H1/AS1 slab PSI and R-values for NZGBC

Slab NZBC R-value and Passive House Ψ and fRSI

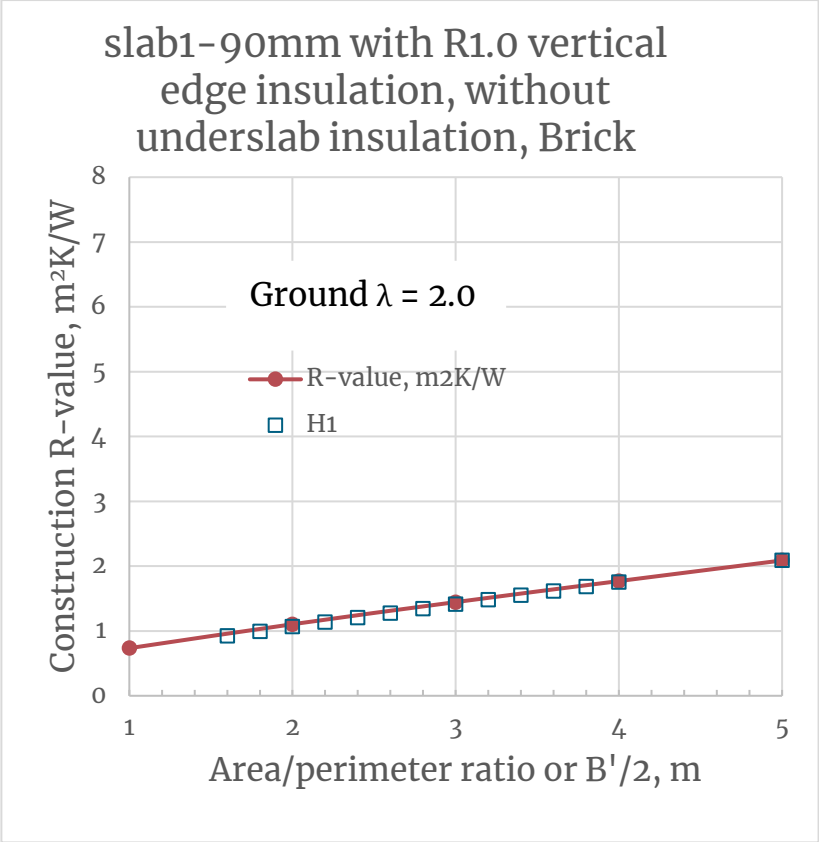
1 February 2022

Sustainable Engineering Ltd

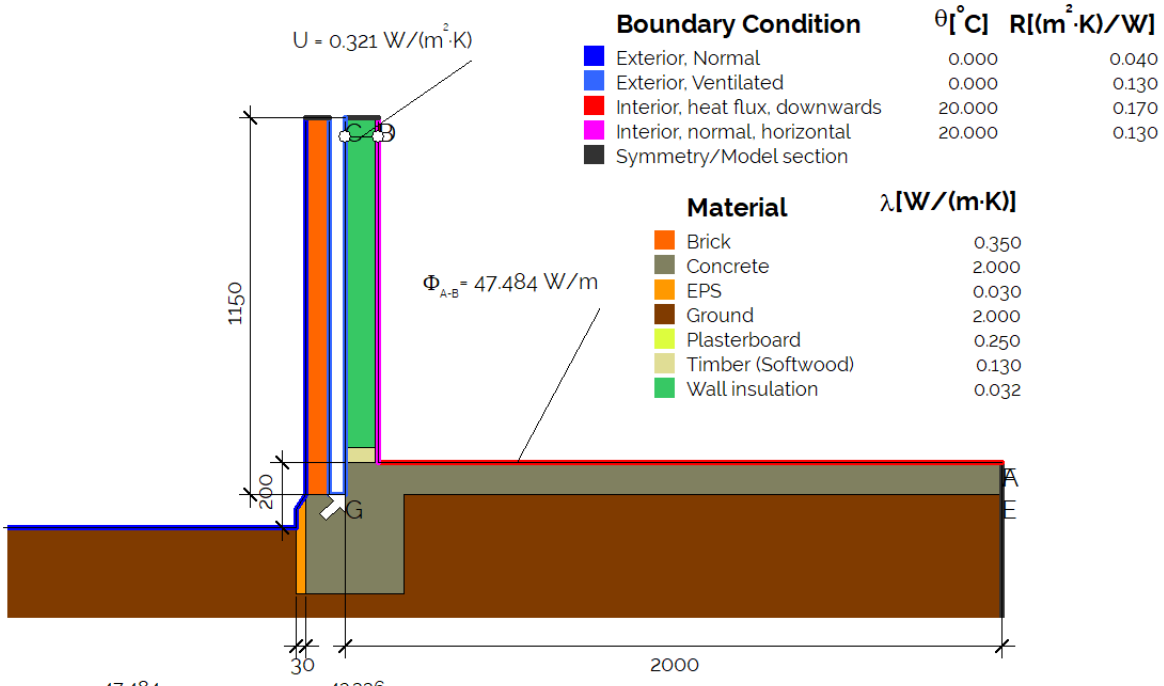
SUSTAINABLE ENGINEERING LTD

CONTENTS

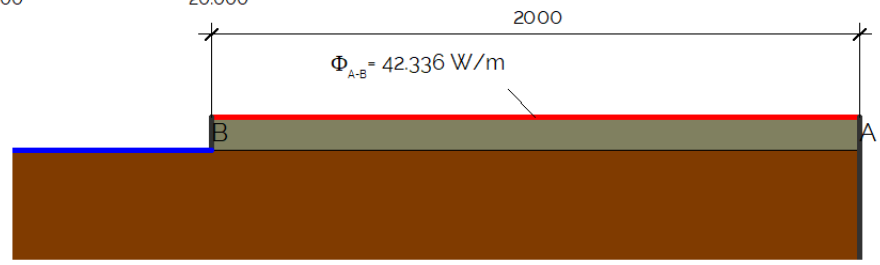
Slab1-90mm with R1.0 vertical edge insulation, without underslab insulation, Brick

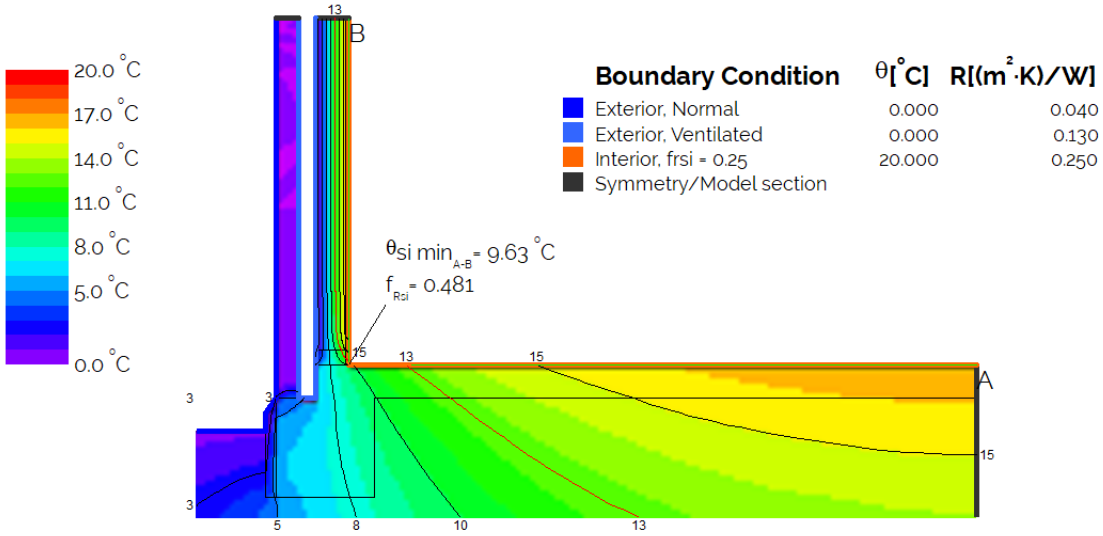


A/P, m	R-value, m2K/W
1	0.73
2	1.10
3	1.45
4	1.77
5	2.09

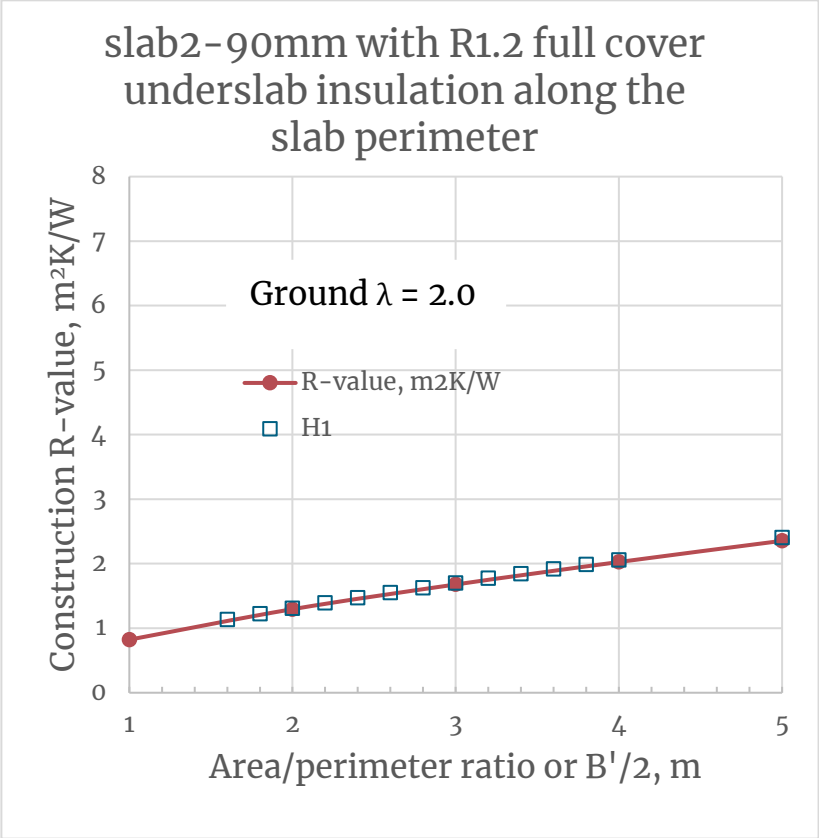


$$\psi_{C\text{-}G\text{-}E} = \frac{47.484}{20.000} - 0.321 \cdot 1.150 - \frac{42.336}{20.000} = -0.112 \text{ W/(m·K)}$$

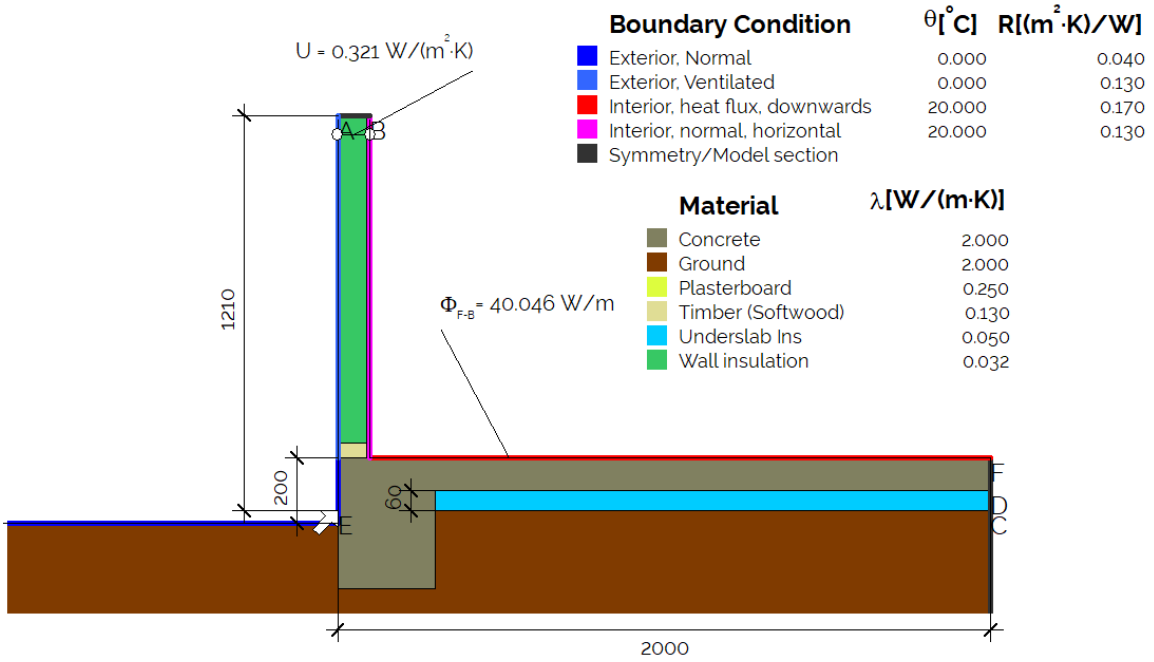




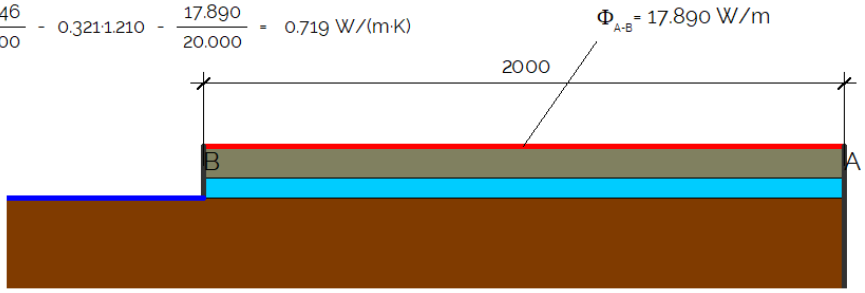
slab2-90mm with R1.2 full cover underslab insulation along the slab perimeter

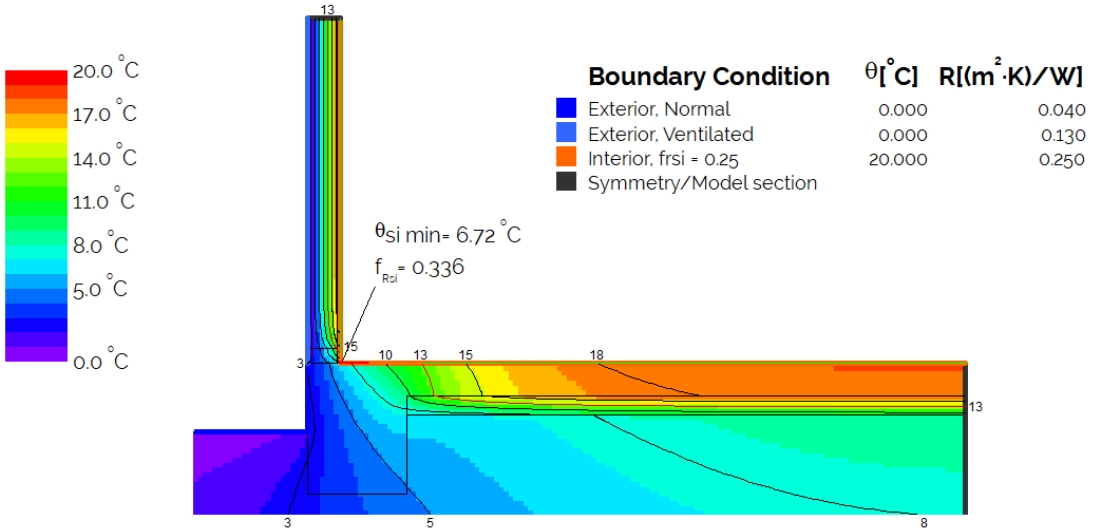


A/P, m	R-value, m2K/W
1	0.82
2	1.29
3	1.68
4	2.03
5	2.35

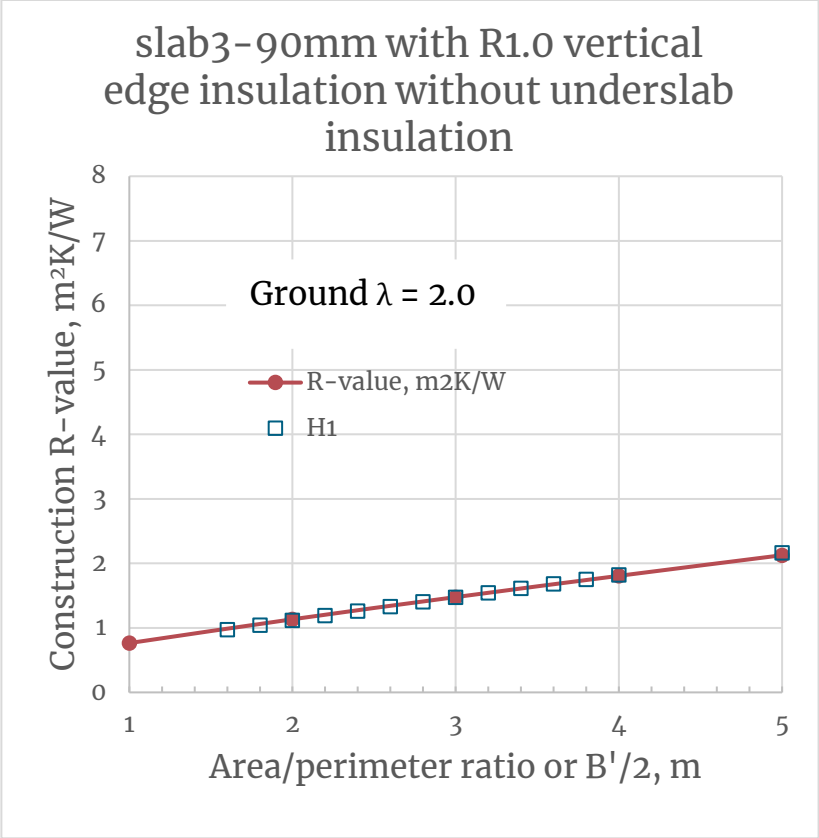


$$\Psi_{A\text{-}E\text{-}C} = \frac{40.046}{20.000} - 0.321 \cdot 1.210 - \frac{17.890}{20.000} = 0.719 \text{ W/(m·K)}$$

