Příloha A

Protokol výpočtu čtvercového modelu vytápěného suterénu ve svahu se sklonem 60° v softwaru Comsol Multiphysics

Model 60°

Date	Dec 14, 2020 8:57:28 PM

Contents

Component 1 (comp1)

Definitions

Coordinate Systems

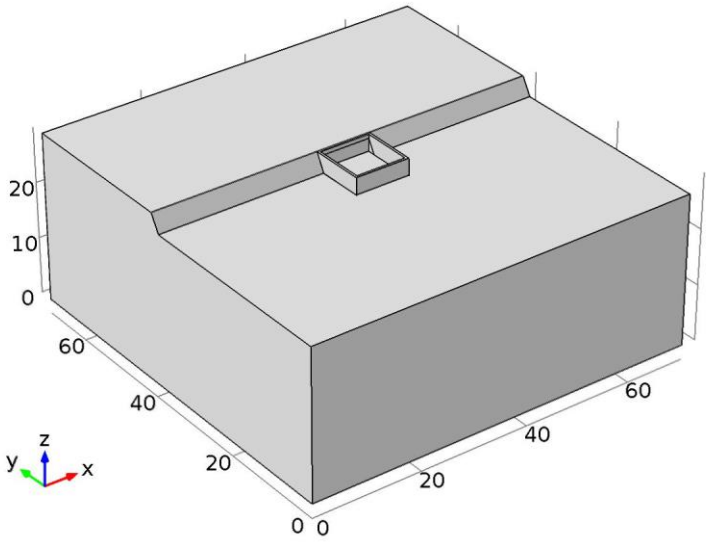
Boundary System 1

Coordinate system type	Boundary system
Identifier	sys1

Settings

Name	Value
Coordinate names	{t1, t2, n}
Create first tangent direction from	Global Cartesian

Geometry 1



Geometry 1

Units

Length unit	m
Angular unit	deg

Geometry statistics

Property	Value
Space dimension	3
Number of domains	4
Number of boundaries	32
Number of edges	65
Number of vertices	38

Import 1 (imp1)

Selections of resulting entities

Name	Value
Geometry import	STL/VRML file
Filename	D:\VŠ\Magisterské studium\3.semestr\Diplomová práce\ctverec\Model 60°\Model 1.1.stl

Import 2 (imp2)

Selections of resulting entities

Name	Value
Geometry import	STL/VRML file
Filename	D:\VŠ\Magisterské studium\3.semestr\Diplomová práce\ctverec\Model 60°\Model 1.2.stl

Import 3 (imp3)

Selections of resulting entities

Name	Value
Geometry import	STL/VRML file
Filename	D:\VŠ\Magisterské studium\3.semestr\Diplomová práce\ctverec\Model 60°\Model 1.3.stl

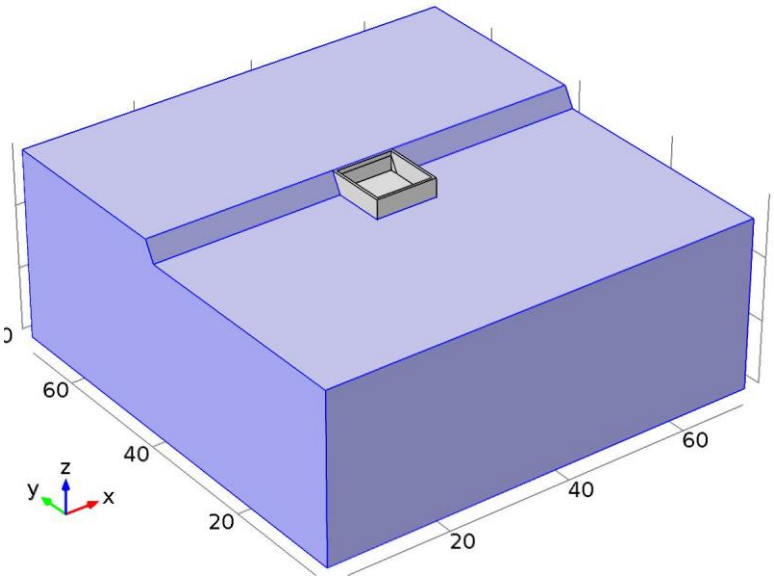
Import 4 (imp4)

Selections of resulting entities

Name	Value
Geometry import	STL/VRML file
Filename	D:\VŠ\Magisterské studium\3.semestr\Diplomová práce\ctverec\Model 60°\Model 1.4.stl

Materials

Zemina



Zemina

Selection

Geometric entity level	Domain
Selection	Domain 1

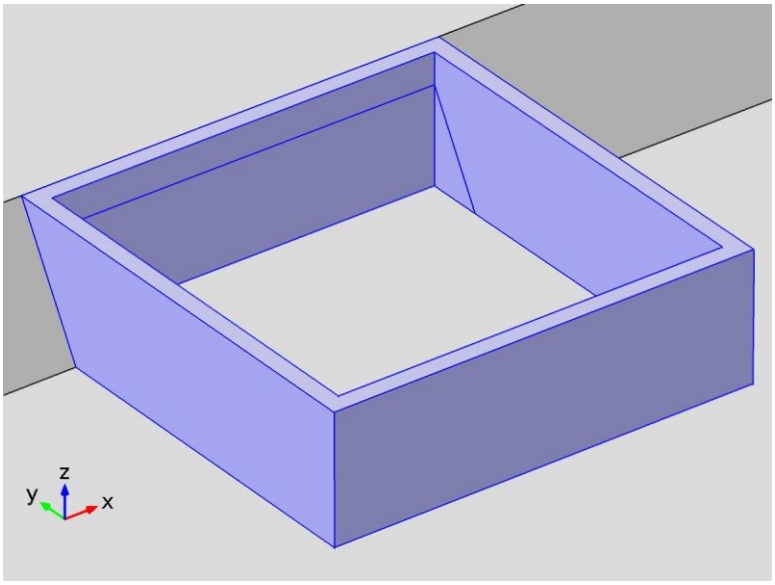
Material parameters

Name	Value	Unit
Thermal conductivity	2	W/(m*K)
Density	2000	kg/m^3
Heat capacity at constant pressure	920	J/(kg*K)

Basic Settings

Description	Value
Thermal conductivity	{{2, 0, 0}, {0, 2, 0}, {0, 0, 2}}
Density	2000
Heat capacity at constant pressure	920

Stěny



Stěny

Selection

Geometric entity level	Domain
Selection	Domains 3–4

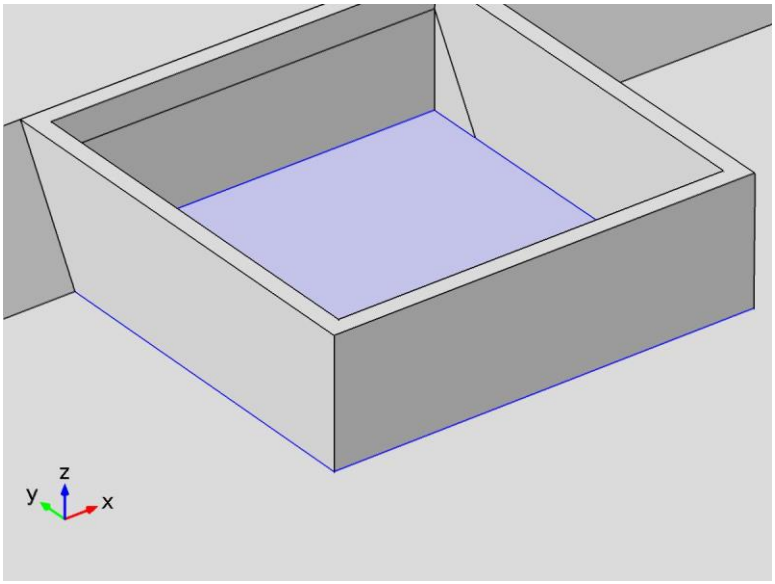
Material parameters

Name	Value	Unit
Heat capacity at constant pressure	1111	J/(kg*K)
Density	1431	kg/m^3
Thermal conductivity	0.093	W/(m*K)

