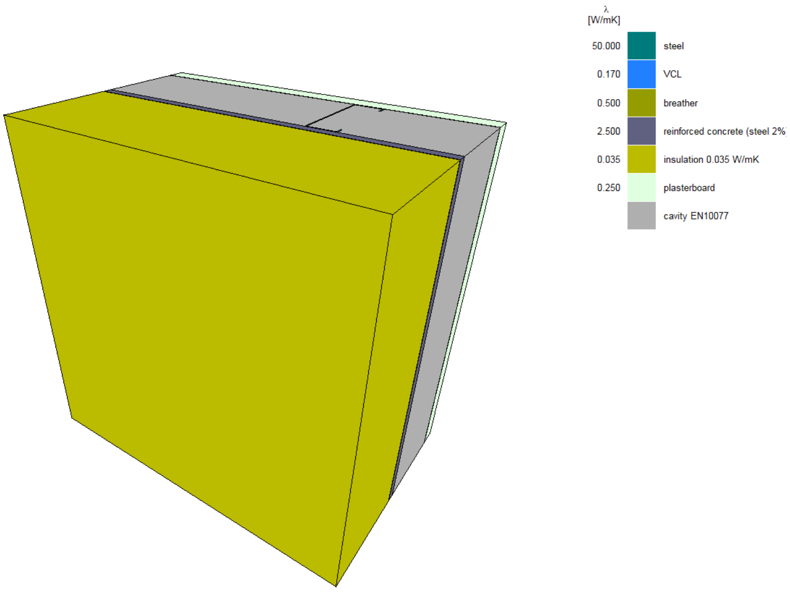


Figure 61 External material thermal conductivity diagram

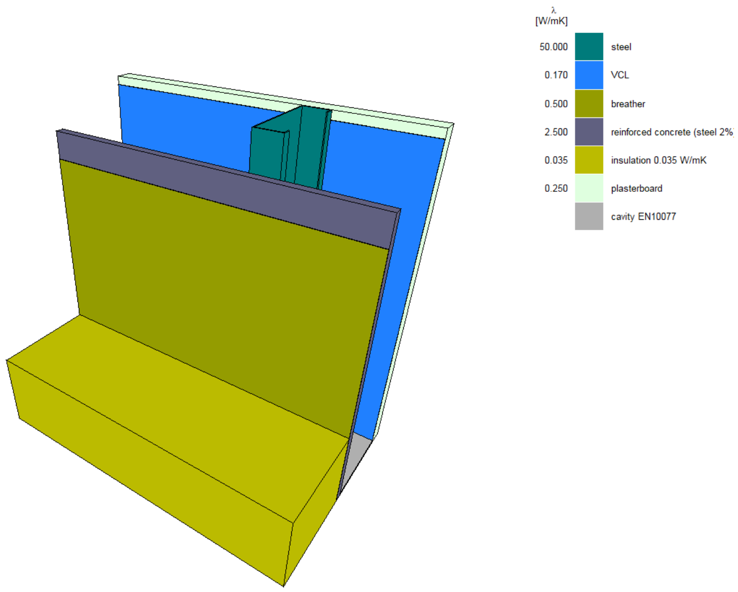


Figure 62 Thermal conductivity diagram –materials cut back for clarity

Temperature Gradient Diagrams

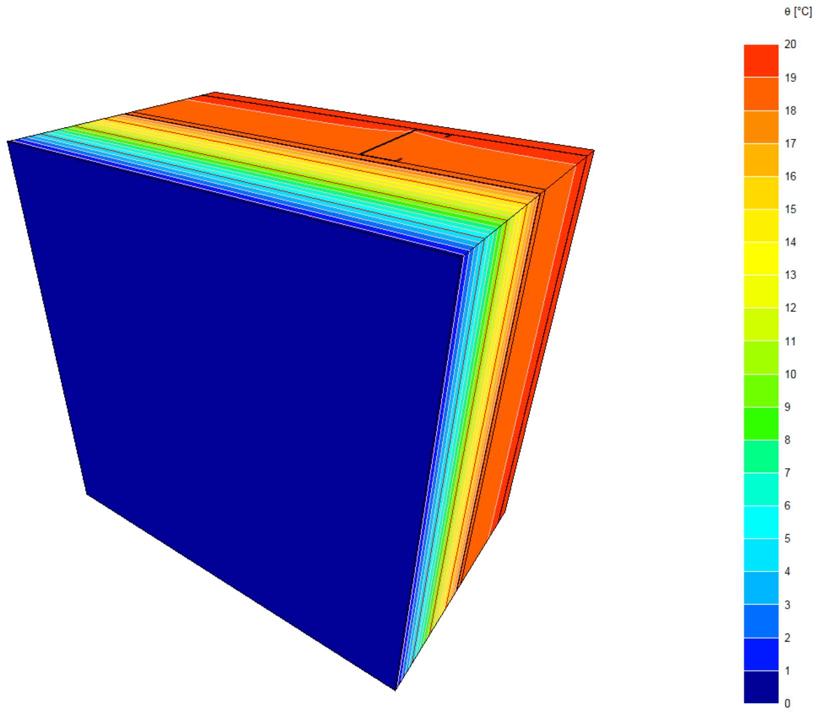


Figure 63 External temperature gradient diagram

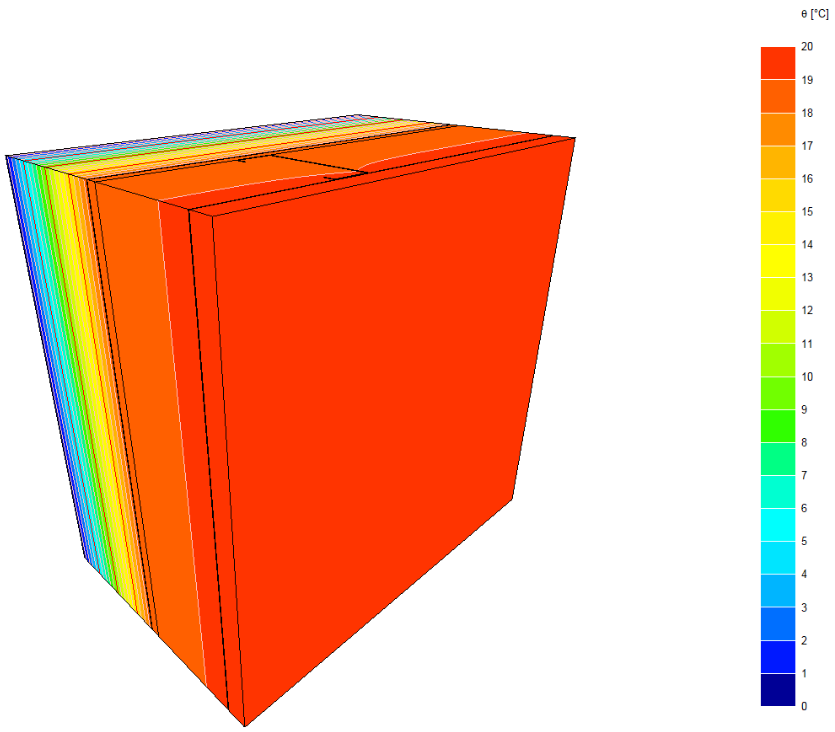


Figure 64 Internal temperature gradient diagram

TRISCO – Input Data

TRISCO data file: 08 cen.trc

COLOURS

Col.	Type	Subtype	Phys. flow	Geom. flow	Name	eps1 / eps2 [- / -]
13	MATERIAL				steel	
42	MATERIAL				VCL	
43	MATERIAL				breather	
136	MATERIAL				reinforced_concrete_(stee	
151	MATERIAL				insulation_0.035_W/mK_	
161	MATERIAL				plasterboard	
174	BC_SIMPL	HI_NORML	HOR		interior	
185	BC_SIMPL	NIHIL			highly_ventilated_cavity,	
200	EQUIMAT	CAVITY	HOR	Yx	cavity_non-vent_physical_	0.90 / 0.90

Col.	lambda [W/mK]	eps [-]	t [°C]	h [W/m²K]	q [W/m²]	ta [°C]	hc [W/m²K]	Pc [W/m]	tr [°C]	Standard
13	50.000									
42	0.170									
43	0.500									
136	2.500									
151	0.035									
161	0.250									
174			20.0	7.70	0					EN10077
185			0.0	7.70	0					NIHIL
200	0.785									EN10077

CALCULATION PARAMETERS
Iteration cycles = 5
Maximum number of iterations (within each iteration cycle) = 10000