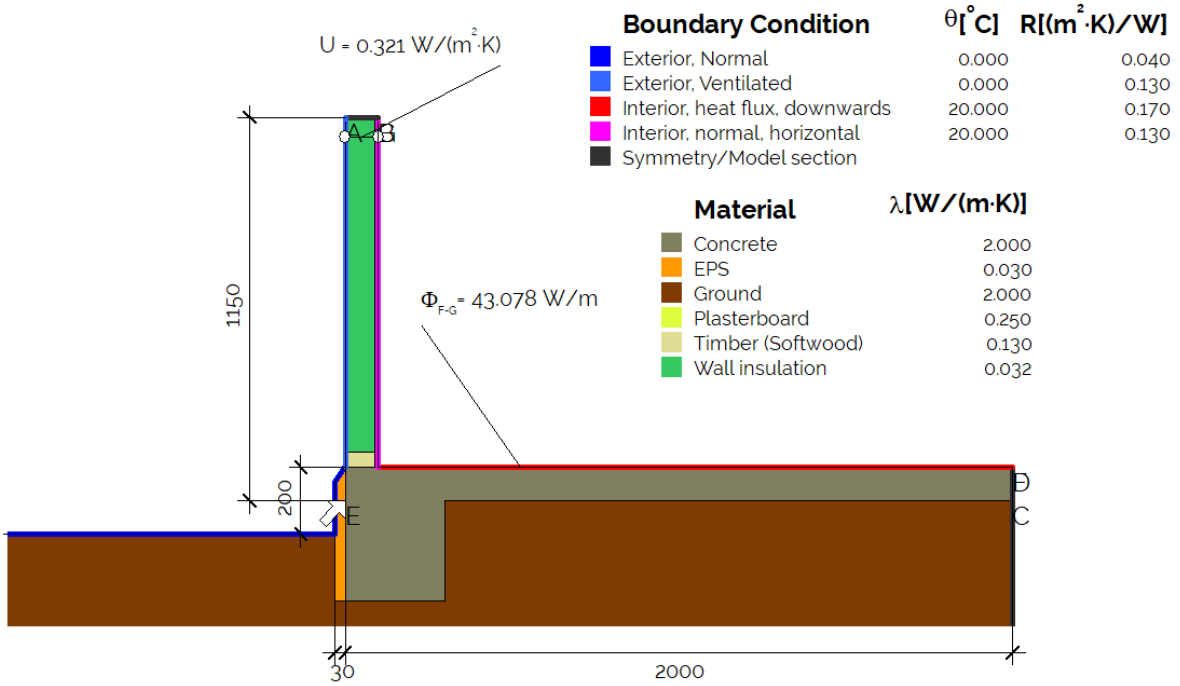




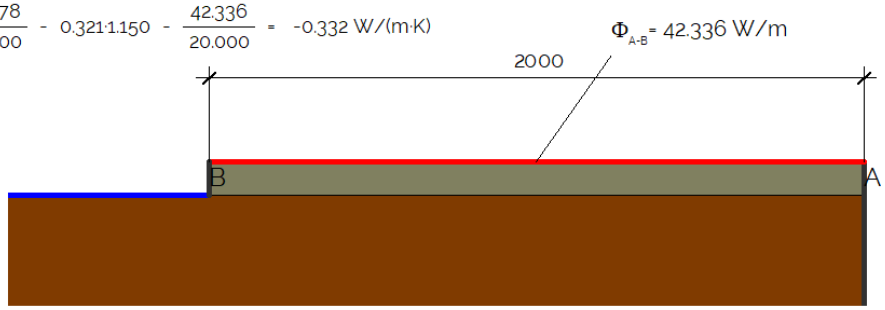
slab3-90mm with R1.0 vertical edge insulation without underslab insulation

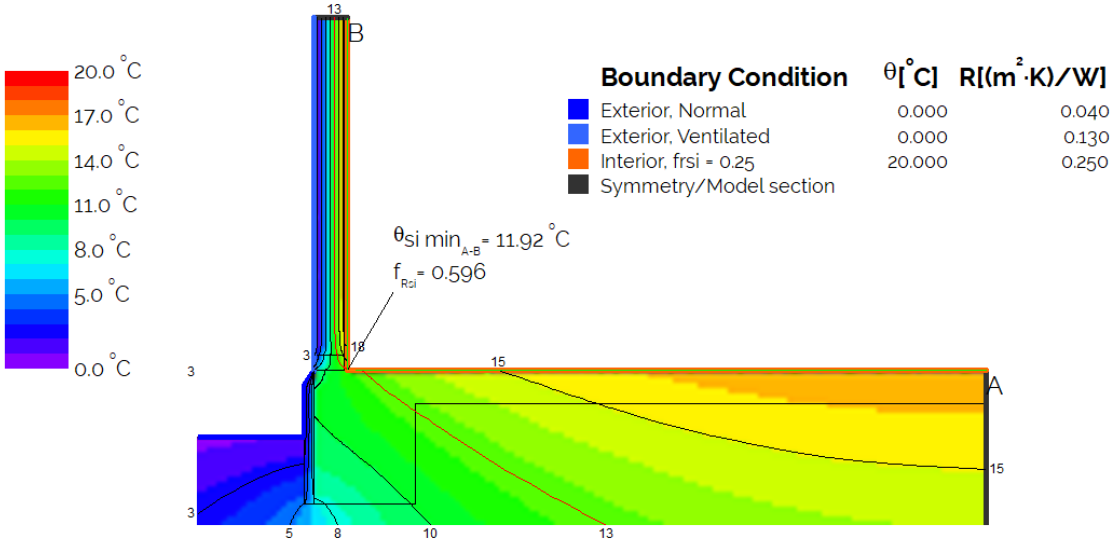


A/P, m	R-value, m2K/W
1	0.76
2	1.13
3	1.48
4	1.81
5	2.13

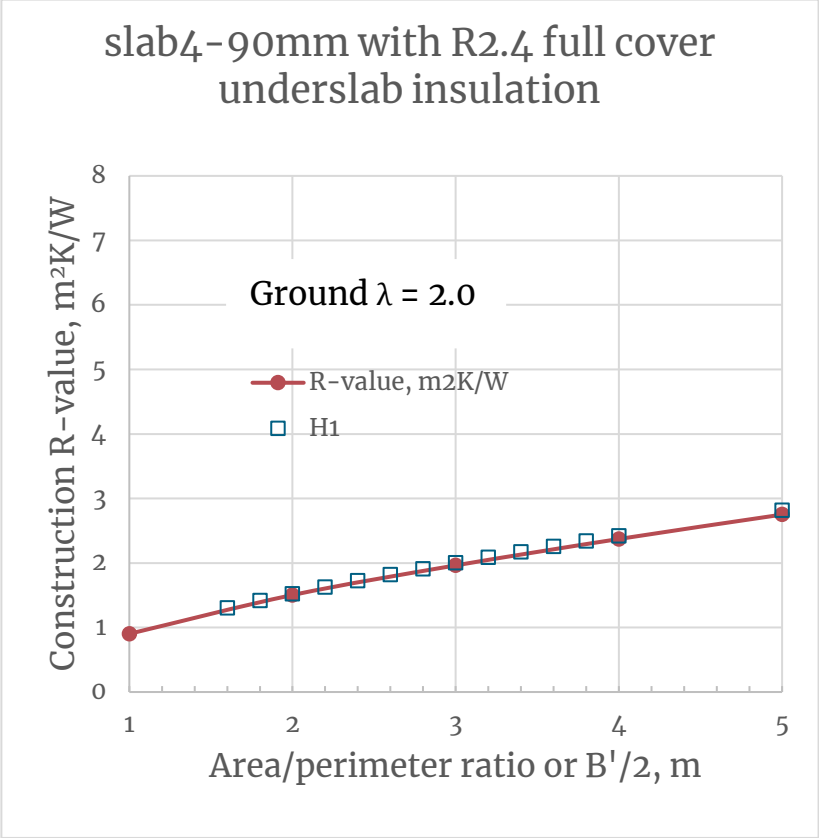


$$\psi_{A\text{-}E\text{-}C} = \frac{43.078}{20.000} - 0.321 \cdot 1.150 - \frac{42.336}{20.000} = -0.332 \text{ W/(m·K)}$$

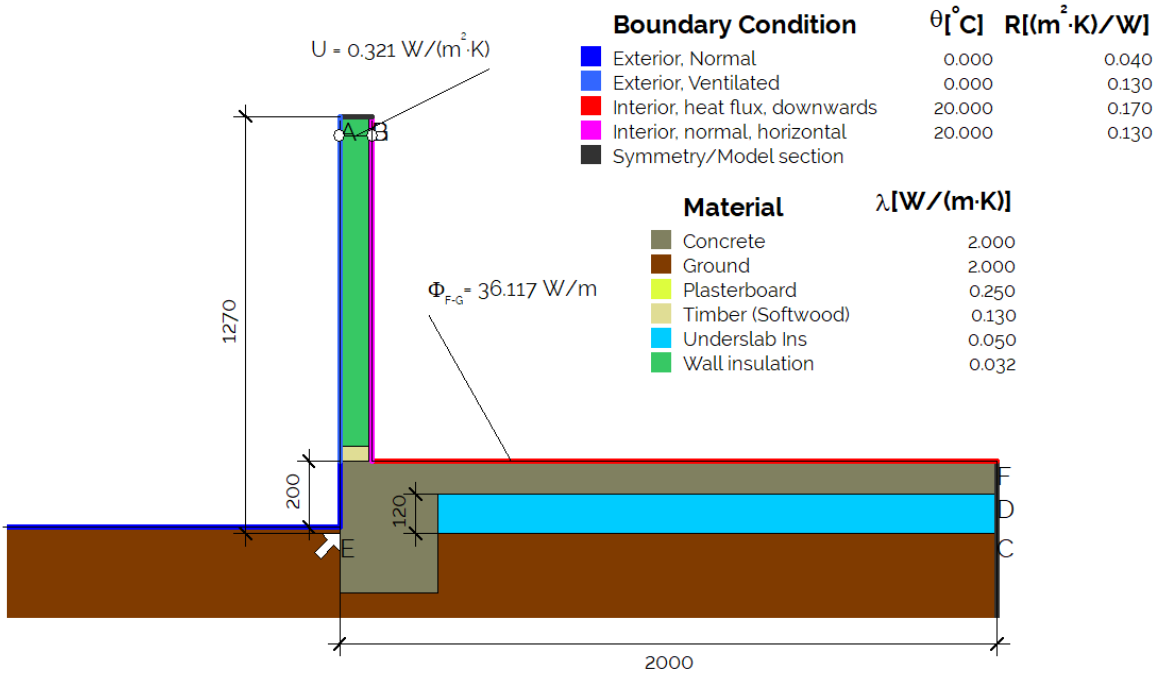




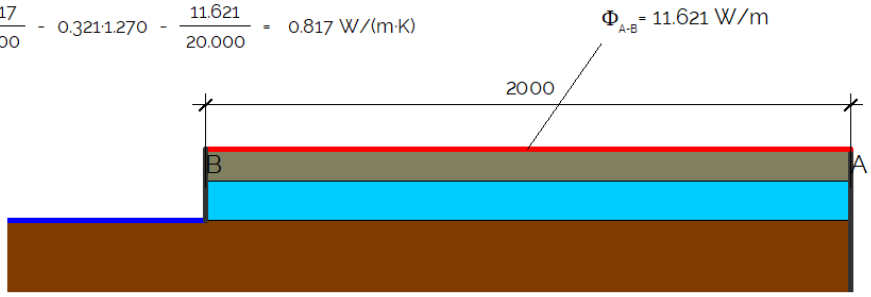
slab4-90mm with R2.4 full cover underslab insulation

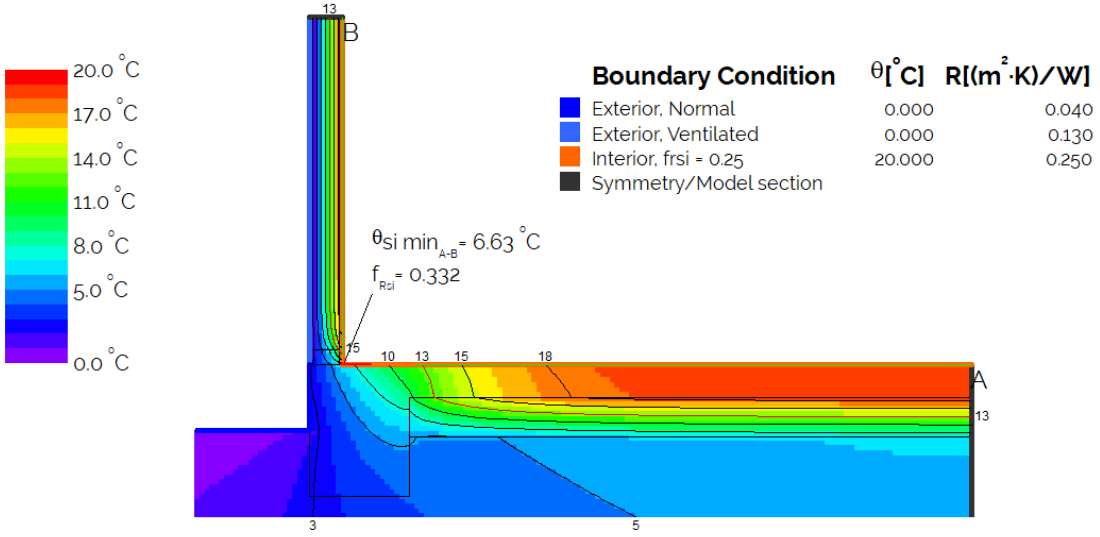


A/P, m	R-value, m2K/W
1	0.90
2	1.50
3	1.96
4	2.37
5	2.75

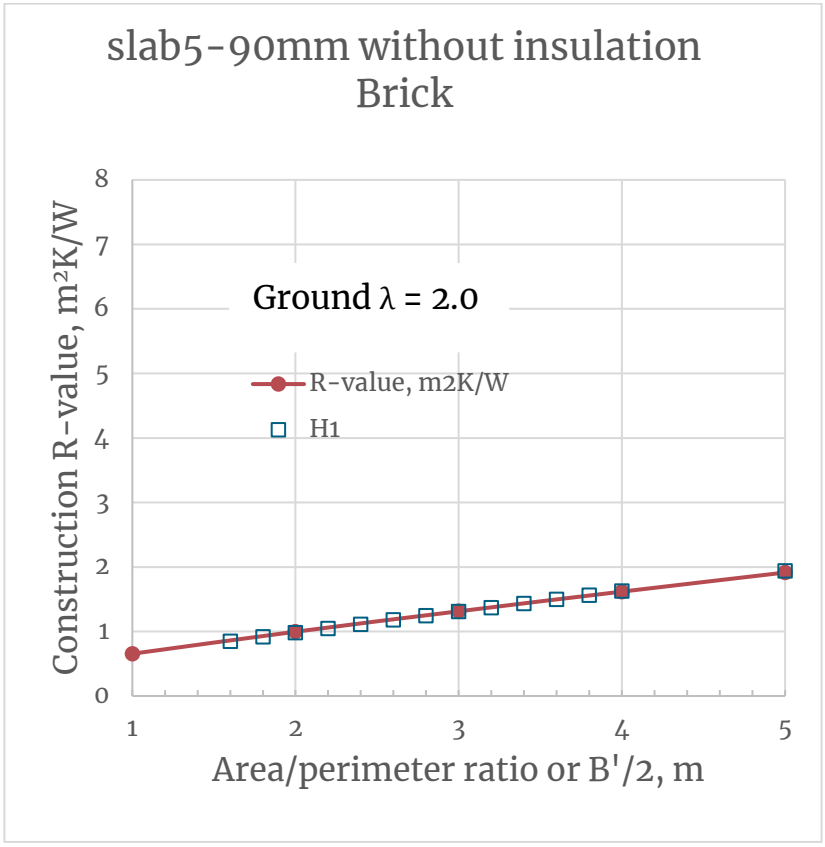


$$\psi_{A\text{-}E\text{-}C} = \frac{36.117}{20.000} - 0.321 \cdot 1.270 - \frac{11.621}{20.000} = 0.817 \text{ W/(m·K)}$$

