Simple Simulation Tool for Thermally Activated Building Systems

IBPSA-Nordic Seminar 2013

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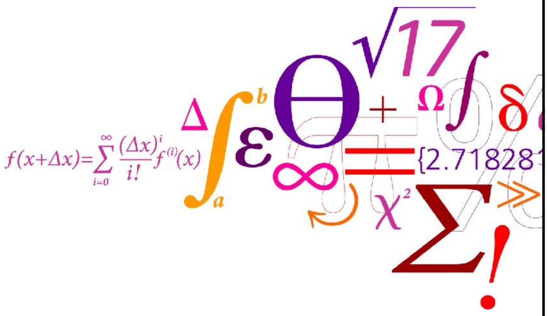

DTU Civil Engineering
Department of Civil Engineering

The Problem

Today it is neccessary to make a full blown building simulation to design an Embedded Radient System.

- Possible solutions are IDA ICE 4, TRNSYS, IES VE, Energy+, ect.
- These Simulations are
  - time consuming,
  - complicated and
  - prone to errors.

⇒ We need a simple solution to effectively design embedded radiant systems

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What's the Solution?

- ISO 11855 describes an iterative resistance approach to size embedded radiant systems.
- This system has been implemented in C++
- The program is called the Simple Simulation Tool (SSTe)

⇒ How dose the SSTe work?

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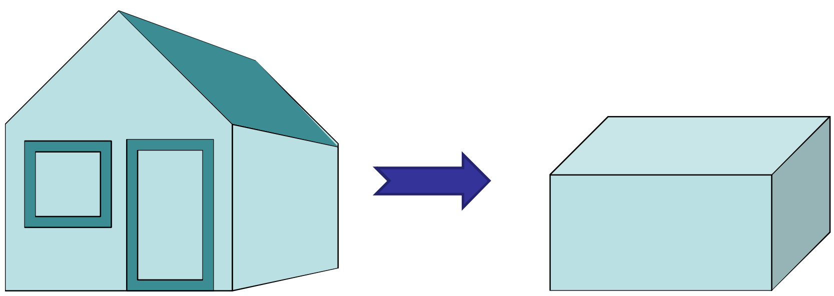
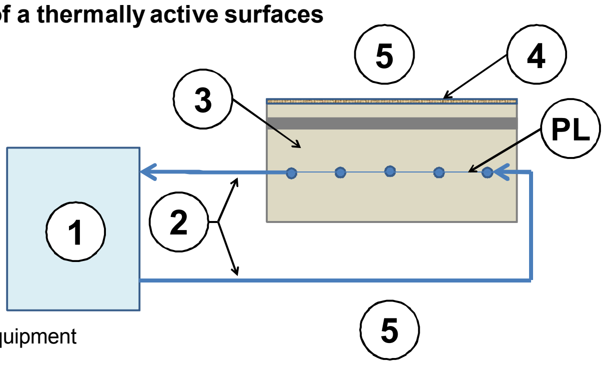
The principle of the SST

Simplification of problem



The principle of the SST

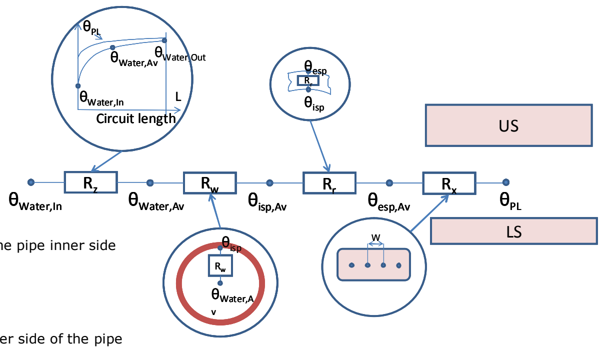
Simple scheme of a thermally active surfaces



where:
PL = Pipe level
1 = Heating/Cooling equipment
2 = Hydraulic circuit
3 = Slab including core layer with pipes
4 = Possible additional resistances (floor covering or suspended ceiling)
5 = Room below and room above