Basic Settings

Description	Value
Heat capacity at constant pressure	1111
Density	1431
Thermal conductivity	{{0.093, 0, 0}, {0, 0.093, 0}, {0, 0, 0.093}}

Podlaha



Podlaha

Selection

Geometric entity level	Domain
Selection	Domain 2

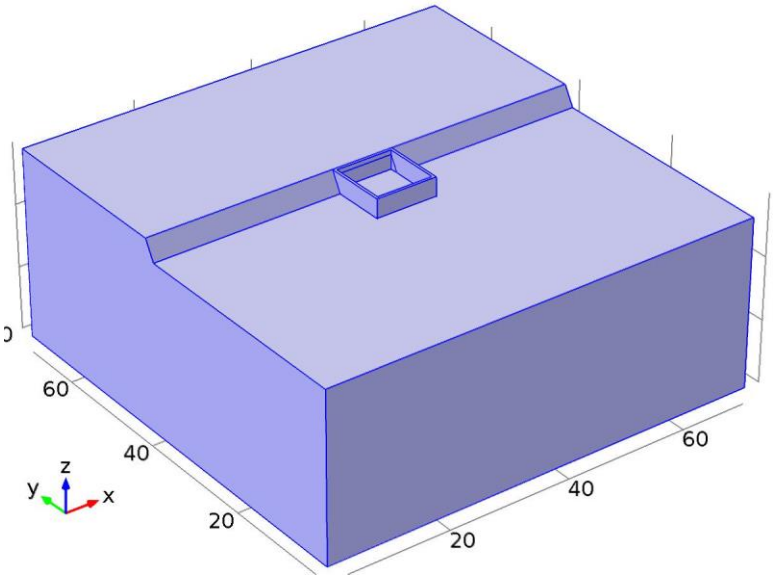
Material parameters

Name	Value	Unit
Heat capacity at constant pressure	1101	J/(kg*K)
Density	1513	kg/m^3
Thermal conductivity	0.107	W/(m*K)

Basic Settings

Description	Value
Heat capacity at constant pressure	1101
Density	1513
Thermal conductivity	{{0.107, 0, 0}, {0, 0.107, 0}, {0, 0, 0.107}}

Heat Transfer in Solids (ht)



Heat Transfer in Solids

Selection

Geometric entity level	Domain
Selection	Domains 1–4

Equations

$$\rho C_p \mathbf{u} \cdot \nabla T = \nabla \cdot (k \nabla T) + Q$$

Settings

Description	Value
Temperature	Quadratic
Compute boundary fluxes	On
Apply smoothing to boundary fluxes	On
Value type when using splitting of complex variables	Real
Surface-to-surface radiation	Off
Radiation in participating media	Off
Heat transfer in biological tissue	Off
Heat transfer in porous media	Off
Streamline diffusion	On
Crosswind diffusion	On
Isotropic diffusion	Off

Used products

COMSOL Multiphysics

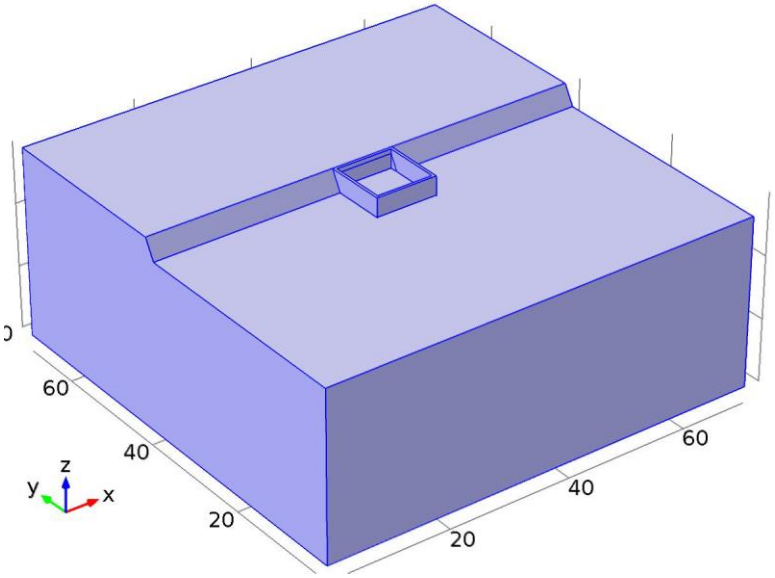
Variables

Name	Expression	Unit	Description	Selection
ht.q0	0	W/m^2	Inward heat flux	Boundaries 1–32
ht.dz	1	m	Thickness	Domains 1–4
ht.nx	nx	1	Normal vector, x component	Boundaries 8–10, 13, 15–19, 28, 30
ht.ny	ny	1	Normal vector, y component	Boundaries 8–10, 13, 15–19, 28, 30
ht.nz	nz	1	Normal vector, z component	Boundaries 8–10, 13, 15–19, 28, 30
ht.nx	dnx	1	Normal vector, x component	Boundaries 1–7, 11–12, 14, 20–27, 29, 31–32
ht.ny	dny	1	Normal vector, y component	Boundaries 1–7, 11–12, 14, 20–27, 29, 31–32
ht.nz	dnz	1	Normal vector, z component	Boundaries 1–7, 11–12, 14, 20–27, 29, 31–32
ht.nxmesh	root.nxmesh	1	Normal vector (mesh), x component	Boundaries 8–10, 13, 15–19, 28, 30
ht.nymesh	root.nymesh	1	Normal vector (mesh), y component	Boundaries 8–10, 13, 15–19, 28, 30
ht.nzmesh	root.nzmesh	1	Normal vector (mesh), z component	Boundaries 8–10, 13, 15–19, 28, 30
ht.nxmesh	root.dnxmesh	1	Normal vector (mesh), x component	Boundaries 1–7, 11–12, 14, 20–27, 29, 31–32
ht.nymesh	root.dnymesh	1	Normal vector	Boundaries 1–7, 11–12,

Name	Expression	Unit	Description	Selection
			(mesh), y component	14, 20–27, 29, 31–32
ht.nzmesh	root.dnzmesh	1	Normal vector (mesh), z component	Boundaries 1–7, 11–12, 14, 20–27, 29, 31–32
ht.dnx	dnx	1	Normal vector down direction, x component	Boundaries 1–32
ht.dny	dny	1	Normal vector down direction, y component	Boundaries 1–32
ht.dnz	dnz	1	Normal vector down direction, z component	Boundaries 1–32
ht.unx	unx	1	Normal vector up direction, x component	Boundaries 1–32
ht.uny	uny	1	Normal vector up direction, y component	Boundaries 1–32
ht.unz	unz	1	Normal vector up direction, z component	Boundaries 1–32
ht.dEiInt	ht.intDom(d(ht.rho*ht.Ei,t))	W	Total accumulated heat power	Global
ht.dEi0Int	ht.intDom(d(ht.rho*ht.Ei0,t))	W	Total accumulated energy power	Global
ht.ntfluxInt	ht.intExtBnd(ht.ntflux)	W	Total net heat power	Global
ht.ntefluxInt	ht.intExtBnd(ht.nteflux)	W	Total net energy power	Global
ht.QInt	ht.intDom(ht.Qtot)-ht.intIntBnd(ht.ndflux_u+ht.ndflux_d)	W	Total heat source	Global

Name	Expression	Unit	Description	Selection
ht.WnsInt	0	W	Total work source	Global
ht.WInt	0	W	Total work source	Global

Heat Transfer in Solids 1



Heat Transfer in Solids 1

Selection

Geometric entity level	Domain
Selection	Domains 1–4

Equations

Settings

Settings

Description	Value
Thermal conductivity	From material
Thermal conductivity	{{0, 0, 0}, {0, 0, 0}, {0, 0, 0}}
Density	From material
Heat capacity at constant pressure	From material

Properties from material

Property	Material	Property group
Thermal conductivity	Zemina	Basic
Density	Zemina	Basic
Heat capacity at constant pressure	Zemina	Basic
Thermal conductivity	Stěny	Basic

Property	Material	Property group
Density	Stěny	Basic
Heat capacity at constant pressure	Stěny	Basic
Thermal conductivity	Podlaha	Basic
Density	Podlaha	Basic
Heat capacity at constant pressure	Podlaha	Basic