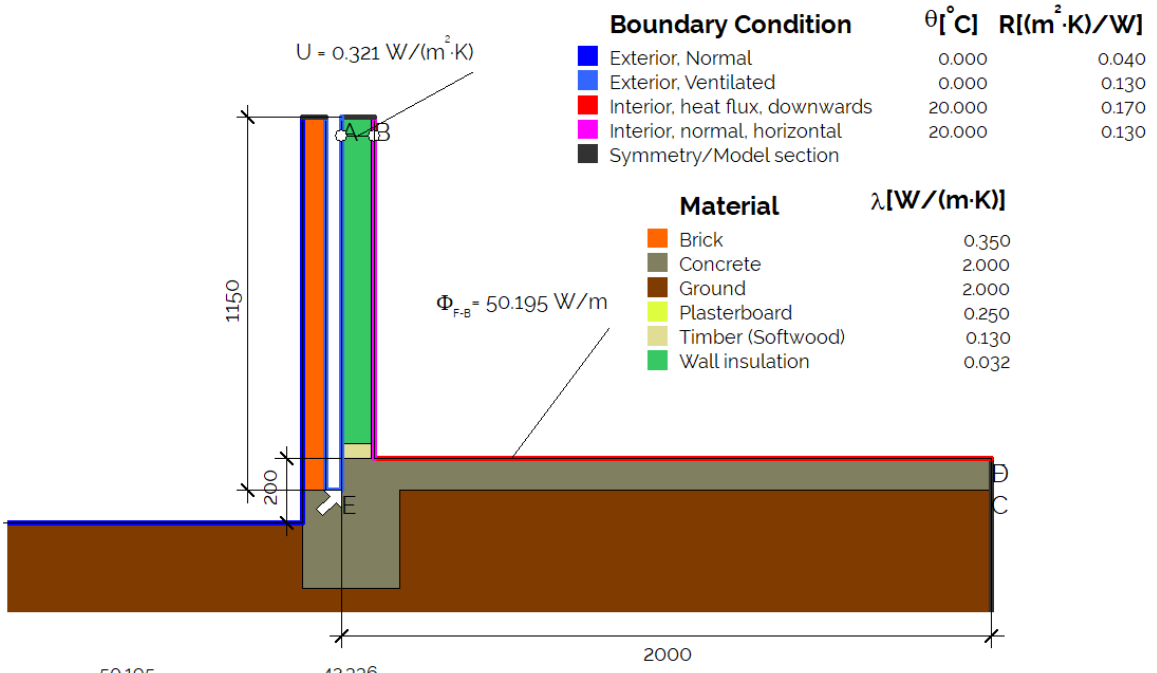




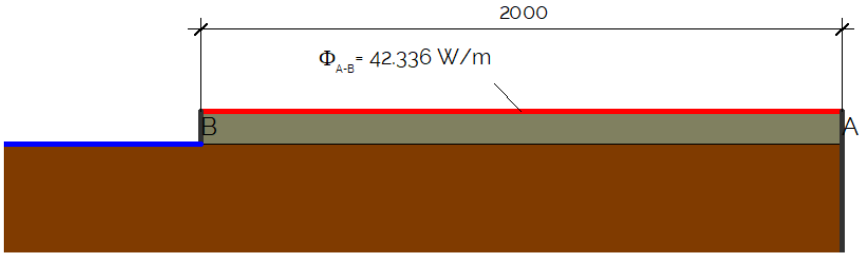
slab5-90mm without insulation Brick

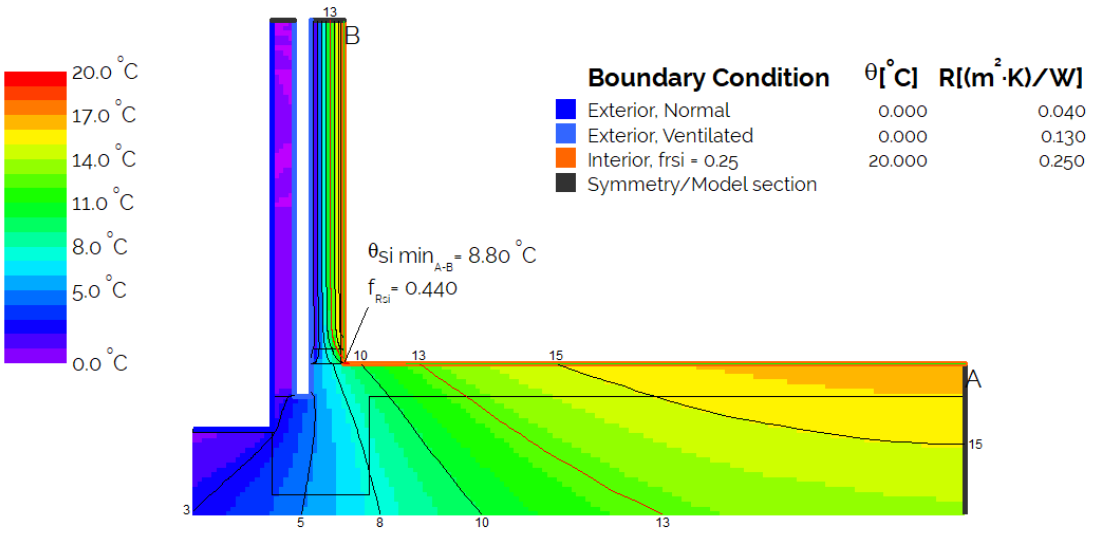


A/P, m	R-value, m2K/W
1	0.66
2	1.00
3	1.31
4	1.62
5	1.91

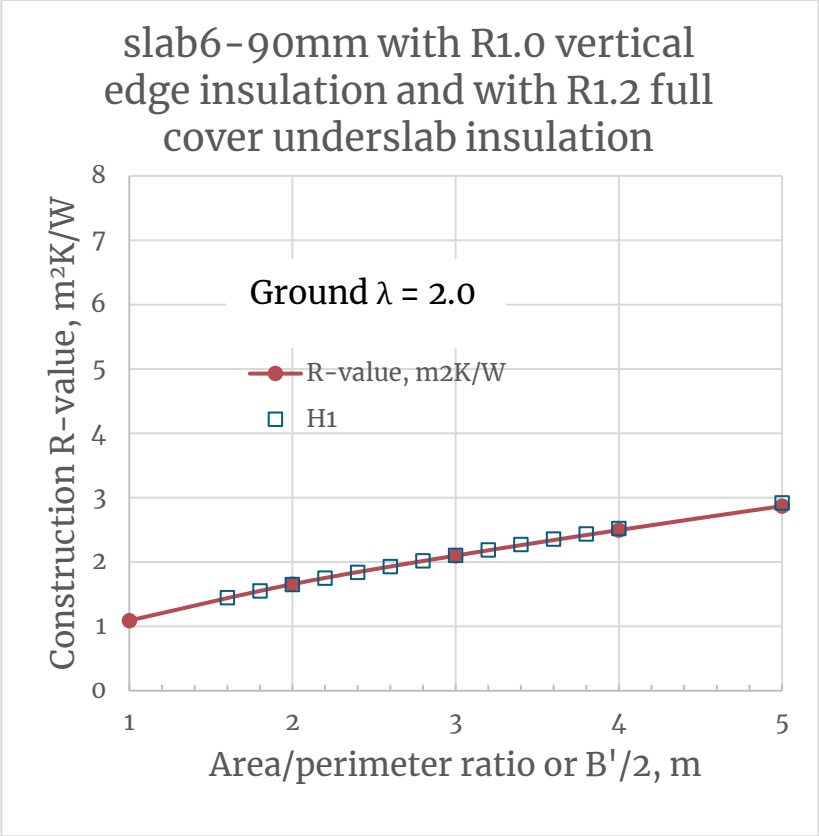


$$\psi_{A\text{-}E\text{-}C} = \frac{50.195}{20.000} - 0.321 \cdot 1.150 - \frac{42.336}{20.000} = 0.023 \text{ W/(m·K)}$$

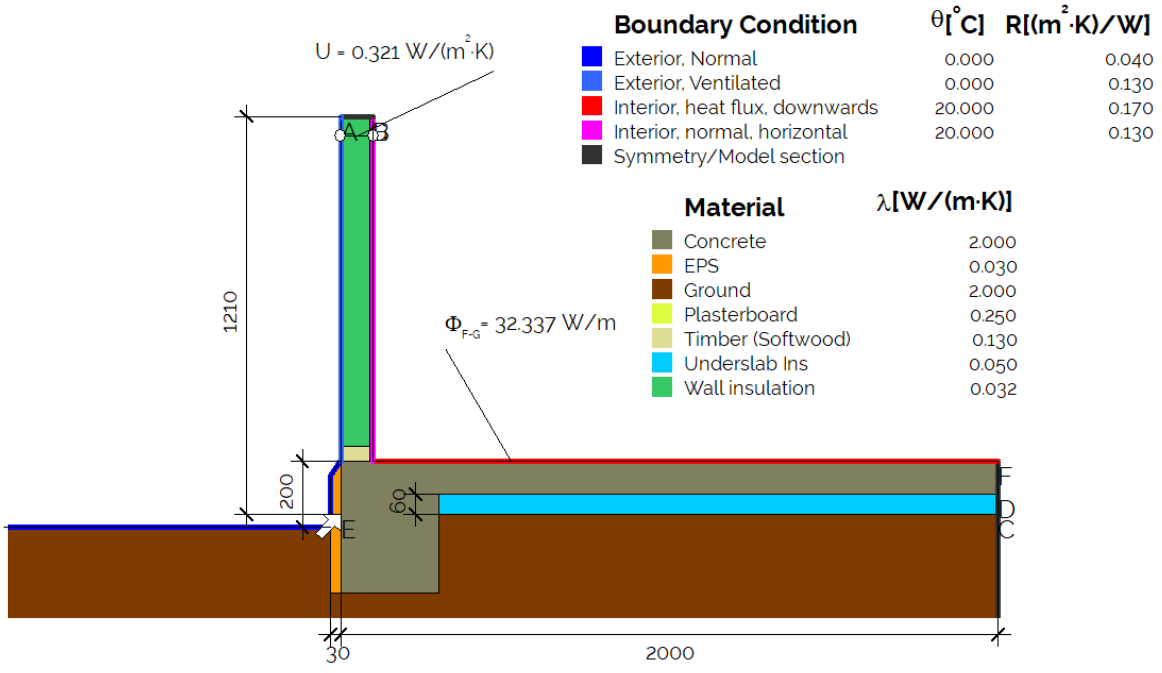




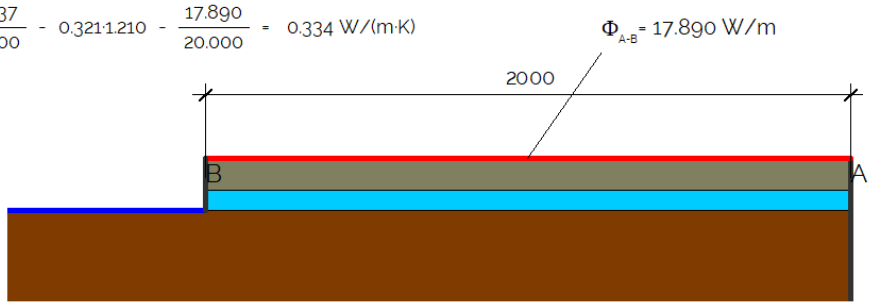
slab6-90mm with R1.0 vertical edge insulation and with R1.2 full cover underslab insulation

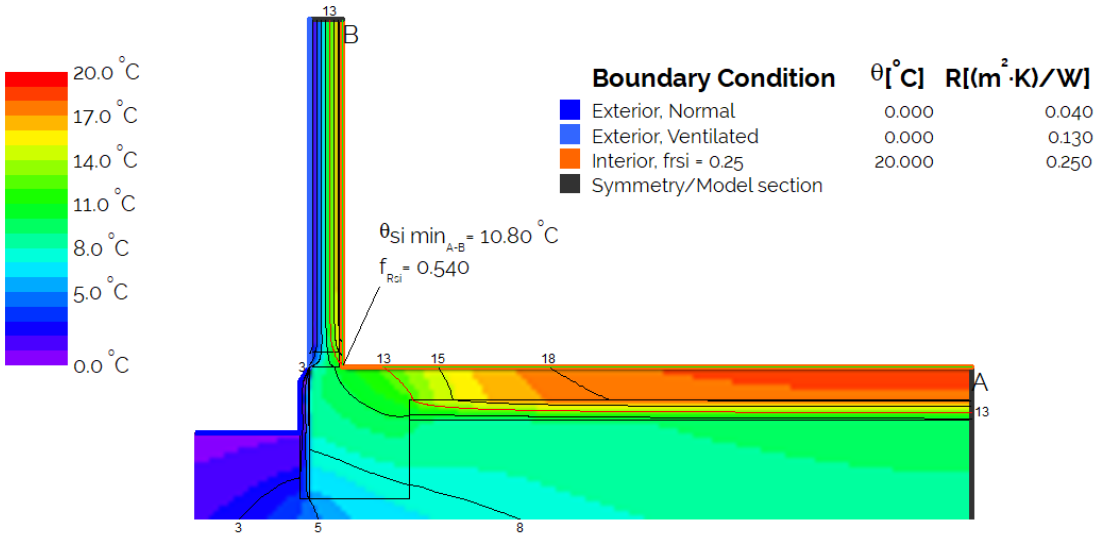


A/P, m	R-value, m2K/W
1	1.09
2	1.66
3	2.10
4	2.50
5	2.87

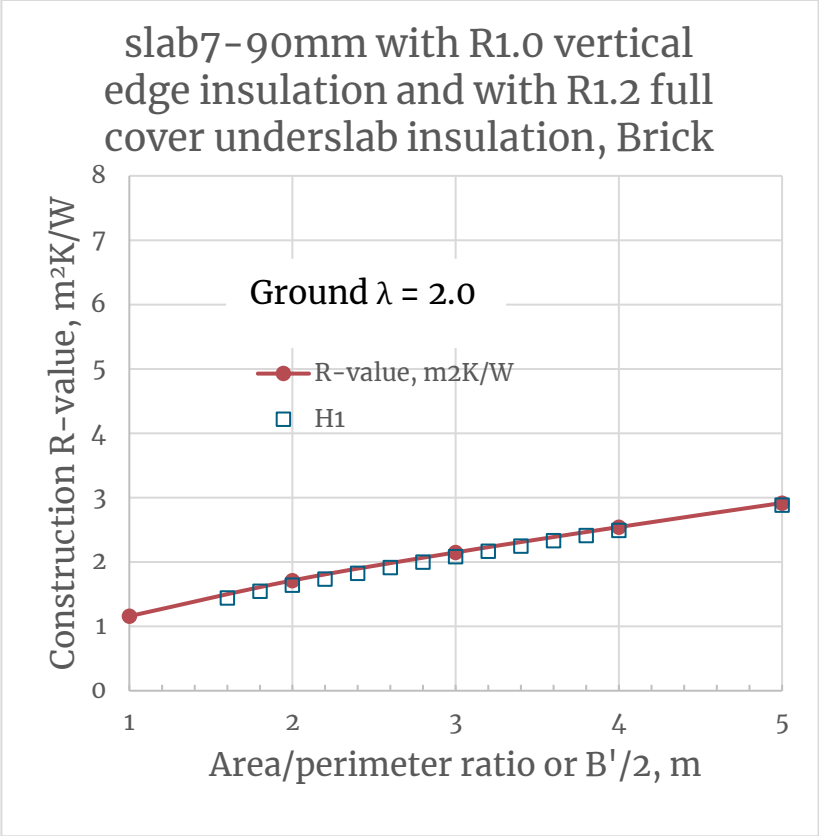


$$\Psi_{A\text{-}E\text{-}C'} = \frac{32.337}{20.000} - 0.321 \cdot 1.210 - \frac{17.890}{20.000} = 0.334 \text{ W/(m·K)}$$