The principle of the SST

General scheme of the Resistance Method



where:
L = Length of installed pipes
LS = Lower part of the slab
R_r = Pipe thickness thermal resistance
R_w = Convection thermal resistance at the pipe inner side
R_x = Pipe level thermal resistance
R_z = Water flow thermal resistance
T = Pipe spacing
US = Upper part of the slab
$\theta_{esp,Av}$ = Average temperature at the outer side of the pipe
$\theta_{isp,Av}$ = Average temperature at the inner side of the pipe
θ_{PL} = Average temperature at the pipe level
$\theta_{Water,Av}$ = Water average temperature
$\theta_{Water,In}$ = Water inlet temperature
$\theta_{Water,Out}$ = Water outlet temperature

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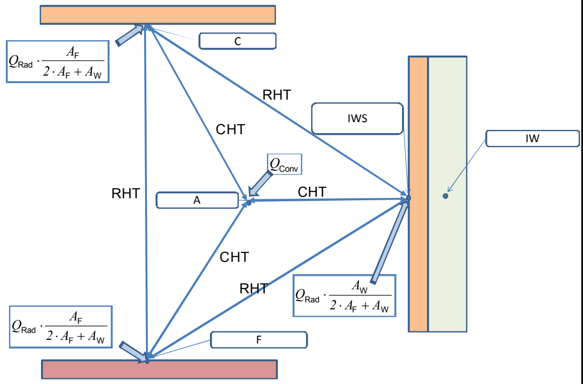
The principle of the SST

Scheme of the thermal network representing the room



where:
A = Thermal node representing the air in the room
C = Thermal node representing the ceiling surface
CHT = Convective heat transfer
F = Thermal node representing the floor surface
IW = Thermal node representing the internal walls
IWS = Thermal node representing the internal wall surface
RHT = Radiant heat transfer
Q_{Conv} = Total convective heat gains
Q_{Rad} = Total radiant heat gains

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SSTe Interface

Overview

Project	11855-4	TRUE
Boundary	11855-4	TRUE
Circuit	11855-4	TRUE
Pipe	11855-4	TRUE
Room	11855-4	TRUE
Slab	11855-4	TRUE

Library: Sort Libraries, Save and Backup
Project: Export, Run, Export and Run Project, Create Report

Boundary Data	11855-4	Unit
nTimeSteps	24	[-]
lTimeStep	3600	[s]
nSubTimeStep	500	[-]
tolDayMax	0.0001	[-]
tolHourMax	0.00001	[-]
nHoures	8	[-]
convHeatFlux	30	[W]
radHeatFlux	10	[W]
runningMode	1	[-]
tWater	20	[C]
maxCoolPower	1000	[W]
nHoures	11	[-]
convHeatFlux	400	[W]
radHeatFlux	300	[W]
runningMode	0	[-]
tWater	20	[C]
maxCoolPower	0	[W]
nHoures	5	[-]
convHeatFlux	150	[W]
radHeatFlux	100	[W]
runningMode	1	[-]
tWater	20	[C]
maxCoolPower	1000	[W]

Circuit Data	11855-4	Unit
pipe_spacing	0.1	[m]
area_perc	1	[-]
mass_flow_mm	36	[kg/h*m2]
fluid_char_rho	1000	[kg/m3]
fluid_c_w	4187	[J/kg.K]

Pipe Data	11855-4	Unit
diameter_ext	0.02	[m]
wall_thickness	0.0023	[m]
thermal_cond	0.35	[W/(m.K)]

Room Data	11855-4	Unit
FloorArea	30	[m2]
WallArea	48	[m2]
hAirToFloor	1.5	[W/(m2*K)]
hAirToCeiling	5.5	[W/(m2*K)]
hAirToWalls	2.5	[W/(m2*K)]
FvFloorToCeiling	0.21	[-]
FvSlabToExtWall	0.35	[-]
FloorResistance	0.1	[(m2*K)/W]
CeilingResistance	0	[(m2*K)/W]
WallResistance	0.05	[(m2*K)/W]
CWalls	25600	[J/(m2*K)]

Macro Report (last macro executed)
File and Backup saved.
Timestampe: 2013-09-17 02:41:35