Variables

Name	Expression	Unit	Description	Selection
domflux.Tx	-ht.k_effxx*Tx-ht.k_effxy*Ty-ht.k_effxz*Tz	W/m^2	Domain flux	Domains 1–4
domflux.Ty	-ht.k_effyx*Tx-ht.k_effyy*Ty-ht.k_effyz*Tz	W/m^2	Domain flux	Domains 1–4
domflux.Tz	-ht.k_effzx*Tx-ht.k_effzy*Ty-ht.k_effzz*Tz	W/m^2	Domain flux	Domains 1–4
ht.WnsInt	ht.solid1.intDom(ht.pA*(d(ht.ux,x)+d(ht.uy,y)+d(ht.uz,z)))	W	Total work source	Global
ht.kxx	model.input.k11	W/(m*K)	Thermal conductivity, xx component	Domain 1
ht.kyx	model.input.k21	W/(m*K)	Thermal conductivity, yx component	Domain 1
ht.kzx	model.input.k31	W/(m*K)	Thermal conductivity, zx component	Domain 1
ht.kxy	model.input.k12	W/(m*K)	Thermal conductivity, xy component	Domain 1
ht.kyy	model.input.k22	W/(m*K)	Thermal conductivity, yy component	Domain 1
ht.kzy	model.input.k32	W/(m*K)	Thermal conductivity, zy component	Domain 1
ht.kxz	model.input.k13	W/(m*K)	Thermal conductivity, xz component	Domain 1
ht.kyz	model.input.k23	W/(m*K)	Thermal conductivity, yz component	Domain 1

Name	Expression	Unit	Description	Selection
ht.kzz	model.input.k33	W/(m*K)	Thermal conductivity, zz component	Domain 1
ht.kxx	model.input.k11	W/(m*K)	Thermal conductivity, xx component	Domains 3–4
ht.kyx	model.input.k21	W/(m*K)	Thermal conductivity, yx component	Domains 3–4
ht.kzx	model.input.k31	W/(m*K)	Thermal conductivity, zx component	Domains 3–4
ht.kxy	model.input.k12	W/(m*K)	Thermal conductivity, xy component	Domains 3–4
ht.kyy	model.input.k22	W/(m*K)	Thermal conductivity, yy component	Domains 3–4
ht.kzy	model.input.k32	W/(m*K)	Thermal conductivity, zy component	Domains 3–4
ht.kxz	model.input.k13	W/(m*K)	Thermal conductivity, xz component	Domains 3–4
ht.kyz	model.input.k23	W/(m*K)	Thermal conductivity, yz component	Domains 3–4
ht.kzz	model.input.k33	W/(m*K)	Thermal conductivity, zz component	Domains 3–4
ht.kxx	model.input.k11	W/(m*K)	Thermal conductivity, xx component	Domain 2
ht.kyx	model.input.k21	W/(m*K)	Thermal conductivity, yx component	Domain 2
ht.kzx	model.input.k31	W/(m*K)	Thermal conductivity, zx component	Domain 2
ht.kxy	model.input.k12	W/(m*K)	Thermal conductivity, xy component	Domain 2
ht.kyy	model.input.k22	W/(m*K)	Thermal conductivity, yy component	Domain 2

Name	Expression	Unit	Description	Selection
ht.kzy	model.input.k32	W/(m*K)	Thermal conductivity, zy component	Domain 2
ht.kxz	model.input.k13	W/(m*K)	Thermal conductivity, xz component	Domain 2
ht.kyz	model.input.k23	W/(m*K)	Thermal conductivity, yz component	Domain 2
ht.kzz	model.input.k33	W/(m*K)	Thermal conductivity, zz component	Domain 2
ht.rho	model.input.rho	kg/m^3	Density	Domain 1
ht.rho	model.input.rho	kg/m^3	Density	Domains 3–4
ht.rho	model.input.rho	kg/m^3	Density	Domain 2
ht.Cp	model.input.Cp	J/(kg*K)	Heat capacity at constant pressure	Domain 1
ht.Cp	model.input.Cp	J/(kg*K)	Heat capacity at constant pressure	Domains 3–4
ht.Cp	model.input.Cp	J/(kg*K)	Heat capacity at constant pressure	Domain 2
ht.alphap	-d(ht.rho,T)/(ht.rho+eps)	1/K	Isobaric compressibility coefficient	Domains 1–4
ht.pA	1[atm]	Pa	Absolute pressure	Domains 1–4
ht.gradTmag	sqrt(ht.gradTx^2+ht.gradTy^2+ht.gradTz^2)	K/m	Temperature gradient magnitude	Domains 1–4
ht.kmean	(ht.k_effxx+ht.k_effyy+ht.k_effzz)/3	W/(m*K)	Mean effective thermal conductivity	Domains 1–4
ht.dfluxx	-ht.k_effxx*Tx-ht.k_effxy*Ty-ht.k_effxz*Tz	W/m^2	Conductive heat flux, x component	Domains 1–4
ht.dfluxy	-ht.k_effyx*Tx-ht.k_effyy*Ty-ht.k_effyz*Tz	W/m^2	Conductive heat flux, y component	Domains 1–4
ht.dfluxz	-ht.k_effzx*Tx-ht.k_effzy*Ty-ht.k_effzz*Tz	W/m^2	Conductive heat flux, z component	Domains 1–4

Name	Expression	Unit	Description	Selection
ht.dfluxMag	sqrt(ht.dfluxx^2+ht.dfluxy^2+ht.dfluxz^2)	W/m^2	Conductive heat flux magnitude	Domains 1–4
ht.Q	0	W/m^3	Heat source	Domains 1–4
ht.qs	0	W/(m^3*K)	Production/absorption coefficient	Domains 1–4
ht.Qmet	0	W/m^3	Metabolic heat source	Domains 1–4
ht.Qtot	0	W/m^3	Total heat source	Domains 1–4
ht.rhoInt	subst(ht.rho,root.comp1.ht.solid1.minput_pressure,ht.pA)	kg/m^3	Density for integration	Domains 1–4
ht.CpInt	subst(ht.Cp,root.comp1.ht.solid1.minput_pressure,ht.pA)	J/(kg*K)	Specific heat capacity for integration	Domains 1–4
ht.gammaInt	subst(ht.gamma,root.comp1.ht.solid1.minput_pressure,ht.pA)	1	Ratio of specific heats for integration	Domains 1–4
ht.TRef	298.15[K]	K	Temperature	Domains 1–4
ht.pRef	1[atm]	Pa	Intermediate variable	Domains 1–4
ht.HRef	0	J/kg	Reference enthalpy	Domains 1–4
ht.DeltaH	integrate(subst(ht.CpInt,ht.pA,ht.pRef),T,ht.TRef,T)	J/kg	Sensible enthalpy	Domains 1–4
ht.H	ht.HRef+ht.DeltaH	J/kg	Enthalpy	Domains 1–4
ht.H0	ht.H	J/kg	Total enthalpy	Domains 1–4
ht.Ei	ht.H	J/kg	Internal energy	Domains 1–4
ht.Ei0	ht.Ei	J/kg	Total internal energy	Domains 1–4
ht.trlfluxx	0	W/m^2	Translational heat flux, x component	Domains 1–4
ht.trlfluxy	0	W/m^2	Translational heat flux, y component	Domains 1–4
ht.trlfluxz	0	W/m^2	Translational heat flux, z component	Domains 1–4