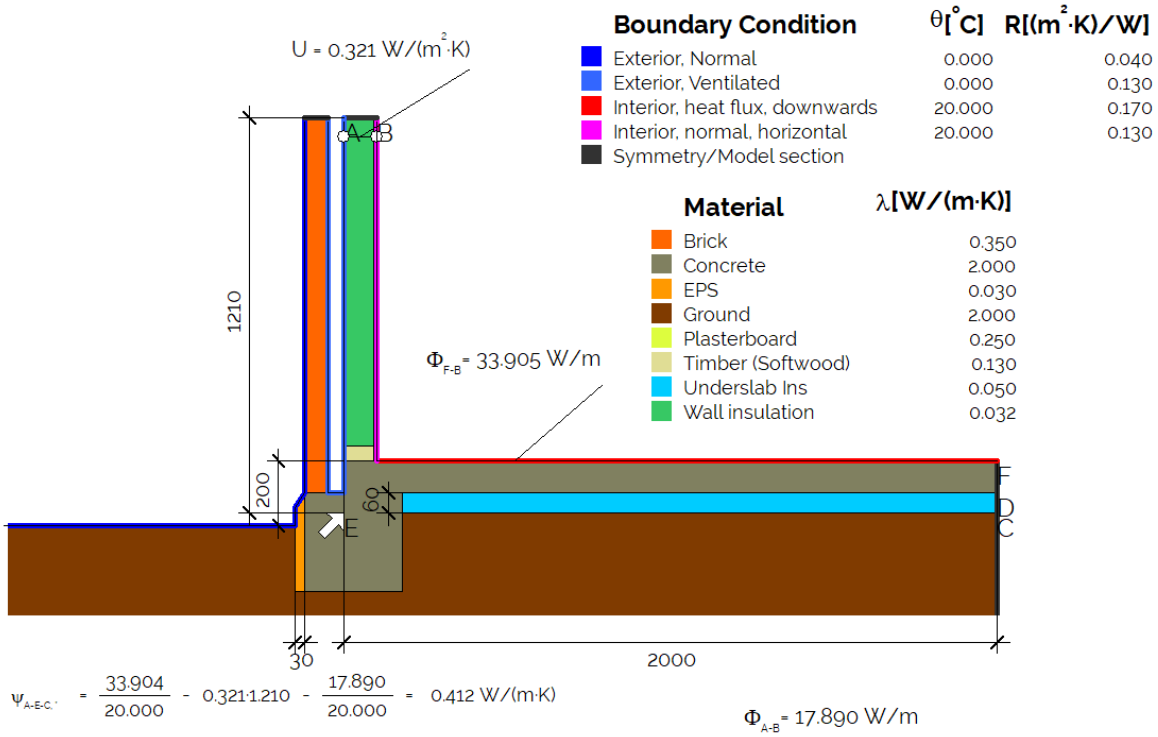


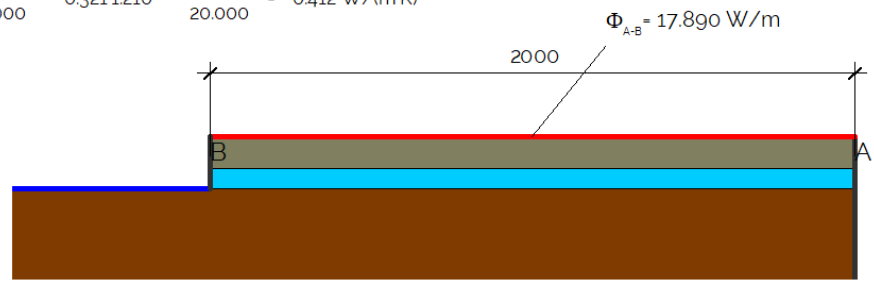


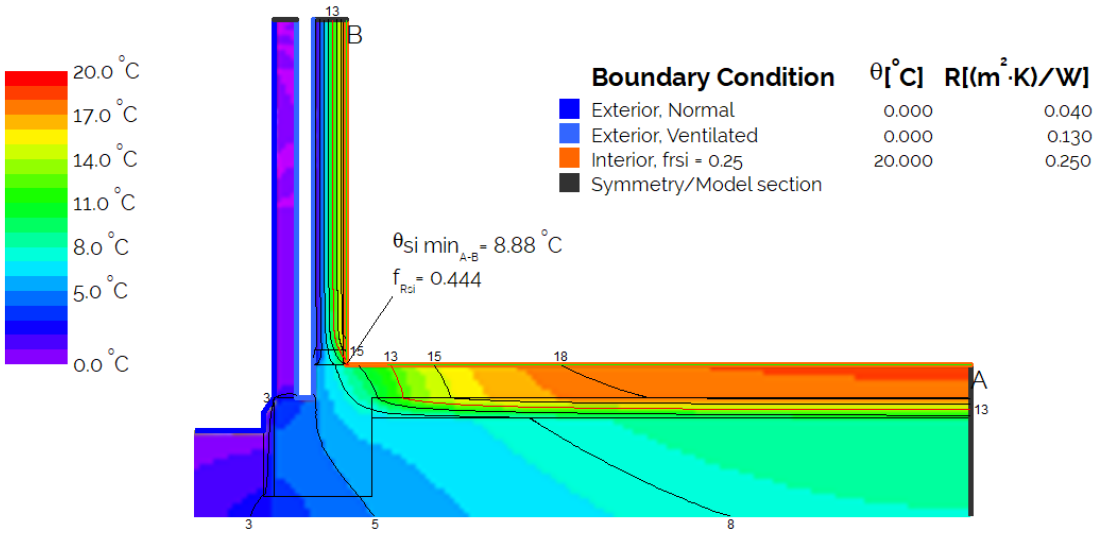
slab7-90mm with R1.0 vertical edge insulation and with R1.2 full cover underslab insulation, Brick



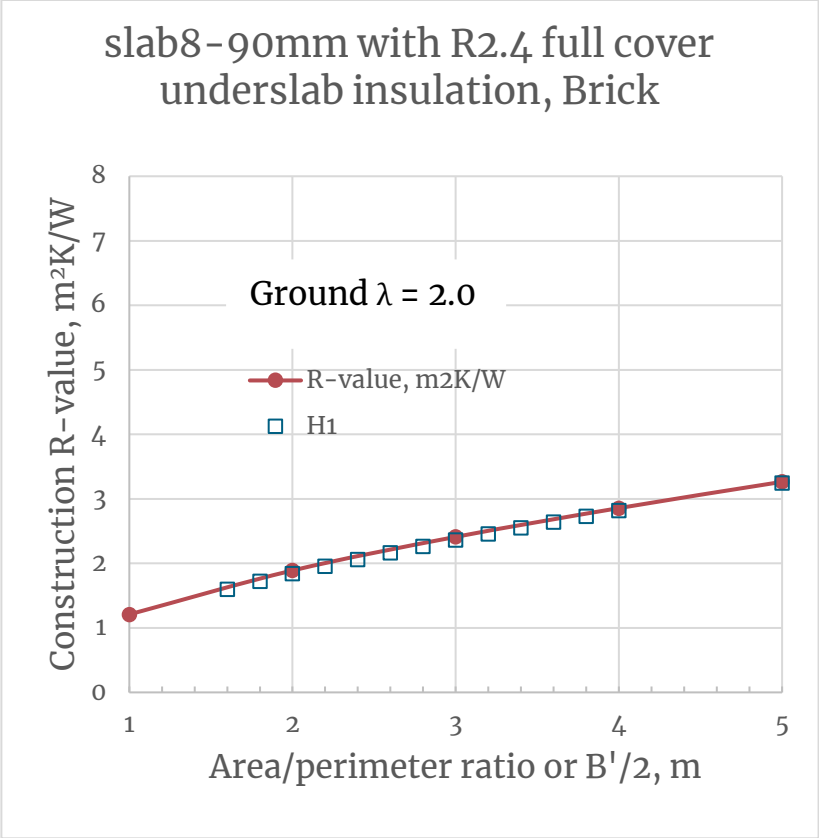
A/P, m	R-value, m2K/W
1	1.16
2	1.71
3	2.15
4	2.54
5	2.92


U = 0.321 W/(m²·K)
Boundary Condition θ[°C] R[(m²·K)/W]
Exterior, Normal 0.000 0.040
Exterior, Ventilated 0.000 0.130
Interior, heat flux, downwards 20.000 0.170
Interior, normal, horizontal 20.000 0.130
Symmetry/Model section
Material λ[W/(m·K)]
Brick 0.350
Concrete 2.000
EPS 0.030
Ground 2.000
Plasterboard 0.250
Timber (Softwood) 0.130
Underslab Ins 0.050
Wall insulation 0.032
Φ F-B = 33.905 W/m
1210
200
60
30
2000
A
B
C
D
E
F
ψ A-E-C' = 33.904/20.000 - 0.321·1.210 - 17.890/20.000 = 0.412 W/(m·K)

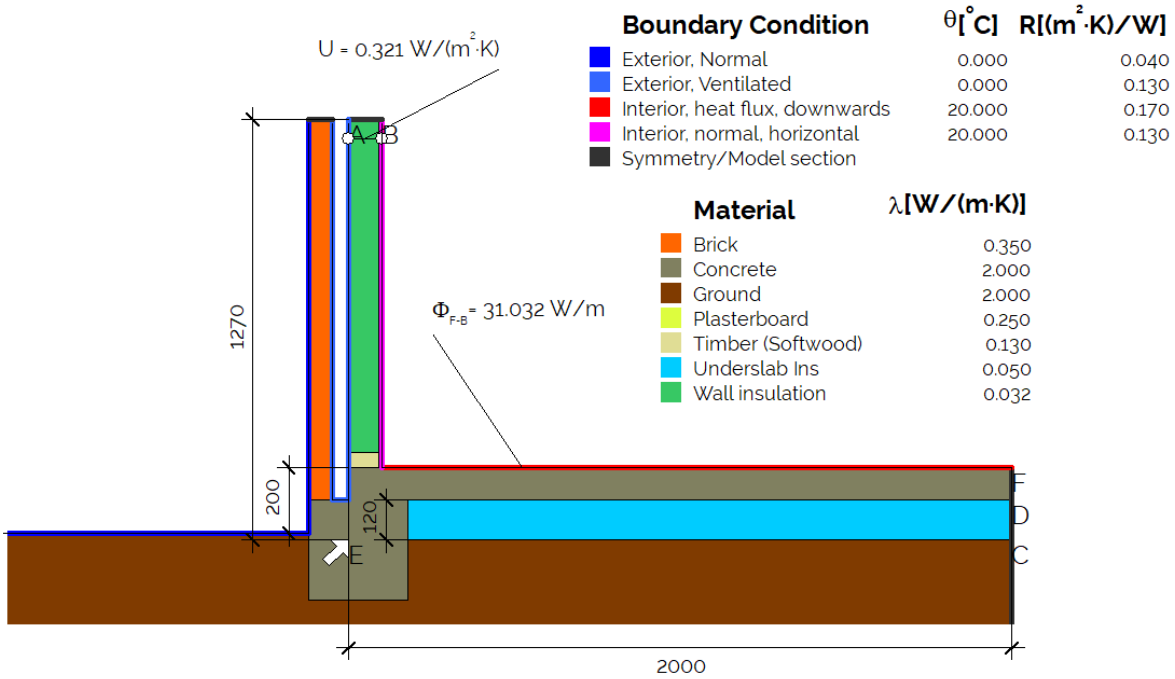

Φ A-B = 17.890 W/m
2000
A
B


20.0 °C
17.0 °C
14.0 °C
11.0 °C
8.0 °C
5.0 °C
0.0 °C
Boundary Condition θ[°C] R[(m²·K)/W]
Exterior, Normal 0.000 0.040
Exterior, Ventilated 0.000 0.130
Interior, frsi = 0.25 20.000 0.250
Symmetry/Model section
θsi min A-B = 8.88 °C
f Rsi = 0.444
A
B

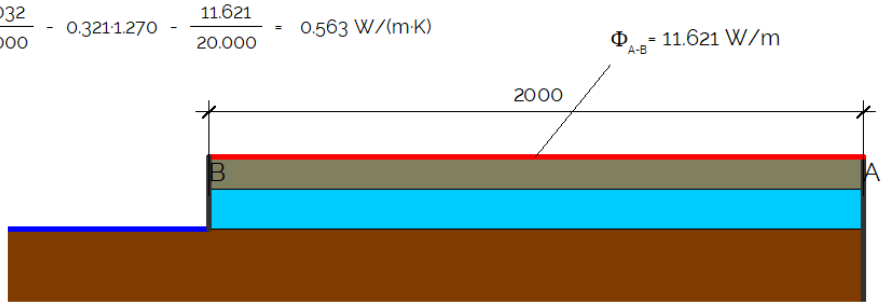
slab8-90mm with R2.4 full cover underslab insulation, Brick