Slab Data	11855-4	Unit
nLayers	4	[-]
ActiveLayer_depth	0.19	[m]
nDivisions	1	[-]
Thickness	0.02	[m]
ThCond	0.17	[W/(m*K)]
SpecHeat	2300	[J/(kg*K)]
Density	700	[kg/m3]
nDivisions	2	[-]
Thickness	0.07	[m]
ThCond	1.1	[W/(m*K)]
SpecHeat	850	[J/(kg*K)]
Density	1900	[kg/m3]
nDivisions	3	[-]
Thickness	0.1	[m]
ThCond	1.9	[W/(m*K)]
SpecHeat	880	[J/(kg*K)]
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nDivisions	3	[-]
Thickness	0.1	[m]
ThCond	1.9	[W/(m*K)]
SpecHeat	880	[J/(kg*K)]
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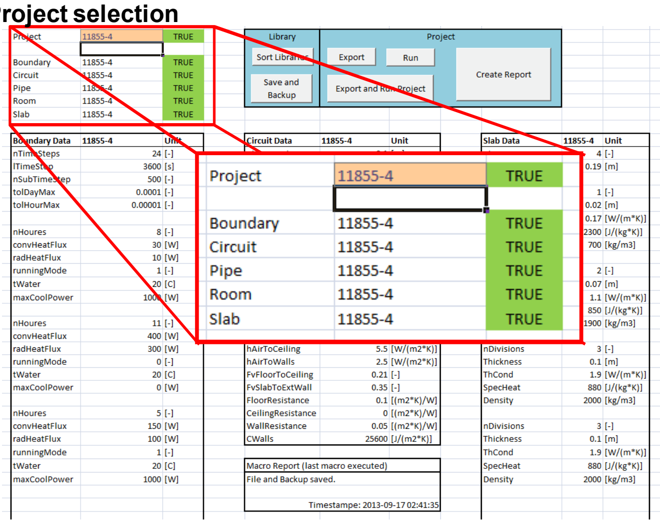
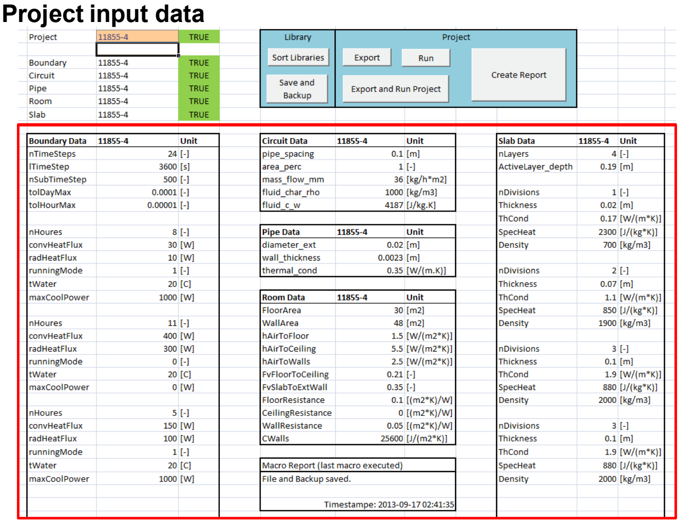
SSTe Interface

Project selection



SSTe Interface

Project input data



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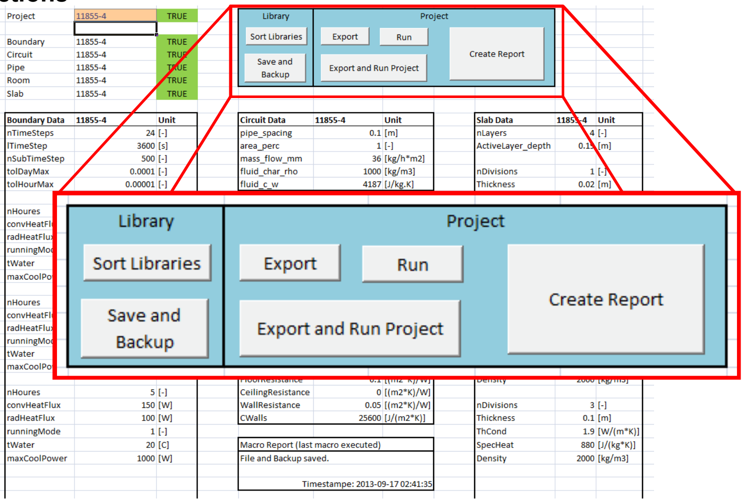
SSTe Interface