Name	Expression	Unit	Description	Selection
ht.trlfluxMag	sqrt(ht.trlfluxx^2+ht.trlfluxy^2+ht.trlfluxz^2)	W/m^2	Translational heat flux magnitude	Domains 1–4
ht.cfluxx	0	W/m^2	Convective heat flux, x component	Domains 1–4
ht.cfluxy	0	W/m^2	Convective heat flux, y component	Domains 1–4
ht.cfluxz	0	W/m^2	Convective heat flux, z component	Domains 1–4
ht.cfluxMag	sqrt(ht.cfluxx^2+ht.cfluxy^2+ht.cfluxz^2)	W/m^2	Convective heat flux magnitude	Domains 1–4
ht.tfluxx	ht.dfluxx+ht.trlfluxx+ht.cfluxx	W/m^2	Total heat flux, x component	Domains 1–4
ht.tfluxy	ht.dfluxy+ht.trlfluxy+ht.cfluxy	W/m^2	Total heat flux, y component	Domains 1–4
ht.tfluxz	ht.dfluxz+ht.trlfluxz+ht.cfluxz	W/m^2	Total heat flux, z component	Domains 1–4
ht.tfluxMag	sqrt(ht.tfluxx^2+ht.tfluxy^2+ht.tfluxz^2)	W/m^2	Total heat flux magnitude	Domains 1–4
ht.tefluxx	ht.dfluxx	W/m^2	Total energy flux, x component	Domains 1–4
ht.tefluxy	ht.dfluxy	W/m^2	Total energy flux, y component	Domains 1–4
ht.tefluxz	ht.dfluxz	W/m^2	Total energy flux, z component	Domains 1–4
ht.tefluxMag	sqrt(ht.tefluxx^2+ht.tefluxy^2+ht.tefluxz^2)	W/m^2	Total energy flux magnitude	Domains 1–4
ht.rflux	0	W/m^2	Radiative heat flux	Boundaries 1–32
ht.chflux	0	W/m^2	Boundary convective heat flux	Boundaries 1–32
ht.ntrlflux	mean(ht.trlfluxx)*ht.nx+mean(ht.trlfluxy)*ht.ny+mean(ht.trlfluxz)*ht.nz	W/m^2	Normal translational heat flux	Boundaries 1–32
ht.ntrlflux_u	up(ht.trlfluxx)*ht.unx+up(ht.trlfluxy)*ht.uny+up(ht.trlfluxz)*ht.unz	W/m^2	Internal normal translational heat flux, upside	Boundaries 8–10, 13, 15–19, 28, 30

Name	Expression	Unit	Description	Selection
ht.ntrlflux_d	down(ht.trlfluxx)*ht.dnx+down(ht.trlfluxy)*ht.dny+down(ht.trlfluxz)*ht.dnz	W/m^2	Internal normal translational heat flux, downside	Boundaries 8–10, 13, 15–19, 28, 30
ht.ncflux	mean(ht.cfluxx)*ht.nx+mean(ht.cfluxy)*ht.ny+mean(ht.cfluxz)*ht.nz	W/m^2	Normal convective heat flux	Boundaries 1–32
ht.ncflux_u	up(ht.cfluxx)*ht.unx+up(ht.cfluxy)*ht.uny+up(ht.cfluxz)*ht.unz	W/m^2	Internal normal convective heat flux, upside	Boundaries 8–10, 13, 15–19, 28, 30
ht.ncflux_d	down(ht.cfluxx)*ht.dnx+down(ht.cfluxy)*ht.dny+down(ht.cfluxz)*ht.dnz	W/m^2	Internal normal convective heat flux, downside	Boundaries 8–10, 13, 15–19, 28, 30
ht.ndflux	-dflux_spatial(T)	W/m^2	Normal conductive heat flux	Boundaries 1–7, 11–12, 14, 20–27, 29, 31–32
ht.ndflux	0.5*(uflux_spatial(T)-dflux_spatial(T))	W/m^2	Normal conductive heat flux	Boundaries 8–10, 13, 15–19, 28, 30
ht.ndflux_u	-uflux_spatial(T)	W/m^2	Internal normal conductive heat flux, upside	Boundaries 8–10, 13, 15–19, 28, 30
ht.ndflux_d	-dflux_spatial(T)	W/m^2	Internal normal conductive heat flux, downside	Boundaries 8–10, 13, 15–19, 28, 30
ht.ntflux	ht.ndflux+ht.ntrlflux+ht.ncflux	W/m^2	Normal total heat flux	Boundaries 1–32
ht.ntflux_u	ht.ndflux_u+ht.ntrlflux_u+ht.ncflux_u	W/m^2	Internal normal total flux, upside	Boundaries 8–10, 13, 15–19, 28, 30
ht.ntflux_d	ht.ndflux_d+ht.ntrlflux_d+ht.ncflux_d	W/m^2	Internal normal total flux, downside	Boundaries 8–10, 13, 15–19, 28, 30
ht.nteflux	mean(ht.tefluxx)*ht.nx+mean(ht.tefluxy)*ht.ny+mean(ht.tefluxz)*ht.nz-mean(ht.dfluxx)*ht.nx-	W/m^2	Normal total energy flux	Boundaries 1–32

Name	Expression	Unit	Description	Selection
	mean(ht.dfluxy)*ht.ny-mean(ht.dfluxz)*ht.nz+ht.ndflux			
ht.nteflux_u	up(ht.tefluxx)*ht.unx+up(ht.tefluxy)*ht.uny+up(ht.tefluxz)*ht.unz-up(ht.dfluxx)*ht.unx-up(ht.dfluxy)*ht.uny-up(ht.dfluxz)*ht.unz+ht.ndflux_u	W/m^2	Internal normal total energy flux, upside	Boundaries 8–10, 13, 15–19, 28, 30
ht.nteflux_d	down(ht.tefluxx)*ht.dnx+down(ht.tefluxy)*ht.dny+down(ht.tefluxz)*ht.dnz-down(ht.dfluxx)*ht.dnx-down(ht.dfluxy)*ht.dny-down(ht.dfluxz)*ht.dnz+ht.ndflux_d	W/m^2	Internal normal total energy flux, downside	Boundaries 8–10, 13, 15–19, 28, 30
ht.Qbtot	0	W/m^2	Total boundary heat source	Boundaries 1–32
ht.k_effxx	ht.kxx	W/(m*K)	Effective thermal conductivity, xx component	Domains 1–4
ht.k_effyx	ht.kyx	W/(m*K)	Effective thermal conductivity, yx component	Domains 1–4
ht.k_effzx	ht.kzx	W/(m*K)	Effective thermal conductivity, zx component	Domains 1–4
ht.k_effxy	ht.kxy	W/(m*K)	Effective thermal conductivity, xy component	Domains 1–4
ht.k_effyy	ht.kyy	W/(m*K)	Effective thermal conductivity, yy component	Domains 1–4
ht.k_effzy	ht.kzy	W/(m*K)	Effective thermal conductivity, zy component	Domains 1–4
ht.k_effxz	ht.kxz	W/(m*K)	Effective thermal conductivity, xz component	Domains 1–4

Name	Expression	Unit	Description	Selection
ht.k_effyz	ht.kyz	W/(m*K)	Effective thermal conductivity, yz component	Domains 1–4
ht.k_effzz	ht.kzz	W/(m*K)	Effective thermal conductivity, zz component	Domains 1–4
ht.C_eff	ht.rho*ht.Cp	J/(m^3*K)	Effective volumetric heat capacity	Domains 1–4
ht.ux	0	m/s	Velocity field, x component	Domains 1–4
ht.uy	0	m/s	Velocity field, y component	Domains 1–4
ht.uz	0	m/s	Velocity field, z component	Domains 1–4
ht.gradTx	Tx	K/m	Temperature gradient, x component	Domains 1–4
ht.gradTy	Ty	K/m	Temperature gradient, y component	Domains 1–4
ht.gradTz	Tz	K/m	Temperature gradient, z component	Domains 1–4
ht.Qltot	0	W/m	Total line heat source	Edges 1–65
ht.Qptot	0	W	Total point heat source	Points 1–38
ht.alphaTdxx	ht.k_effxx/ht.C_eff	m^2/s	Thermal diffusivity, xx component	Domains 1–4
ht.alphaTdyx	ht.k_effyx/ht.C_eff	m^2/s	Thermal diffusivity, yx component	Domains 1–4
ht.alphaTdzx	ht.k_effzx/ht.C_eff	m^2/s	Thermal diffusivity, zx component	Domains 1–4
ht.alphaTdxy	ht.k_effxy/ht.C_eff	m^2/s	Thermal diffusivity, xy component	Domains 1–4
ht.alphaTdyy	ht.k_effyy/ht.C_eff	m^2/s	Thermal diffusivity, yy component	Domains 1–4