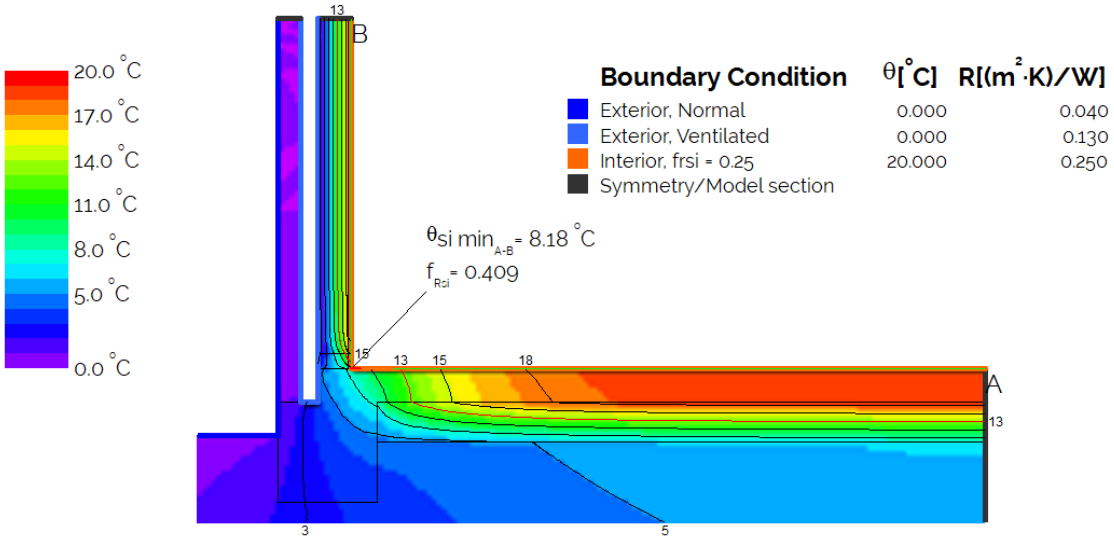


A/P, m	R-value, m2K/W
1	1.21
2	1.89
3	2.41
4	2.86
5	3.26

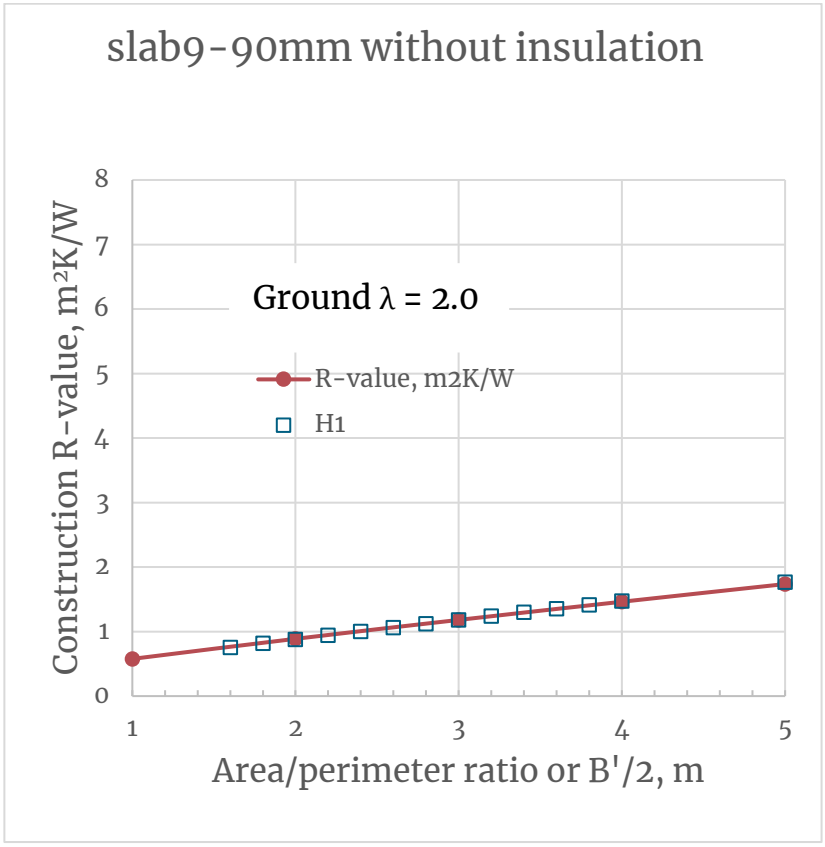


$$\psi_{A\text{-}E\text{-}C} = \frac{31.032}{20.000} - 0.321 \cdot 1.270 - \frac{11.621}{20.000} = 0.563 \text{ W/(m·K)}$$

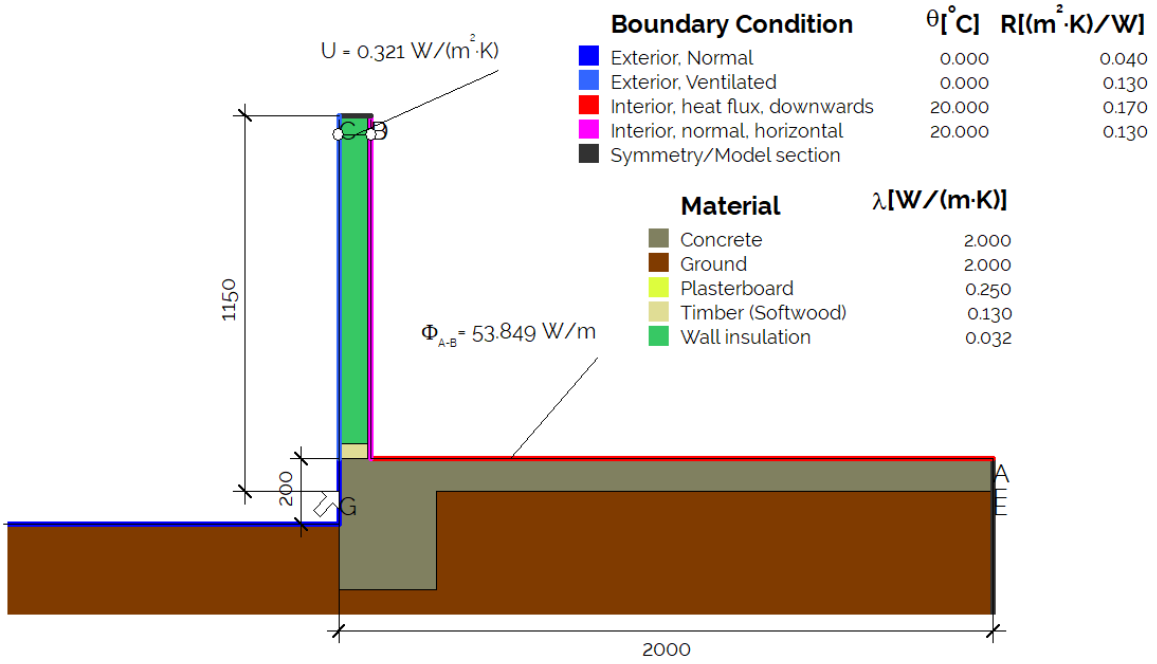




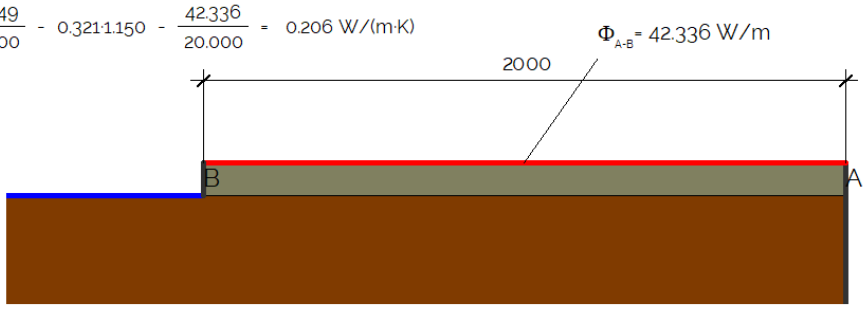
slab9-90mm without insulation

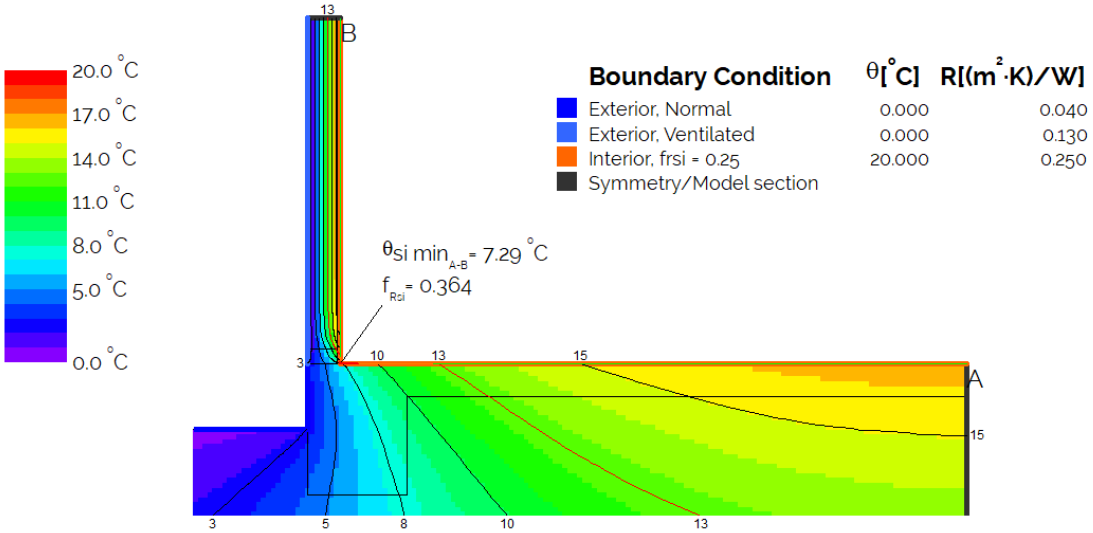


A/P, m	R-value, m2K/W
1	0.58
2	0.89
3	1.18
4	1.46
5	1.74

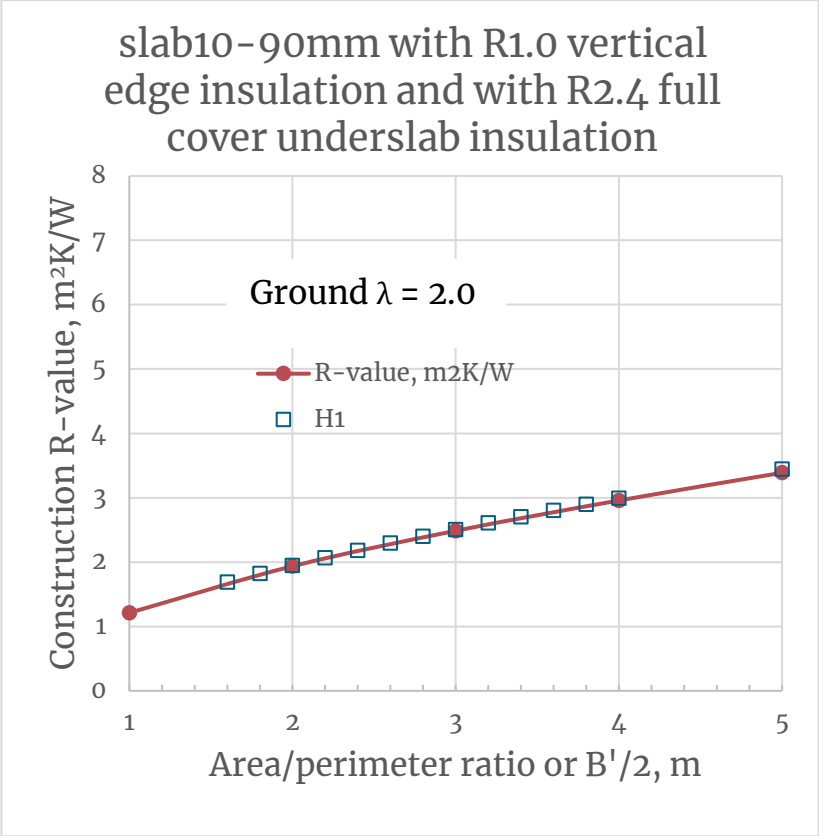


$$\psi_{C\text{-}G\text{-}E} = \frac{53.849}{20.000} - 0.321 \cdot 1.150 - \frac{42.336}{20.000} = 0.206 \text{ W/(m·K)}$$

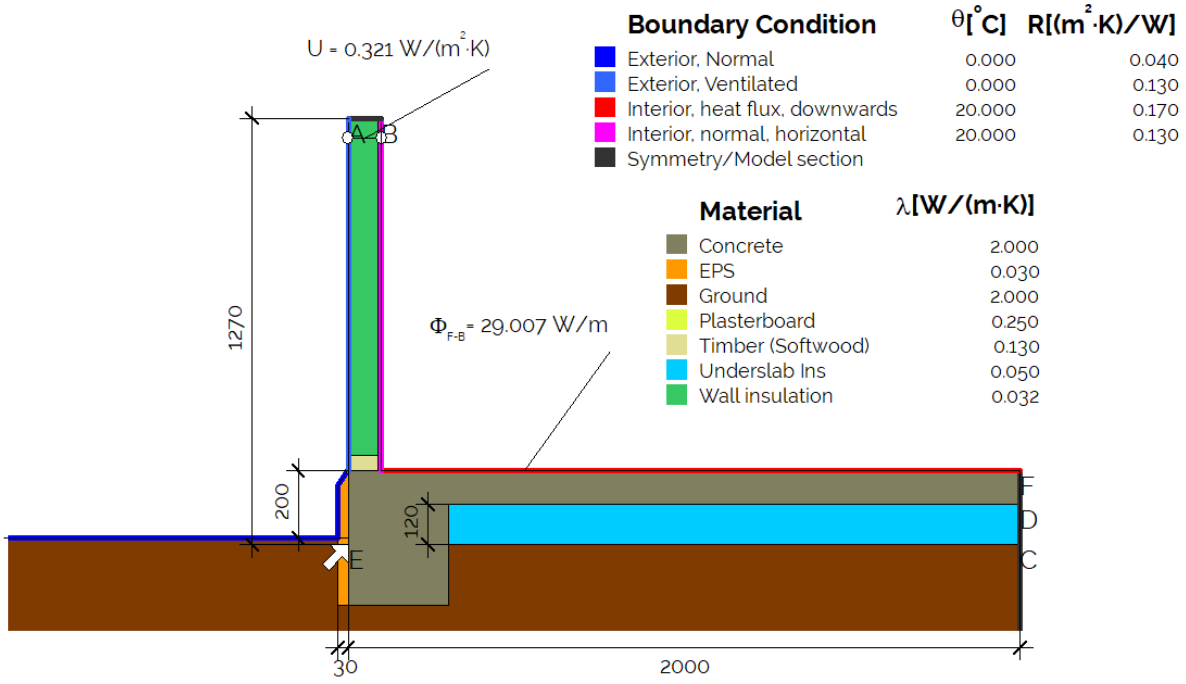




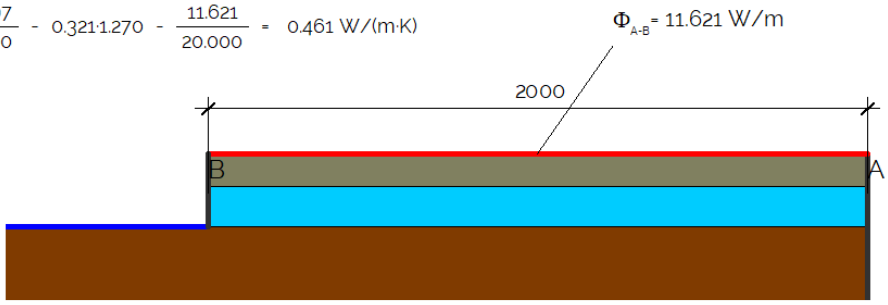
slab10-90mm with R1.0 vertical edge insulation and with R2.4 full cover underslab insulation