Actions



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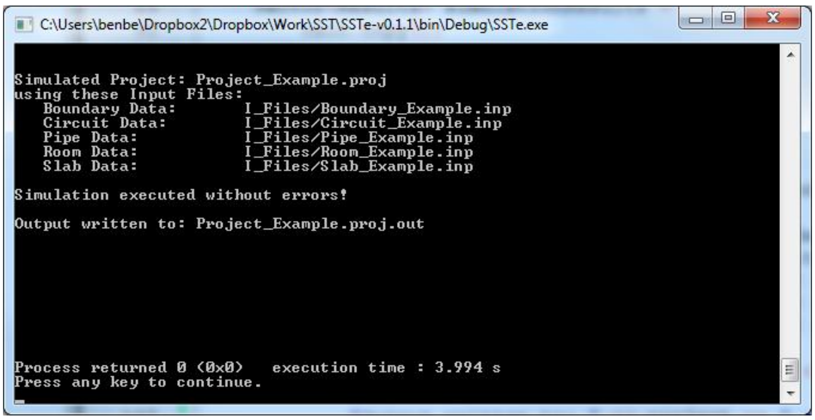
The principle of the SST

The SST Window



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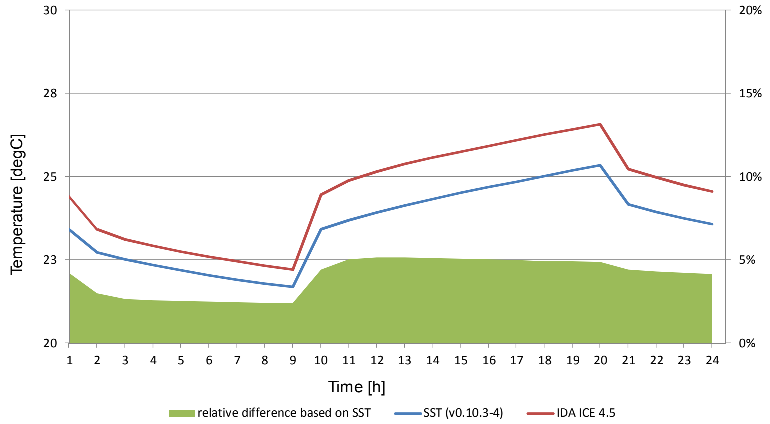
The SST Output – Operative Temperatur



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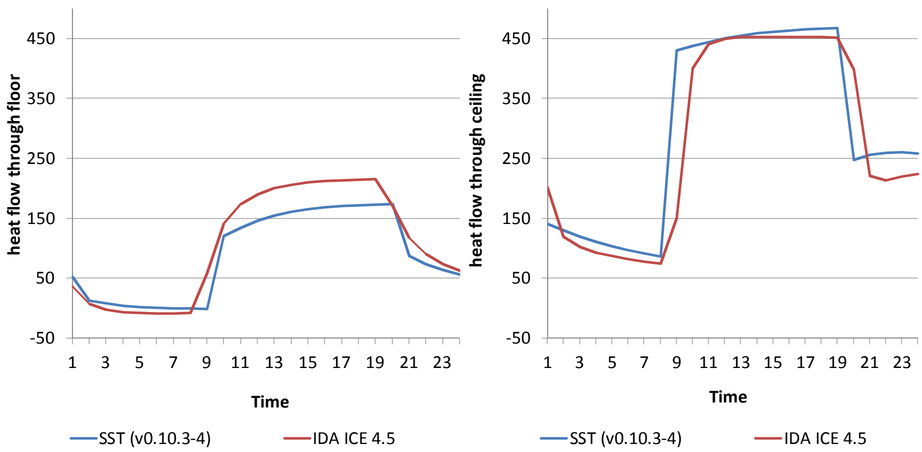
The SST Output – Operative Temperatur



Conclusion

SST is a promising approach

- Fast and easy simulation
- Results are within 5% error (compared to other simulations)
- Input data library is functional
- Input data validation

- Rough system sizing is possible
- No information about humidity constraints

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Thanks for your attention!
Questions?

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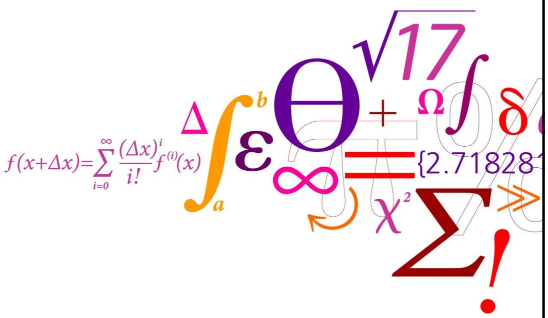

What now?

- Further testing of SST
- Creating a library for the SST
- Creating simple diagrams showing the relation between some key parameters