Name	Expression	Unit	Description	Selection
ht.alphaTdzy	ht.k_effzy/ht.C_eff	m^2/s	Thermal diffusivity, zy component	Domains 1–4
ht.alphaTdxz	ht.k_effxz/ht.C_eff	m^2/s	Thermal diffusivity, xz component	Domains 1–4
ht.alphaTdyz	ht.k_effyz/ht.C_eff	m^2/s	Thermal diffusivity, yz component	Domains 1–4
ht.alphaTdzz	ht.k_effzz/ht.C_eff	m^2/s	Thermal diffusivity, zz component	Domains 1–4
ht.alphaTdMean	ht.kmean/ht.C_eff	m^2/s	Mean thermal diffusivity	Domains 1–4
ht.solid1.dEiInt	ht.solid1.intDom(d(ht.rho*ht.Ei,t))	W	Total accumulated heat power	Global
ht.solid1.dEi0Int	ht.solid1.intDom(d(ht.rho*ht.Ei0,t))	W	Total accumulated energy power	Global
ht.solid1.ntfluxInt	ht.solid1.intExtBnd(ht.ntflux)+ht.solid1.intExtBndUp(ht.ntflux_u)+ht.solid1.intExtBndDown(ht.ntflux_d)	W	Total net heat power	Global
ht.solid1.ntefluxInt	ht.solid1.intExtBnd(ht.nteflux)+ht.solid1.intExtBndUp(ht.nteflux_u)+ht.solid1.intExtBndDown(ht.nteflux_d)	W	Total net energy power	Global
ht.solid1.QInt	ht.solid1.intDom(ht.Qtot)-ht.solid1.intIntBnd(ht.ndflux_u+ht.ndflux_d)	W	Total heat source	Global
ht.solid1.WnsInt	ht.solid1.intDom(ht.pA*(d(ht.ux,x)+d(ht.uy,y)+d(ht.uz,z)))	W	Total work source	Global
ht.solid1.WInt	0	W	Total work source	Global
ht.gamma	1	1	Ratio of specific heats	Domains 1–4
ht.helem	h	m	Element size	Domains 1–4
ht.res_T	-ht.k_effxx*d(Tx,x)-ht.k_effxy*d(Tx,y)-ht.k_effxz*d(Tx,z)-	W/m^3	Equation residual	Domains 1–4

Name	Expression	Unit	Description	Selection
	ht.k_effyx*d(Ty,x)-ht.k_effyy*d(Ty,y)-ht.k_effyz*d(Ty,z)-ht.k_effzx*d(Tz,x)-ht.k_effzy*d(Tz,y)-ht.k_effzz*d(Tz,z)-(ht.qs+ht.qs_oop)*T+ht.rho*ht.Cp*(ht.ux*Tx+ht.uy*Ty+ht.uz*Tz)-ht.Q-ht.Qoop			

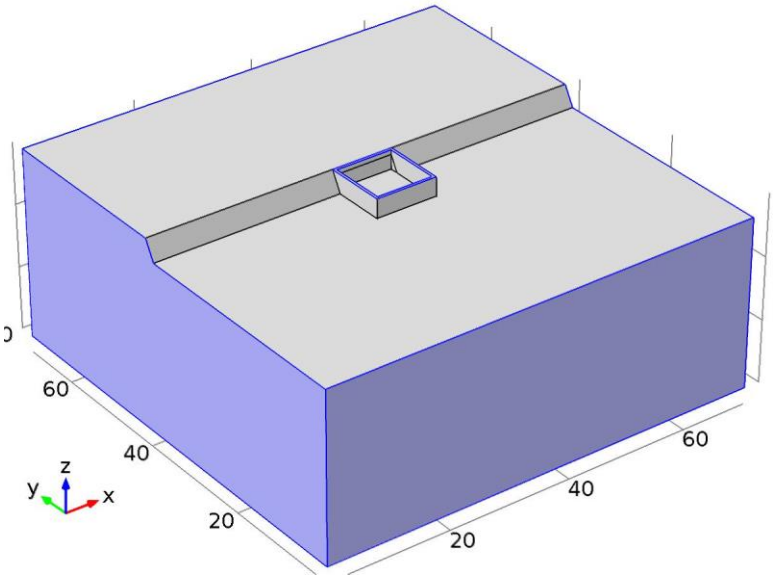
Shape functions

Name	Shape function	Unit	Description	Shape frame	Selection
T	Lagrange (Quadratic)	K	Temperature	Material	Domains 1–4

Weak expressions

Weak expression	Integration frame	Selection
-(ht.k_effxx*Tx+ht.k_effxy*Ty+ht.k_effxz*Tz)*test(Tx)-(ht.k_effyx*Tx+ht.k_effyy*Ty+ht.k_effyz*Tz)*test(Ty)-(ht.k_effzx*Tx+ht.k_effzy*Ty+ht.k_effzz*Tz)*test(Tz)	Material	Domains 1–4
-ht.rho*ht.Cp*(ht.ux*Tx+ht.uy*Ty+ht.uz*Tz)*test(T)	Material	Domains 1–4
ht.streamline	Material	Domains 1–4

Thermal Insulation 1



Thermal Insulation 1

Selection

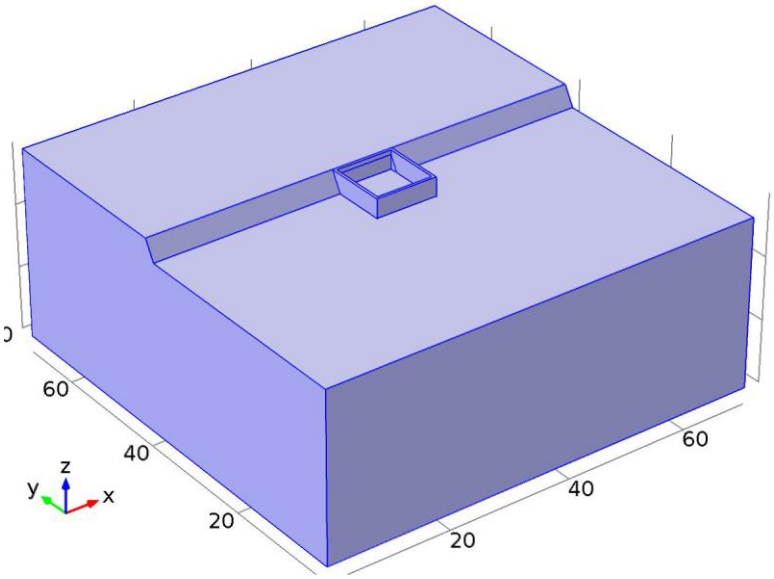
Geometric entity level	Boundary
Selection	Boundaries 1–3, 7, 14, 32

Equations

Variables

Name	Expression	Unit	Description	Selection
ht.ins1.ntfluxInt	ht.ins1.intExtBnd(ht.ntflux)	W	Total net heat power	Global
ht.ins1.ntefluxInt	ht.ins1.intExtBnd(ht.nteflux)	W	Total net energy power	Global
ht.ins1.ntfluxInt_u	ht.ins1.intIntBnd(ht.ntflux_u)	W	Total net heat power, upside	Global
ht.ins1.ntefluxInt_u	ht.ins1.intIntBnd(ht.nteflux_u)	W	Total net energy power, upside	Global
ht.ins1.ntfluxInt_d	ht.ins1.intIntBnd(ht.ntflux_d)	W	Total net heat power, downside	Global
ht.ins1.ntefluxInt_d	ht.ins1.intIntBnd(ht.nteflux_d)	W	Total net energy power, downside	Global
ht.ins1.Tave	if(ht.ins1.intBnd(ht.rho*ht.Cp*(ht.ux*ht.nx+ht.uy*ht.ny+ht.uz*ht.nz))==0,ht.ins1.intBnd(T)/ht.ins1.intBnd(1),ht.ins1.intBnd(ht.rho*ht.Cp*T*(ht.ux*ht.nx+ht.uy*ht.ny+ht.uz*ht.nz))/ht.ins1.intBnd(ht.rho*ht.Cp*(ht.ux*ht.nx+ht.uy*ht.ny+ht.uz*ht.nz)))	K	Weighted average temperature	Global