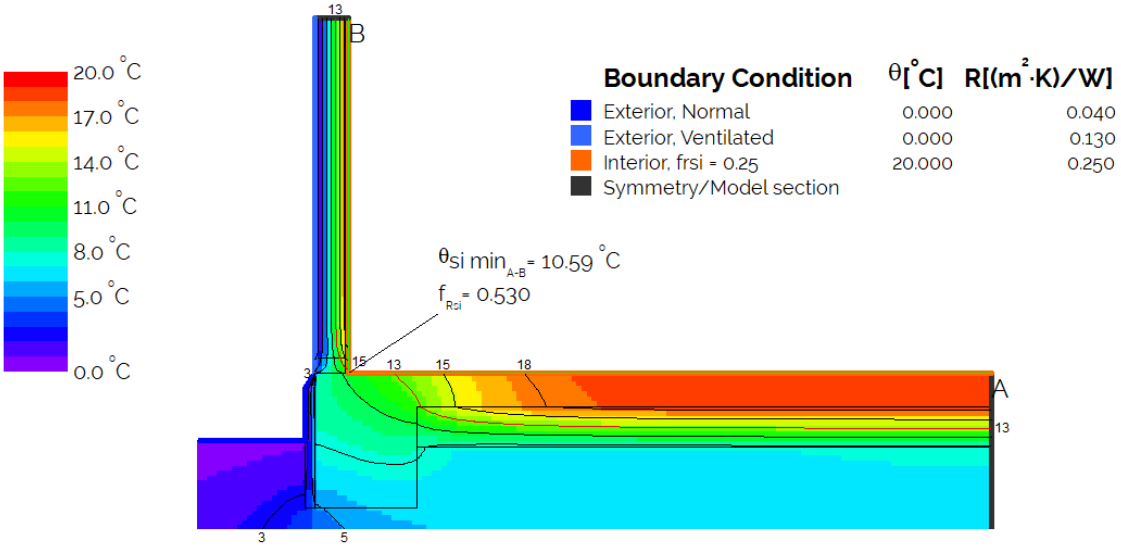


A/P, m	R-value, m2K/W
1	1.21
2	1.94
3	2.49
4	2.96
5	3.39

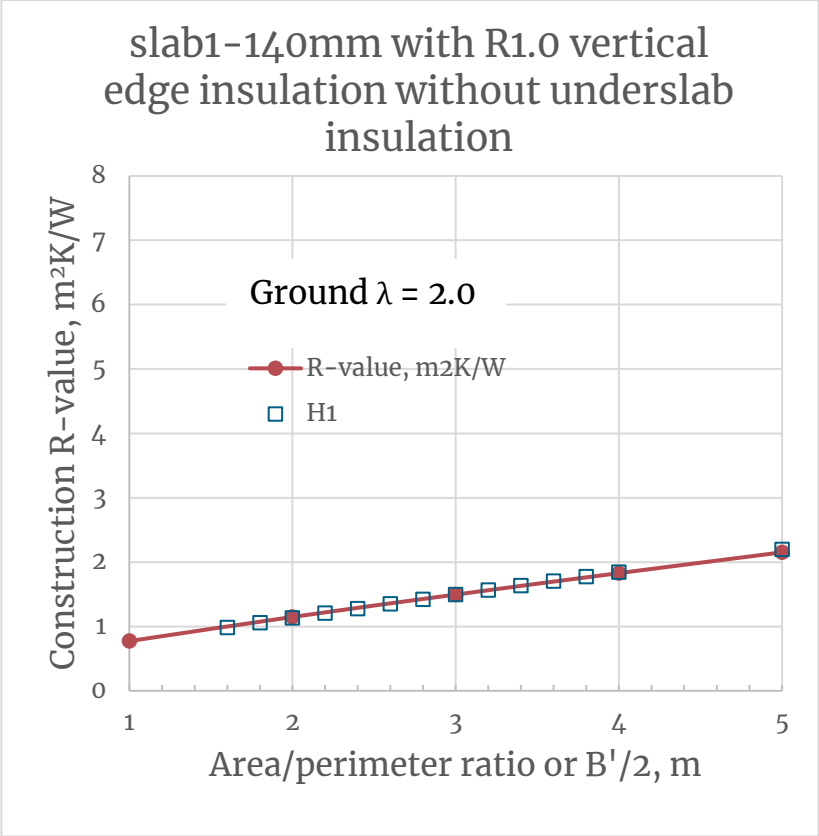


$$\Psi_{A\text{-}E\text{-}C} = \frac{29.007}{20.000} - 0.321 \cdot 1.270 - \frac{11.621}{20.000} = 0.461 \text{ W/(m·K)}$$

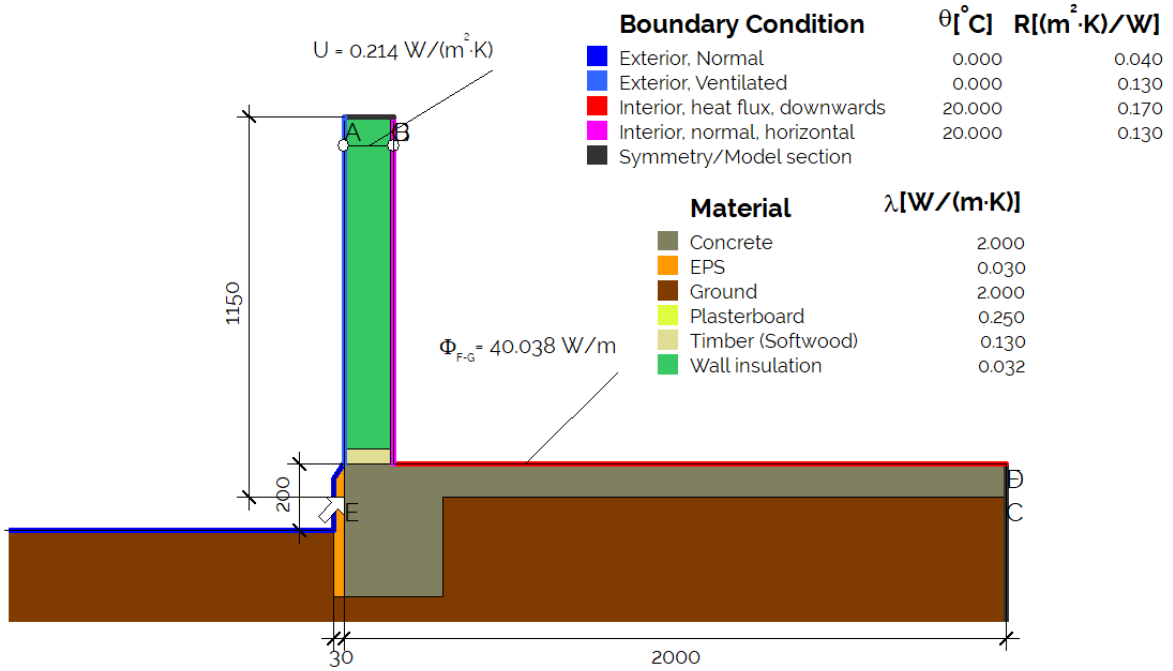




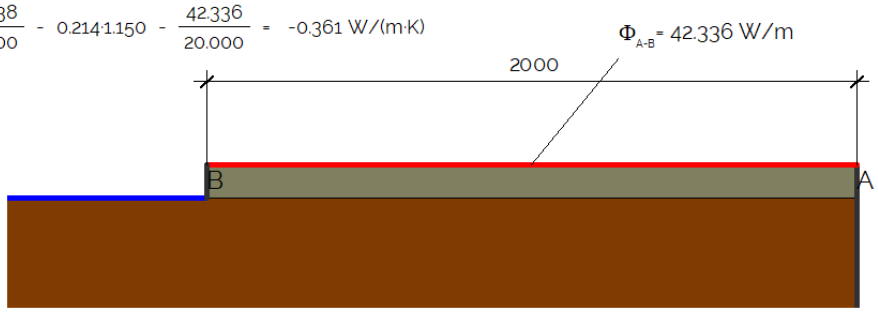
slab1-140mm with R1.0 vertical edge insulation without underslab insulation

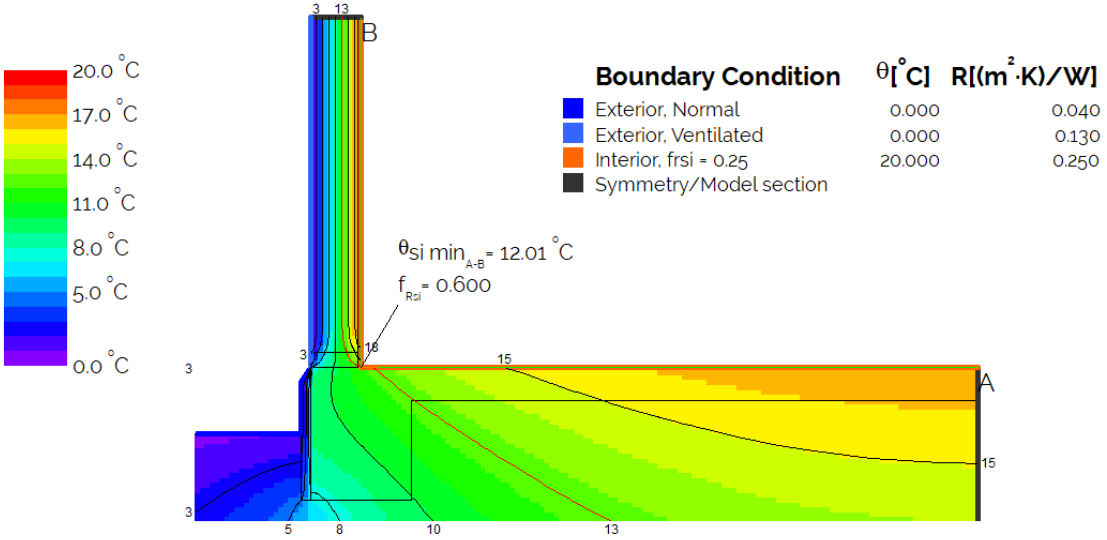


A/P, m	R-value, m2K/W
1	0.77
2	1.15
3	1.50
4	1.83
5	2.15

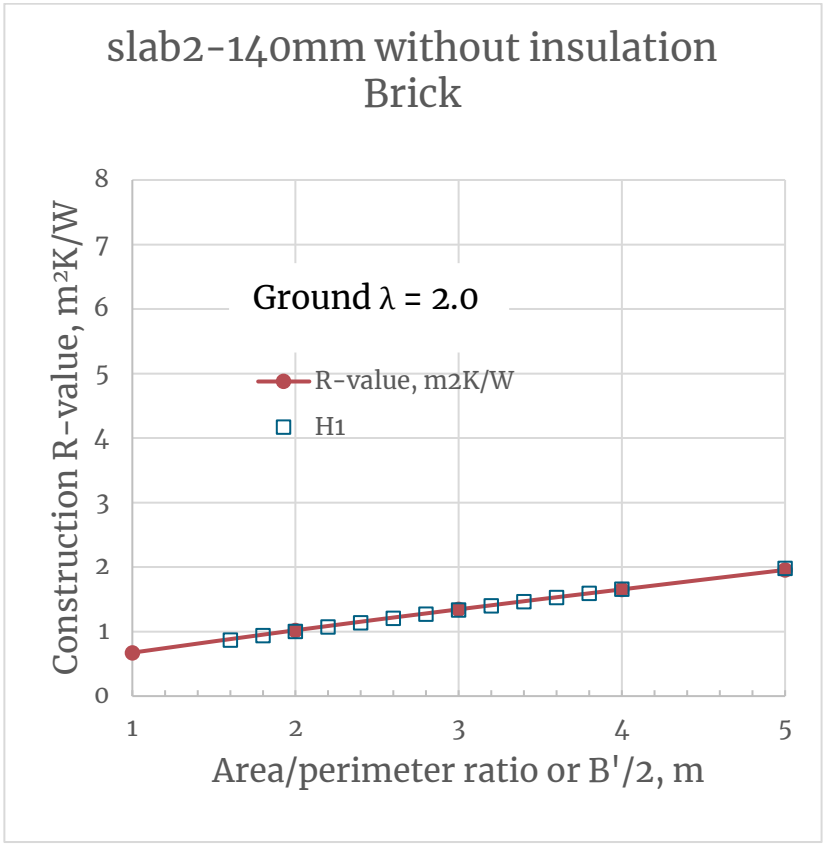


$$\Psi_{A\text{-}E\text{-}C} = \frac{40.038}{20.000} - 0.214 \cdot 1.150 - \frac{42.336}{20.000} = -0.361 \text{ W/(m·K)}$$

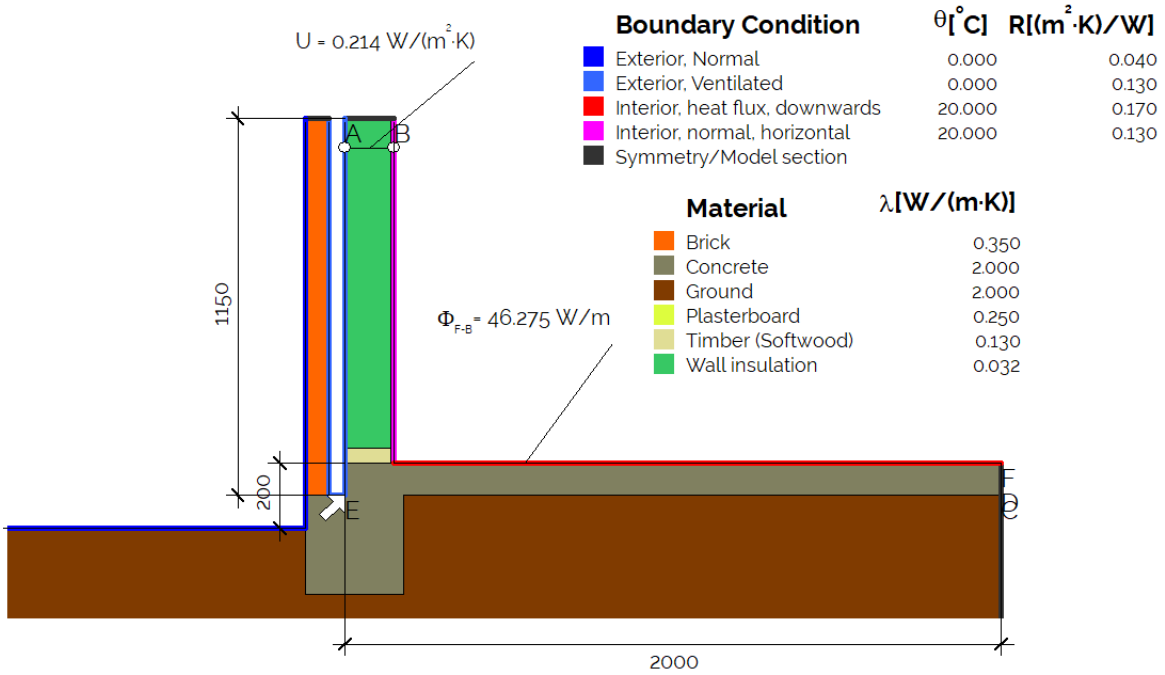




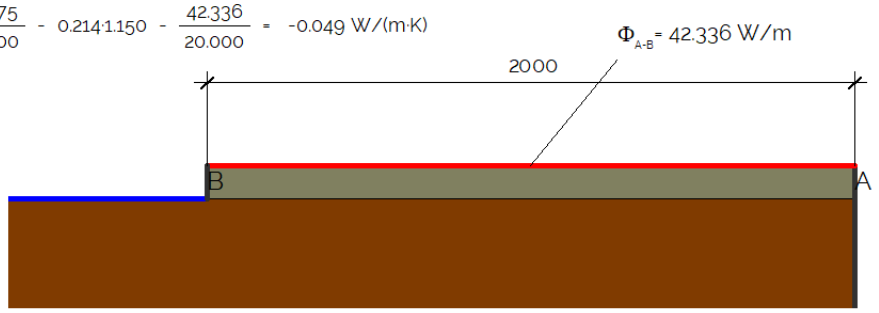
slab2-140mm without insulation Brick

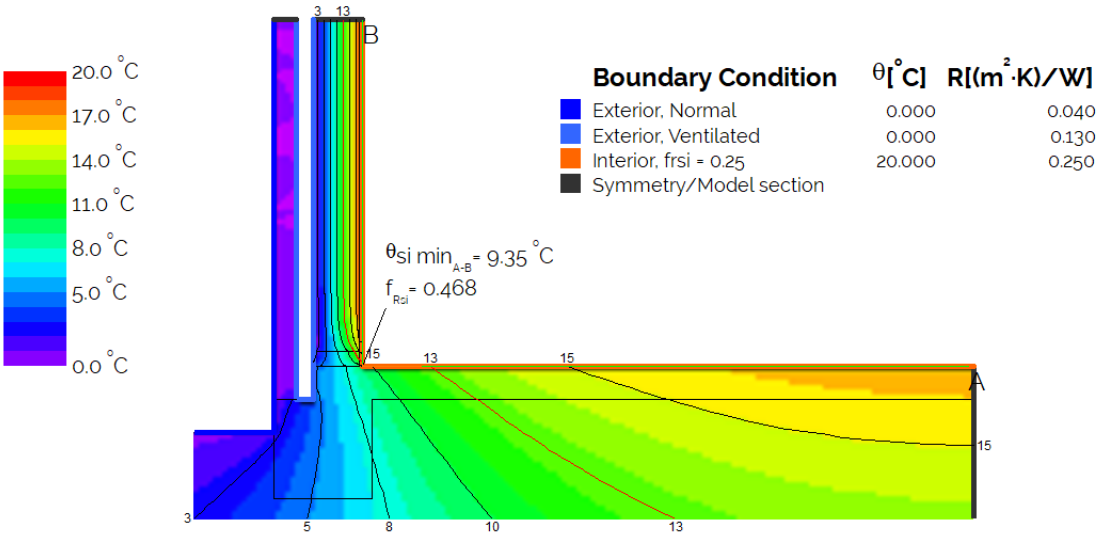


A/P, m	R-value, m2K/W
1	0.67
2	1.02
3	1.35
4	1.65
5	1.96

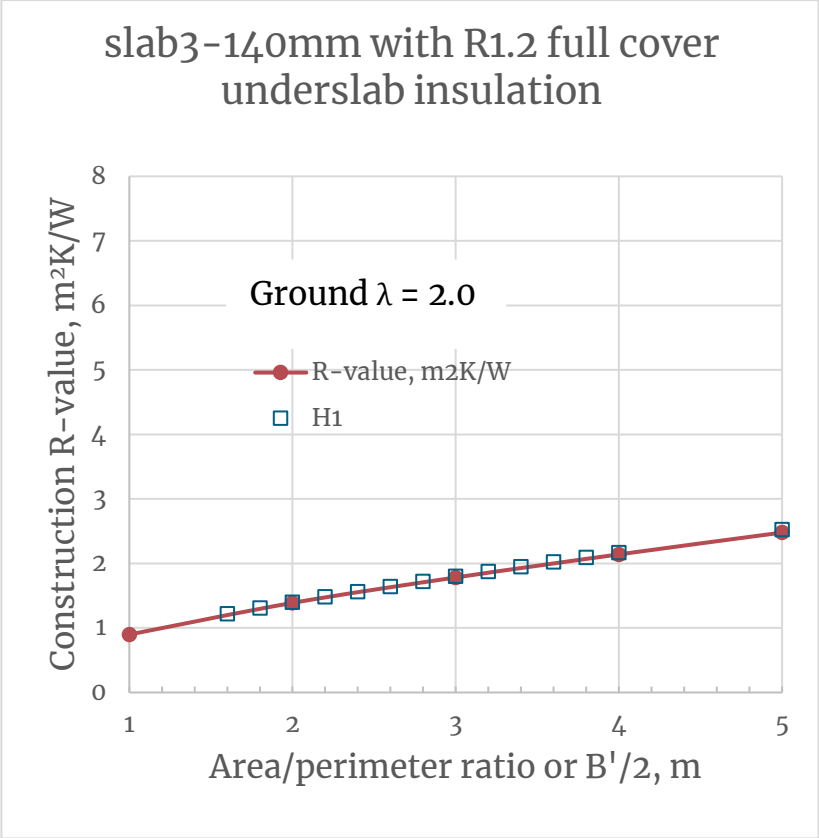


$$\Psi_{A\text{-}E\text{-}C} = \frac{46.275}{20.000} - 0.214 \cdot 1.150 - \frac{42.336}{20.000} = -0.049 \text{ W/(m·K)}$$