Maximum temperature difference (within each iteration cycle) = 0.0001°C
Maximum temperature difference (between iteration cycles) = 0.001°C
Heat flow divergence for total object = 0.001 %
Heat flow divergence for worst node = 1 %
Automatic recalculation of thermal values
Default temperature difference across airspace = 10°C

TRISCO - Calculation Results

TRISCO data file: 08 cen.trc

Number of nodes = 1354328
Heat flow divergence for total object = 0.000987073 %
Heat flow divergence for worst node = 0.104024 %

Q = 1.202 W
ti = 20.0000°C
te = 0.0000°C
A1 = 0.36 m²
Xmin=0 Xmax=126 Ymin=34 Ymax=34 Zmin=0 Zmax=123

Col.	Type	Name	tmin [°C]	X	Y	Z	tmax [°C]	X	Y	Z
13	MATERIAL	steel	18.6572	92	53	0	19.0554	92	85	54
42	MATERIAL	VCL	19.0225	80	85	0	19.1941	126	86	50
43	MATERIAL	breather	18.5132	0	48	0	18.6509	83	49	76
136	MATERIAL	reinforced_concrete_(stee	18.5198	0	49	0	18.6851	81	53	61
151	MATERIAL	insulation_0.035_W/mK_	0.4327	0	7	13	18.6440	83	48	63
161	MATERIAL	plasterboard	19.0508	81	86	0	19.5808	126	92	63
174	BC_SIMPL	interior	19.5197	84	92	0	19.5808	126	92	63
185	BC_SIMPL	highly_ventilated_cavity,	0.4327	0	7	13	0.4343	87	7	119
200	EQUIMAT	cavity_non-vent_physical_	18.5397	0	53	0	19.1752	126	85	55

Col.	Type	Name	ta [°C]	Flow in [W]	Flow out [W]
174	BC_SIMPL	interior		1.2018	0.0000
185	BC_SIMPL	highly_ventilated_cavity,		0.0000	1.2018