Initial Values 1



Initial Values 1

Selection

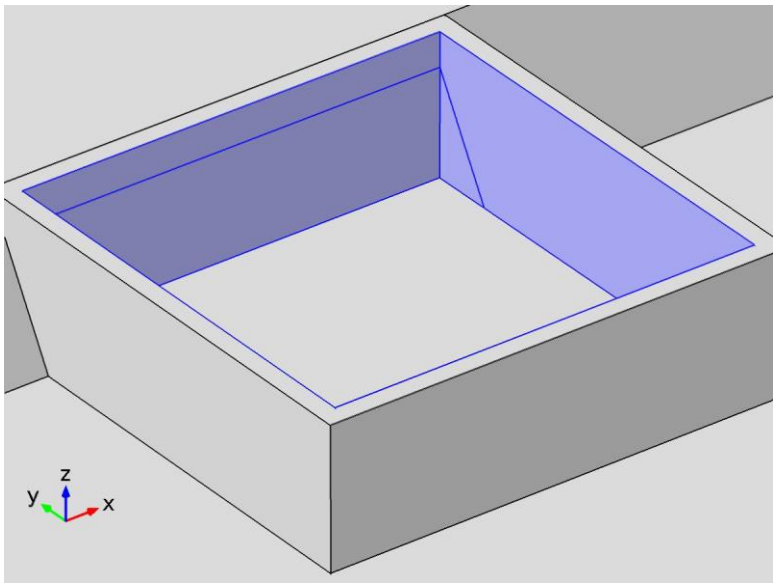
Geometric entity level	Domain
Selection	Domains 1–4

Settings

Settings

Description	Value
Temperature	293.15[K]

Interiér - stěny



Interiér - stěny

Selection

Geometric entity level	Boundary
Selection	Boundaries 20–21, 23–27

Equations

Settings

Settings

Description	Value
Heat flux	Inward heat flux
Heat transfer coefficient	7,7
External temperature	20[degC]

Variables

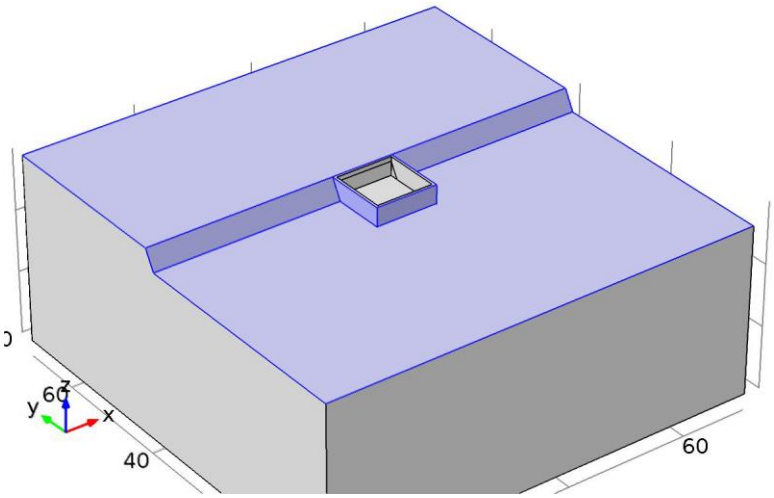
Name	Expression	Unit	Description	Selection
ht.q0	ht.hf1.q0	W/m^2	Inward heat flux	Boundaries 20–21, 23–27
ht.hf1.h	7,7	W/(m^2*K)	Heat transfer coefficient	Boundaries 20–21, 23–27
ht.hf1.Text	20[degC]	K	External temperature	Boundaries 20–21, 23–27
ht.hf1.q0	ht.hf1.h*(ht.hf1.Text-T)	W/m^2	Inward heat flux	Boundaries 20–21, 23–27
ht.hf1.ntfluxInt	ht.hf1.intExtBnd(ht.ntflux)	W	Total net heat power	Global
ht.hf1.ntefluxInt	ht.hf1.intExtBnd(ht.nteflux)	W	Total net energy power	Global
ht.hf1.ntfluxInt_u	ht.hf1.intIntBnd(ht.ntflux_u)	W	Total net heat power, upside	Global
ht.hf1.ntefluxInt_u	ht.hf1.intIntBnd(ht.nteflux_u)	W	Total net energy power, upside	Global
ht.hf1.ntfluxInt_d	ht.hf1.intIntBnd(ht.ntflux_d)	W	Total net heat power, downside	Global
ht.hf1.ntefluxInt_d	ht.hf1.intIntBnd(ht.nteflux_d)	W	Total net energy power, downside	Global

Name	Expression	Unit	Description	Selection
ht.hf1.Tave	if(ht.hf1.intBnd(ht.rho*ht.Cp*(ht.ux*ht.nx+ht.uy*ht.ny+ht.uz*ht.nz))==0,ht.hf1.intBnd(T)/ht.hf1.intBnd(1),ht.hf1.intBnd(ht.rho*ht.Cp*T*(ht.ux*ht.nx+ht.uy*ht.ny+ht.uz*ht.nz))/ht.hf1.intBnd(ht.rho*ht.Cp*(ht.ux*ht.nx+ht.uy*ht.ny+ht.uz*ht.nz)))	K	Weighted average temperature	Global

Weak expressions

Weak expression	Integration frame	Selection
ht.hf1.q0*test(T)	Material	Boundaries 20–21, 23–27

Exteriér



Exteriér

Selection

Geometric entity level	Boundary
Selection	Boundaries 4–6, 11–12, 29, 31

Equations

Settings

Settings

Description	Value
Heat flux	Inward heat flux
Heat transfer coefficient	25
External temperature	-15[degC]

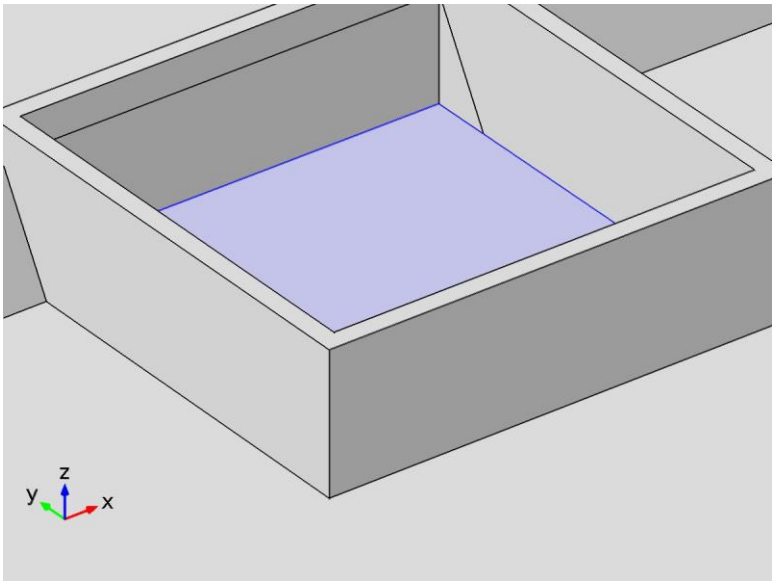
Variables

Name	Expression	Unit	Description	Selection
ht.q0	ht.hf2.q0	W/m^2	Inward heat flux	Boundaries 4–6, 11–12, 29, 31
ht.hf2.h	25	W/(m^2*K)	Heat transfer coefficient	Boundaries 4–6, 11–12, 29, 31
ht.hf2.Text	(-15)[degC]	K	External temperature	Boundaries 4–6, 11–12, 29, 31
ht.hf2.q0	ht.hf2.h*(ht.hf2.Text-T)	W/m^2	Inward heat flux	Boundaries 4–6, 11–12, 29, 31
ht.hf2.ntfluxInt	ht.hf2.intExtBnd(ht.ntflux)	W	Total net heat power	Global
ht.hf2.ntefluxInt	ht.hf2.intExtBnd(ht.nteflux)	W	Total net energy power	Global
ht.hf2.ntfluxInt_u	ht.hf2.intIntBnd(ht.ntflux_u)	W	Total net heat power, upside	Global
ht.hf2.ntefluxInt_u	ht.hf2.intIntBnd(ht.nteflux_u)	W	Total net energy power, upside	Global
ht.hf2.ntfluxInt_d	ht.hf2.intIntBnd(ht.ntflux_d)	W	Total net heat power, downside	Global
ht.hf2.ntefluxInt_d	ht.hf2.intIntBnd(ht.nteflux_d)	W	Total net energy power, downside	Global
ht.hf2.Tave	if(ht.hf2.intBnd(ht.rho*ht.Cp*(ht.ux*ht.nx+ht.uy*ht.ny+ht.uz*ht.nz))==0,ht.hf2.intBnd(T)/ht.hf2.intBnd(1),ht.hf2.intBnd(ht.rho*ht.Cp*T*(ht.ux*ht.nx+ht.uy*ht.ny+ht.uz*ht.nz))/ht.hf2.intBnd(ht.rho*ht.Cp*(ht.ux*ht.nx+ht.uy*ht.ny+ht.uz*ht.nz)))	K	Weighted average temperature	Global