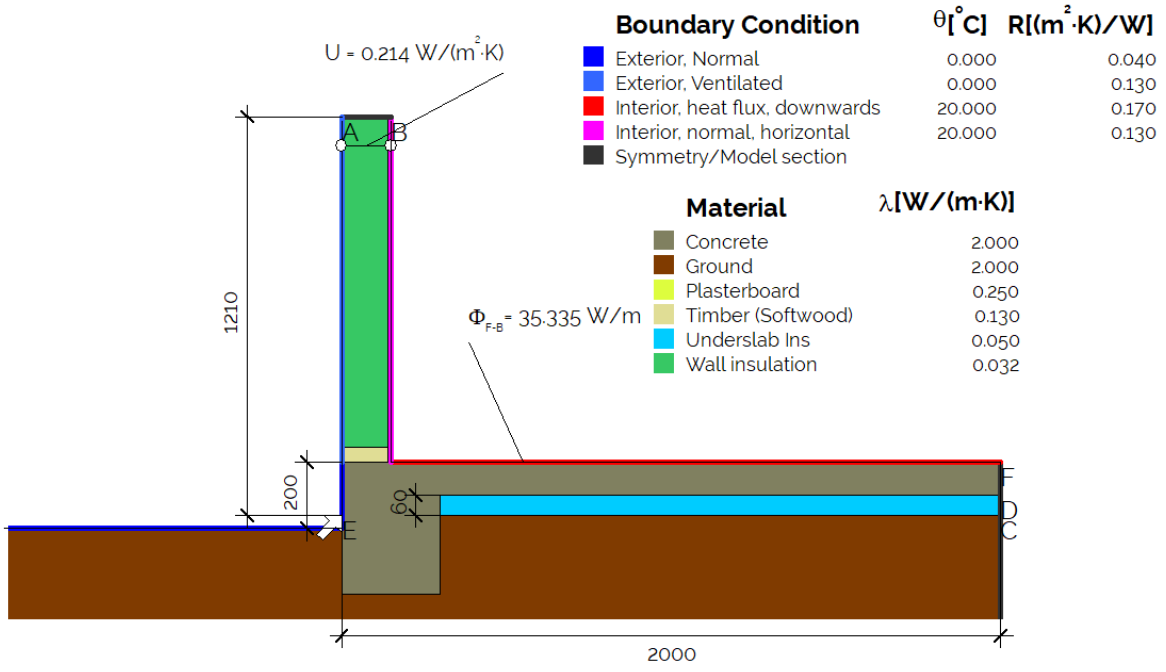




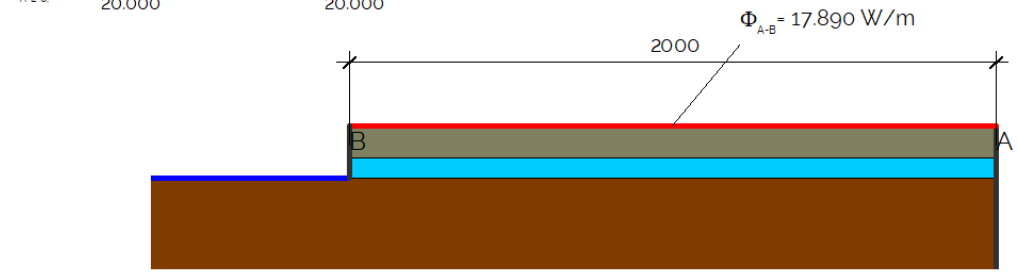
slab3-140mm with R1.2 full cover underslab insulation

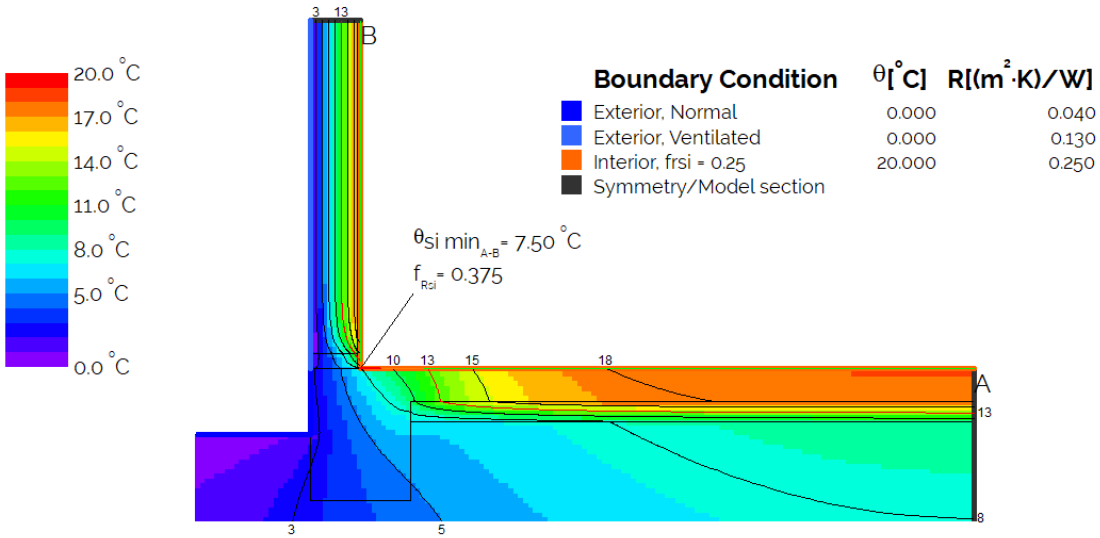


A/P, m	R-value, m2K/W
1	0.90
2	1.39
3	1.78
4	2.14
5	2.48

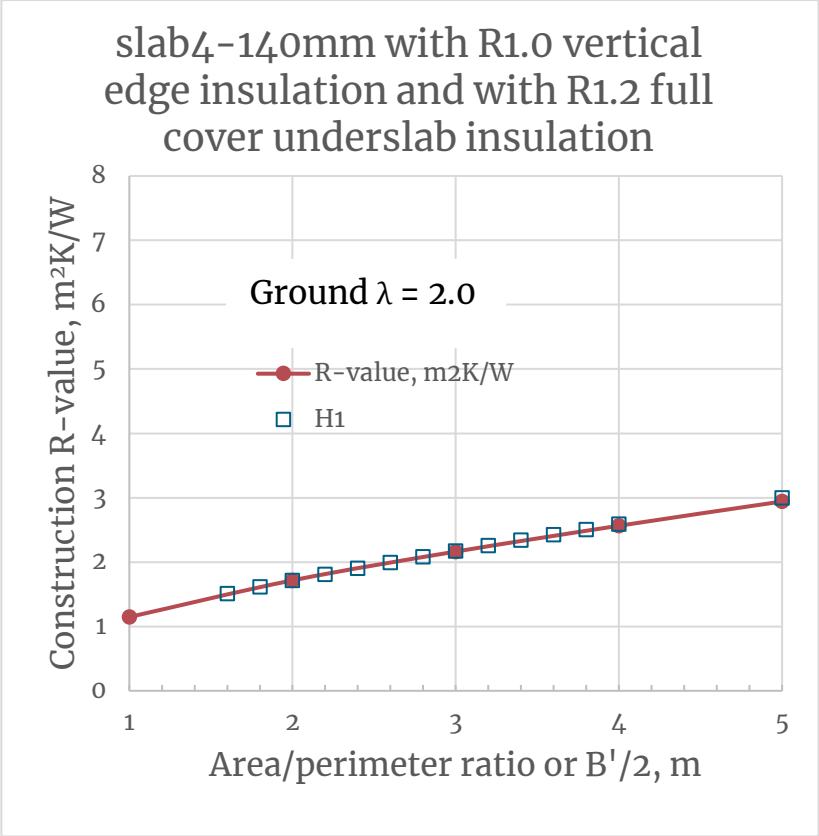


$$\psi_{A\text{-}E\text{-}C} = \frac{35.335}{20.000} - 0.214 \cdot 1.210 - \frac{17.890}{20.000} = 0.613 \text{ W/(m·K)}$$

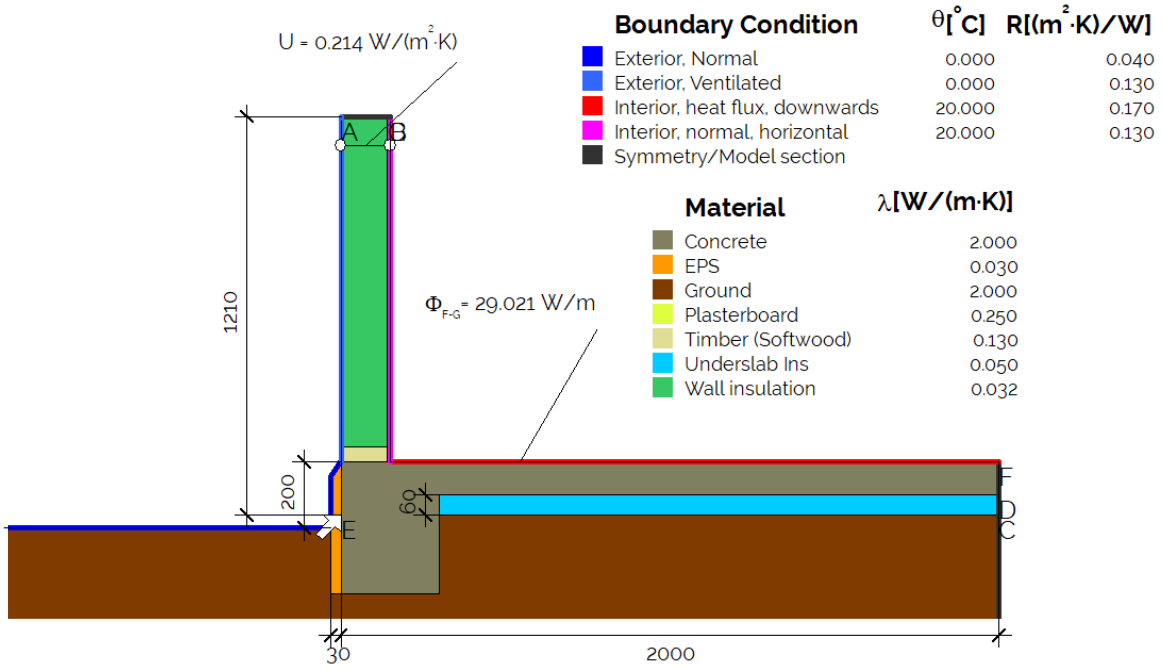




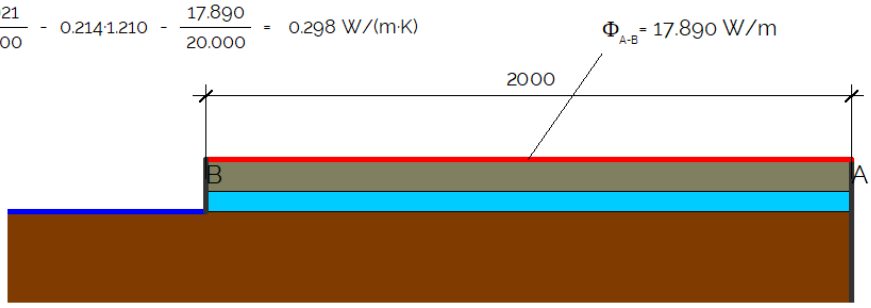
slab4-140mm with R1.0 vertical edge insulation and with R1.2 full cover underslab insulation

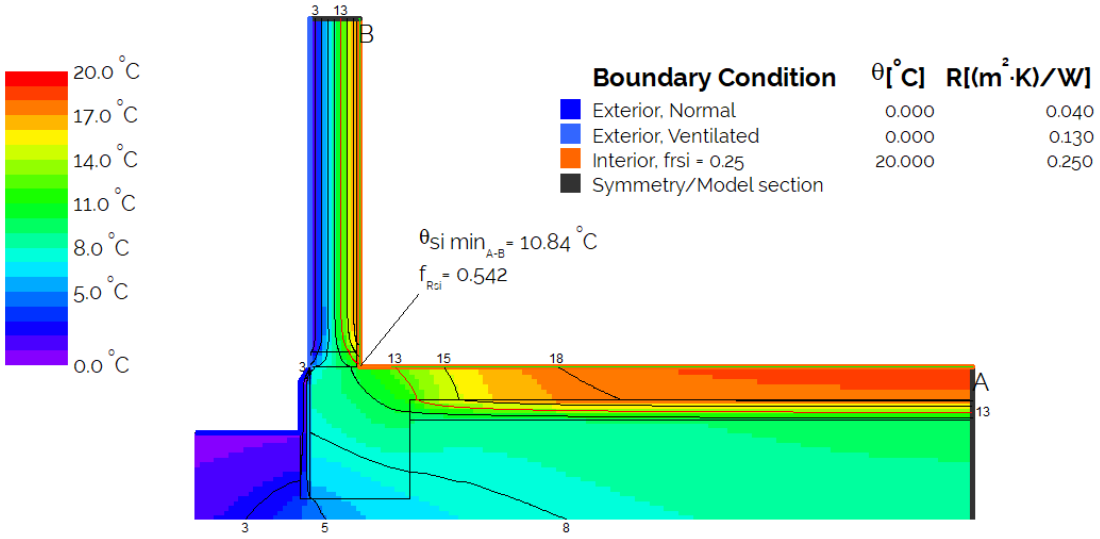


A/P, m	R-value, m2K/W
1	1.15
2	1.72
3	2.16
4	2.56
5	2.94

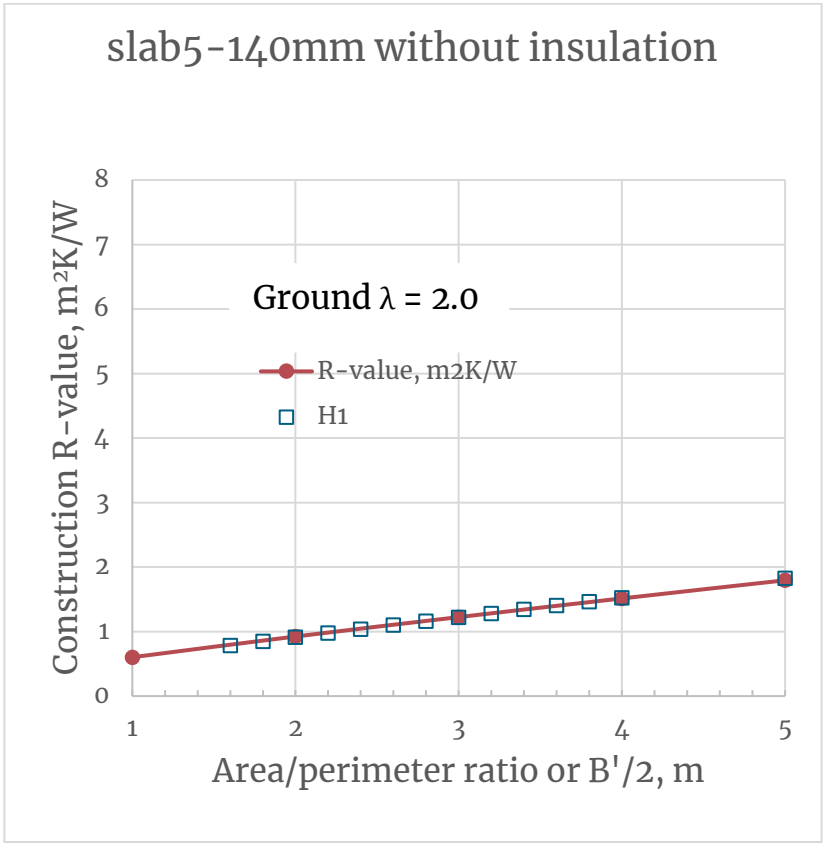


$$\Psi_{A\text{-}E\text{-}C'} = \frac{29.021}{20.000} - 0.214 \cdot 1.210 - \frac{17.890}{20.000} = 0.298 \text{ W/(m·K)}$$