Weak expressions

Weak expression	Integration frame	Selection
ht.hf2.q0*test(T)	Material	Boundaries 4–6, 11–12, 29, 31

Interiér - podlaha



Interiér - podlaha

Selection

Geometric entity level	Boundary
Selection	Boundary 22

Equations

Settings

Settings

Description	Value
Heat flux	Inward heat flux
Heat transfer coefficient	5,9
External temperature	+20[degC]

Variables

Name	Expression	Unit	Description	Selection
ht.q0	ht.hf3.q0	W/m^2	Inward heat flux	Boundary 22
ht.hf3.h	5,9	W/(m^2*K)	Heat transfer coefficient	Boundary 22
ht.hf3.Text	20[degC]	K	External temperature	Boundary 22
ht.hf3.q0	ht.hf3.h*(ht.hf3.Text-T)	W/m^2	Inward heat flux	Boundary 22
ht.hf3.ntfluxInt	ht.hf3.intExtBnd(ht.ntflux)	W	Total net heat power	Global

Name	Expression	Unit	Description	Selection
ht.hf3.ntefluxInt	ht.hf3.intExtBnd(ht.ntefl ux)	W	Total net energy power	Global
ht.hf3.ntfluxInt_u	ht.hf3.intIntBnd(ht.ntflu x_u)	W	Total net heat power, upside	Global
ht.hf3.ntefluxInt_u	ht.hf3.intIntBnd(ht.ntefl ux_u)	W	Total net energy power, upside	Global
ht.hf3.ntfluxInt_d	ht.hf3.intIntBnd(ht.ntflu x_d)	W	Total net heat power, downside	Global
ht.hf3.ntefluxInt_d	ht.hf3.intIntBnd(ht.ntefl ux_d)	W	Total net energy power, downside	Global
ht.hf3.Tave	if(ht.hf3.intBnd(ht.rho*h t.Cp*(ht.ux*ht.nx+ht.uy *ht.ny+ht.uz*ht.nz))==0, ht.hf3.intBnd(T)/ht.hf3.i ntBnd(1),ht.hf3.intBnd(h t.rho*ht.Cp*T*(ht.ux*ht. nx+ht.uy*ht.ny+ht.uz*ht .nz))/ht.hf3.intBnd(ht.rh o*ht.Cp*(ht.ux*ht.nx+ht .uy*ht.ny+ht.uz*ht.nz)))	K	Weighted average temperature	Global

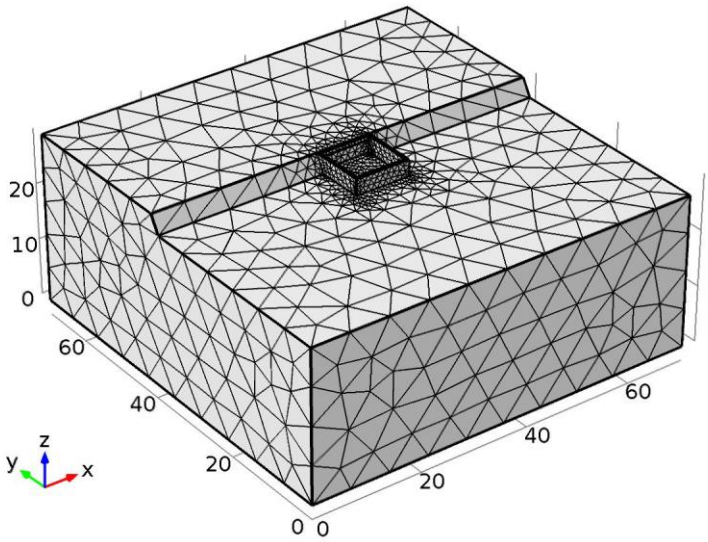
Weak expressions

Weak expression	Integration frame	Selection
ht.hf3.q0*test(T)	Material	Boundary 22

Mesh 1

Mesh statistics

Property	Value
Minimum element quality	0.09151
Average element quality	0.6896
Tetrahedral elements	12305
Triangular elements	2510
Edge elements	378
Vertex elements	38



Mesh 1

Size (size)

Settings

Name	Value
Maximum element size	7.08
Minimum element size	1.28
Curvature factor	0.6
Resolution of narrow regions	0.5
Maximum element growth rate	1.5

Free Tetrahedral 1 (ftet1)

Selection

Geometric entity level	Remaining

Study 1

Stationary

Study settings

Property	Value
Include geometric nonlinearity	Off

Mesh selection

Geometry	Mesh
Geometry 1 (geom1)	mesh1

Physics selection

Physics	Discretization
Heat Transfer in Solids (ht)	physics

Solver Configurations

Solver 1

Compile Equations: Stationary (st1)

Study and step

Name	Value
Use study	Study 1
Use study step	Stationary

Dependent Variables 1 (v1)

General

Name	Value
Defined by study step	Stationary

Initial values of variables solved for

Name	Value
Solution	Zero

Values of variables not solved for

Name	Value
Solution	Zero

Temperature (comp1.T) (comp1_T)

General

Name	Value
Field components	comp1.T

Stationary Solver 1 (s1)

General

Name	Value
Defined by study step	Stationary

Log

Stationary Solver 1 in Solver 1 started at 1-X-2020 16:49:57.
Linear solver
Number of degrees of freedom solved for: 18507 (plus 7236 internal DOFs).
Symmetric matrices found.
Scales for dependent variables:
Temperature (comp1.T): 2.9e+002
Iter Damping Stepsize #Res #Jac #Sol LinErr LinRes
1 1.0000000 0.12 1 1 1 1.3e-012 6e-016
Stationary Solver 1 in Solver 1: Solution time: 1 s
Physical memory: 914 MB
Virtual memory: 1082 MB

Fully Coupled 1 (fc1)

General

Name	Value
Linear solver	Direct 1

Direct 1 (d1)