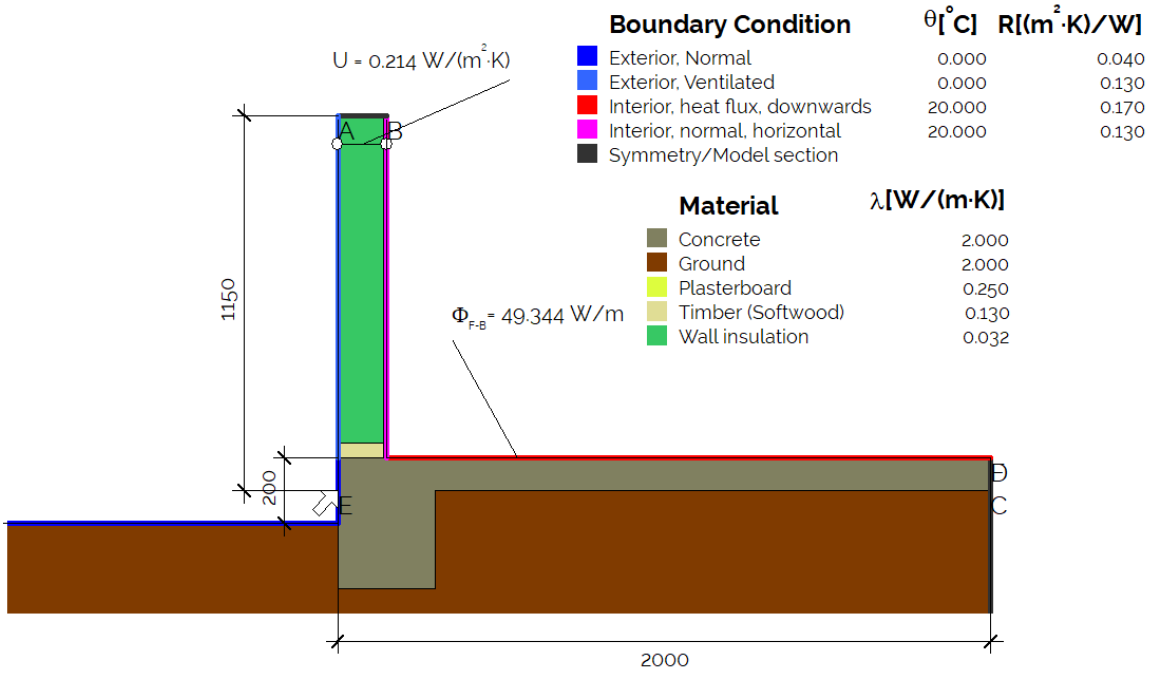




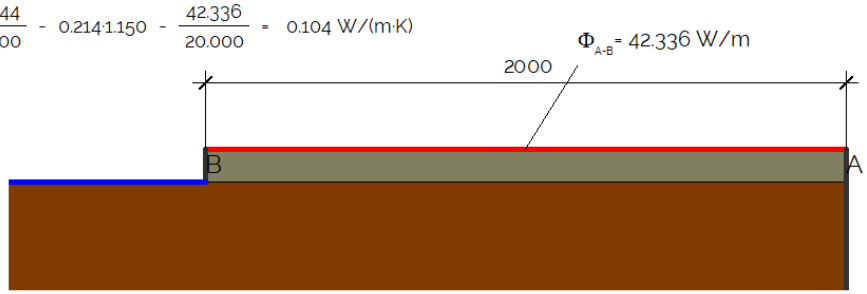
slab5-140mm without insulation

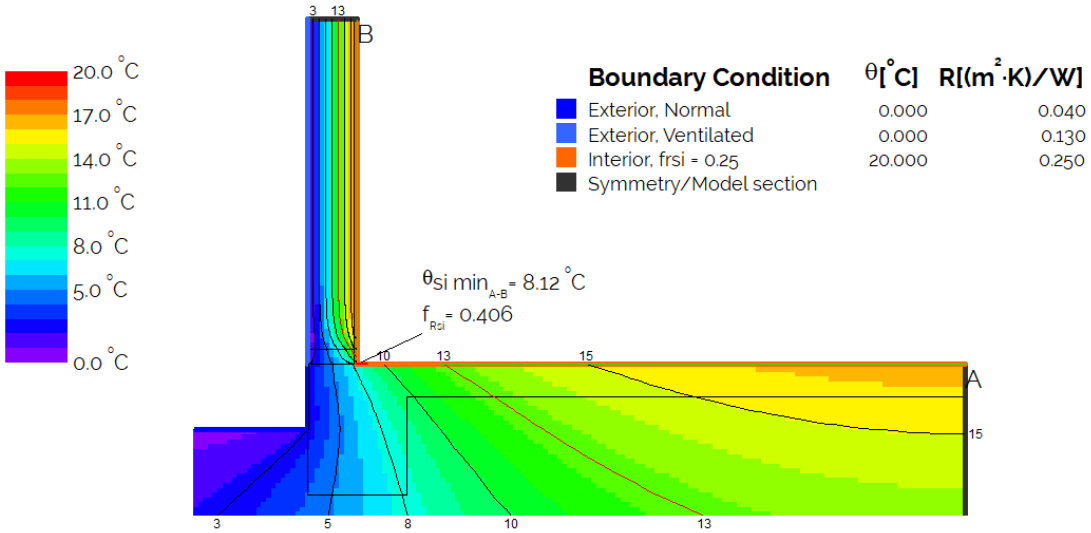


A/P, m	R-value, m2K/W
1	0.60
2	0.92
3	1.22
4	1.51
5	1.80



$$\Psi_{A\text{-}E\text{-}C} = \frac{49.344}{20.000} - 0.214 \cdot 1.150 - \frac{42.336}{20.000} = 0.104 \text{ W/(m·K)}$$





Methodology

NZBC R-VALUES

NZBC calculations are per the TBD NZBC H1 standard Verification Method H1/VM1 Appendix F summarized here:

Using internal slab dimensions in accordance with Equation 1 from this standard.

Equation 1: $slab\ area\ to\ perimeter\ ratio = Aslab,internal\ /\ Pslab,internal$

where:

Aslab,internal is the area of the slab-on-ground floor that is part of the thermal envelope, measured between the interior surfaces of the walls that form the thermal envelope (m2) and

Pslab,internal is the perimeter of the slab-on-ground floor that is part of the thermal envelope, measured along the interior surfaces of the walls that form the thermal envelope, including the length of any wall(s) between conditioned and unconditioned spaces (m).

This is done using a two-dimensional numerical calculation in accordance with ISO 13370 Section 5.2b), a geometrical model in accordance with ISO 10211 Sections 7.3, 12.4.1 and 12.4.2 shall be used. The model shall have a floor width equal to half the characteristic dimension of the floor.

COMMENT: 1. The characteristic dimension of the floor (B, see ISO 13370) equals the area of the floor divided by half the perimeter of the floor and should be determined using internal dimensions. 2. A two-dimensional geometrical model with a floor width equal to half the characteristic dimension of the floor represents a floor that is infinitely long and has a width equal to the characteristic dimension of the floor, as required by ISO 13370 Section 5.2 b).

F.1.2.5 The calculation shall use the default values for the thermal properties of the ground from ISO 13370 Table7 category 2. For other materials, thermal conductivity values from ISO 10456 shall be used and, for materials used below ground level, reflect the moisture and temperature conditions of the application. Values of surface resistance shall conform to ISO 13370 Section 6.4.3.

Note: Soil or Ground thermal conductivity = 2 W/(mK). The remaining thermal conductivities are shown in the results.

F.1.2.6 The construction R-value of the slab-on-ground floor shall be calculated according to Equation F.1.

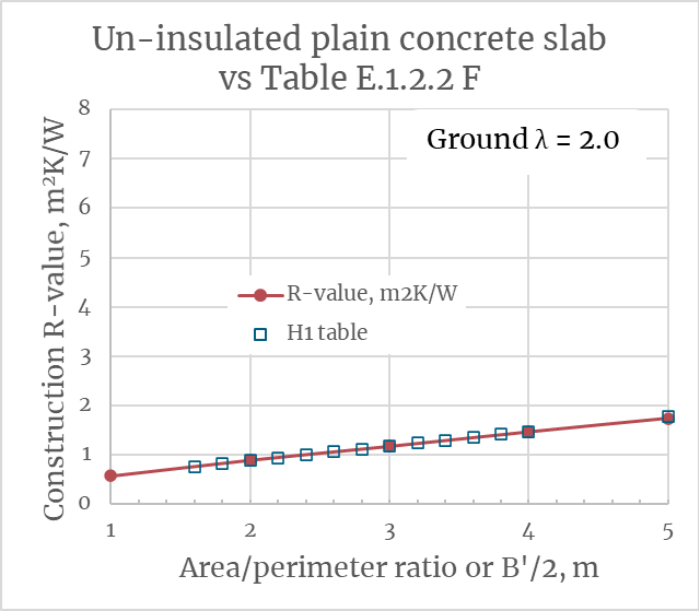
Equation F.1: $Rfloor = 1/U$

where:

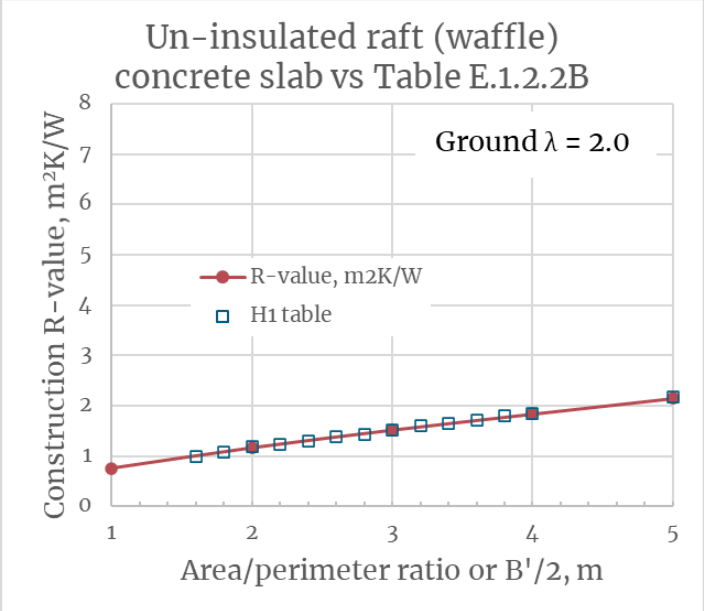
U is the temperature-specific heat flux through the internal floor surface of the two- or three-dimensional geometrical model, with the internal floor surface extending from the internal surface of the external wall to the cut-off plane of the floor (W/(m2 ·K)), determined by a numerical calculation as per F.1.2.1 to F.1.2.5.

The below two graphs compare our Implementation of the H1 methodology compared to the BRANZ calculated table values in H1/AS1. They agree to within less than 2%. The small variation is from different finite element meshing routines. The results are given to two decimal places to help with interpolation but the accuracy only justifies a single decimal place and we'd recommend tables provided to designers show only a single decimal place (ie R1.33 show as R1.3).

NZBC R-values for an un-insulated plain concrete slab



NZBC R-values for an un-insulated raft (waffle) concrete slab

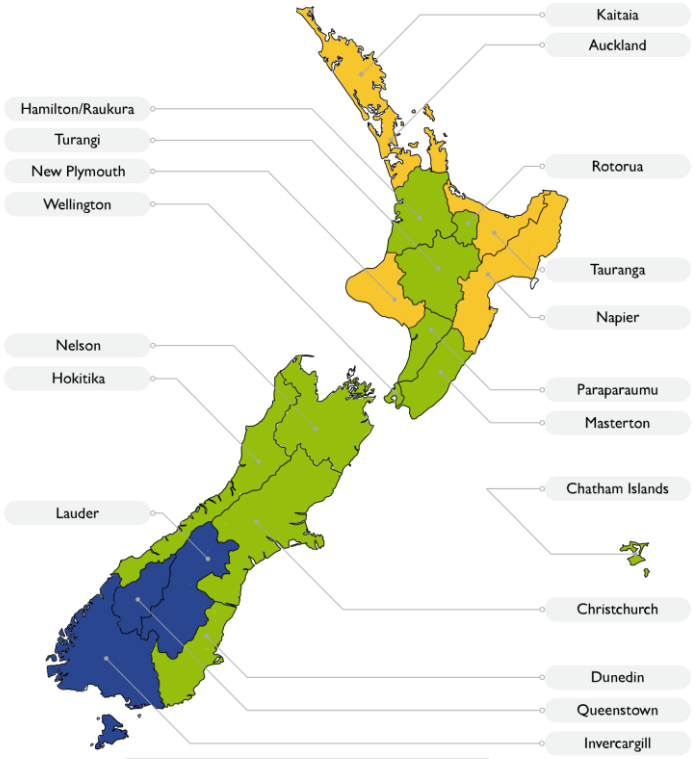


Both examples for 90mm stud + 10mm gypsum wall board or 100mm wall.

PASSIVE HOUSE Ψ AND FRSI

Slab Passive House calculations of Ψ are in accordance with ISO10211:2017 with Passive House Institute (PHI) modifications and fRSI criteria. These use EXTERNAL DIMENSIONS and the heat loss at the sill plate (which should not be neglected) is included in this Ψ calculation. NZBC has no official requirements for a particular fRSI value but NZGBC Homestar V5 does have requirements Intended to parallel the Passive House requirements. In PHPP10 these will be calculated via a moisture balance for each specific building to allow lower fRSI values to be used as less conservative criteria are appropriate with more detailed knowledge of the building ventilation rates, loads, and heating setpoints.

FRSI REQUIREMENTS FOR NZ REGIONS FOR PASSIVE HOUSE



Climate zone	Minimum Temperature Factor fRSI = 0.25 m²K/W
Arctic	0.80
Cold	0.75
Cool-temperate	0.70
Warm-temperate	0.65
Warm	0.55
Hot	-
Very hot	-

Figure 1: This map shows the three different fRSI zones at the weather station altitudes. The climate zone and thus the fRSI requirements also vary with altitude as the average temperatures typically drop by 0.6C per 100m of elevation gain. In general these zones can be used without considering the elevation change. Illustration: Sustainable Engineering Ltd. fRSI requirements from PHI Passive House Standard Building Criteria.