General

Name	Value
Solver	PARDISO

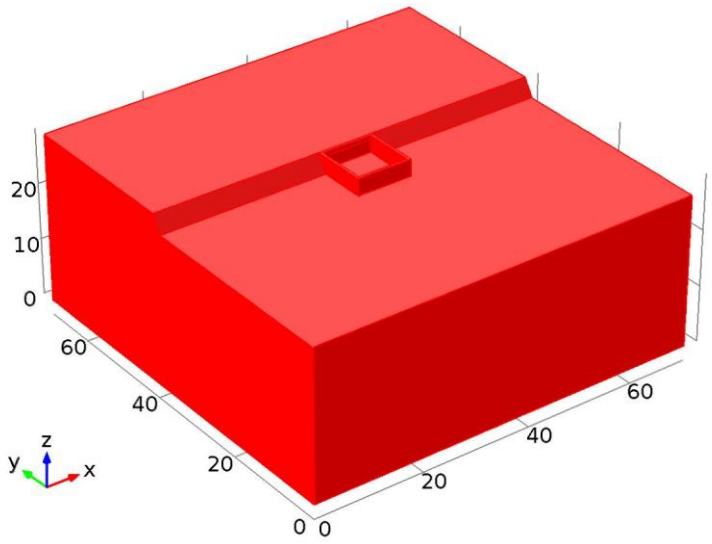
Results

Data Sets

Solution 1

Solution

Name	Value
Solution	Solver 1
Component	Save Point Geometry 1



Data set: Solution 1

Derived Values

Tepelný tok - stěny

Selection

Geometric entity level	Boundary
Selection	Boundaries 23–25, 27

Data

Name	Value
Data set	Solution 1

Expression

Name	Value
Expression	ht.q0
Unit	W
Description	Inward heat flux

Tepelný tok - podlaha

Selection

Geometric entity level	Boundary
Selection	Boundary 22

Data

Name	Value
Data set	Solution 1

Expression

Name	Value
Expression	ht.q0
Unit	W
Description	Inward heat flux

Tepelný tok - zemina

Selection

Geometric entity level	Boundary
Selection	Boundaries 4–6, 31

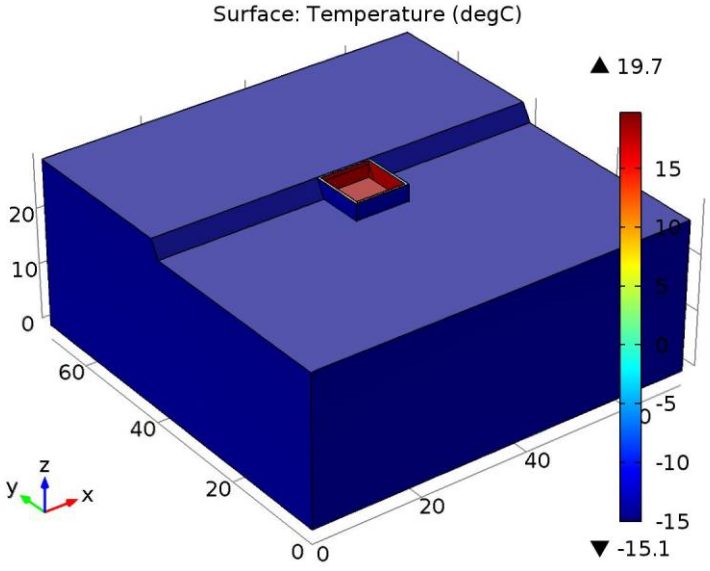
Data

Name	Value
Data set	Solution 1

Expression

Name	Value
Expression	ht.q0
Unit	W
Description	Inward heat flux

Temperature (ht)



Surface: Temperature (degC)

Příloha B

Stanovení měrných tepelných toků pro jednotlivé zjednodušené metody pro vytápěný suterén ve svahu se sklonem 60°

STĚNY pomocí činitele teplotní redukce

$U_{stěna}$ (W/m²K) 0,215

hloubka	plocha	b
0-1m	13,345	0,66
1-2m	12,191	0,56
2-3m	11,038	**0,49**
3 a více m	4,092	0,43

h (m) 2,61

H_g (W/K) **4,29**

$$H_g = A \cdot U \cdot b$$

PODLAHA pomocí činitele teplotní redukce

$U_{podlaha}$ (W/m²K) 0,257

hloubka	plocha	b
0-1m	0	0,66
1-2m	0	0,56
2-3m	0	0,49
3 a více m	100	**0,43**

H_g (W/K) **11,03**

$$H_g = A \cdot U \cdot b$$

PODLAHA na zemině dle EN ISO

A (m²)	100
P (m)	40
$d_{w;e}$ (m)	0,42
λ_g	2
R_{si} (m²K/W)	0,17
R_{se} (m²K/W)	0
$R_{f;b}$ (m²K/W)	3,73
B (m) =	5,0
d_f (m) =	8,22

$$d_f = d_{w;e} + \lambda_g \cdot (R_{si} + R_{f;b} + R_{se})$$

$U_{fg;sog}$ (W/m²K)	0,190	$d_f < B$ $U_{fg;sog} = \frac{2 \cdot \lambda_g}{\pi \cdot B + d_f} \cdot \ln\left(\frac{\pi \cdot B}{d_f} + 1\right)$ $d_f \geq B$ $U_{fg;sog} = \frac{\lambda_g}{0{,}457 \times B + d_f}$
H_g (W/K)	**19,05**	$H_g = A \cdot U_{fg;sog}$

STĚNY suterénní dle EN ISO

P (m)	40	
d_f (m)	8,22	$d_f = d_{w;e} + \lambda_g \cdot (R_{si} + R_{f;b} + R_{se})$
z (m)	3,00	
λ_g	2	
R_{si} (m²K/W)	0,13	
R_{se} (m²K/W)	0	
$R_{w;b}$ (m²K/W)	4,52	
$d_{w;b}$ (m)	9,29	$d_{w;b} = \lambda_g \cdot (R_{si} + R_{w;b} + R_{se})$
$U_{wg;b}$ (W/m²K)	0,162	$d_{w;b} \geq d_f$ $U_{wg;b} = \frac{2 \cdot \lambda}{\pi \cdot z} \cdot \left(1 + \frac{0{,}5 \times d_f}{d_f + z}\right) \cdot \ln\left(\frac{z}{d_{w;b}} + 1\right)$ $d_{w;b} < d_f$ $U_{wg;b} = \frac{2 \cdot \lambda}{\pi \cdot z} \cdot \left(1 + \frac{0{,}5 \times d_{w;b}}{d_{w;b} + z}\right) \cdot \ln\left(\frac{z}{d_{w;b}} + 1\right)$
H_g (W/K)	**4,87**	$H_g = z \cdot P \cdot U_{wg;b}$

STĚNY ve svahu pomocí činitele teplotní redukce

$U_{stěna}$ (W/m²K) 0,215

hloubka	plocha	b
0-1m	3,345	0,66
1-2m	2,191	**0,56**
2-3m	1,038	0,49
3 a více m	0,092	0,43

h (m) 1,5

H_g (W/K) **0,80**

$$H_g = \mathrm{A} \cdot U \cdot b$$

PODLAHA suterénu dle EN ISO

A (m²)	100
$d_{w;e}$ (m)	0,42
λ_g (W/mK)	2
R_{si} (m²K/W)	0,17
R_{se} (m²K/W)	0
$R_{f;b}$ (m²K/W)	3,73
z (m)	0,88

B (m) = 5,0 $B = \dfrac{A}{0{,}5 \cdot P}$

d_f (m) = 8,22 $d_f = d_{w;e} + \lambda_g \cdot (R_{si} + R_{f;b} + R_{se})$

$U_{fg;b}$ (W/m²K) 0,183

$(d_f + 0{,}5 \times z) < B$

$$U_{fg;b} = \frac{2 \cdot \lambda_g}{\pi \cdot B + d_f + 0{,}5 \times z} \cdot \ln\left(\frac{\pi \cdot B}{d_f + 0{,}5 \times z} + 1\right)$$

$(d_f + 0{,}5 \times z) \geq B$

$$U_{fg;b} = \frac{\lambda_g}{0{,}457 \times B + d_f + 0{,}5 \times z}$$

$$H_g = A \cdot U_{fg;b}$$

H_g (W/K) **18,28**

Přirážka na vliv tepelných vazeb

Plocha celkem (m²)	140,67
Δ U_{em} (W/m²K)	0,02

(W/K) **2,81** $\Delta U_{em} \cdot \Sigma A$

Výpočet měrného tepelného toku pomocí zjednodušených postupů

1) Metoda "béček"

Stěny	4,29	W/K
Podlaha	11,03	W/K
Přirážka na vliv tepelných vazeb	2,81	W/K
Celkem bez přirážky	15,32	W/K
Celkem s přirážkou	**18,13**	**W/K**

2) Metoda "béček" a podlahy na zemině

Stěny	4,29	W/K
Podlaha	19,05	W/K
Přirážka na vliv tepelných vazeb	2,81	W/K
Celkem bez přirážky	23,34	W/K
Celkem s přirážkou	**26,15**	**W/K**

3) Metoda "béček", podlahy na zemině a suterénní stěny

Stěny	5,67	W/K
Podlaha	19,05	W/K
Přirážka na vliv tepelných vazeb	2,81	W/K
Celkem bez přirážky	24,72	W/K
Celkem s přirážkou	**27,53**	**W/K**

4) Metoda "béček", podlahy suterénu a suterénní stěny

Stěny	5,67	W/K
Podlaha	18,28	W/K
Přirážka na vliv tepelných vazeb	2,81	W/K
Celkem bez přirážky	23,95	W/K
Celkem s přirážkou	**26,77**	**W/K**

pozn.: Stejný princip výpočtu byl použit pro dalších 122 modelů