Coupled Heat, Moisture and CFD Modeling in the Built Environment

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Introduction

Museums
- Strict indoor climate
  - Prevent degradation
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- HVAC to stabilize indoor climate
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- High energy consumption and irreversible impact to historic buildings
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- HVAC to stabilize indoor climate
- High energy consumption and irreversible impact to historic buildings
- Local climates caused by HVAC
Objective
Research question

- Understand the impact of short-term temperature and relative humidity changes in indoor air supply on the indoor climate near objects.

Comsol Multiphysics is used to research the effect of fluctuating conditioned supply air on the indoor climate near objects in an exhibition room.
Method
Experimental
Case study Amsterdam Museum

- 15th century building
- Mixed collection
- HVAC since 2007
- Measurements of $T_i$, $T_s$, $RH_i$
Method
Numerical
- Heat transfer in fluids
- Moisture transfer in air
- Non-isothermal flow (k-ε turbulence model)
Method
Numerical
- Grid
  - Fluid dynamics normal element size
  - Inlet/outlet boundaries restricted element size <0.1m
- Boundary Conditions
  - Inlet: step function
  - Walls: constant T
Results

Transient simulation
Results

Validation

![Graphs showing temperature, relative humidity, and specific humidity over time.]

- Temperature [°C]
  - Time [s]
  - Inlet, BMS Inlet, Simulation

- Relative Humidity [%]
  - Time [s]
  - Inlet, BMS Inlet, Simulation

- Specific Humidity [g/kg]
  - Time [s]
  - Inlet, BMS Inlet, Simulation
Results

Validation
Conclusions

Findings
- It is possible to use COMSOL Multiphysics as computational tool for indoor environment modelling influenced by HVAC climate control.

- The outcome is valuable for locating critical areas in an exhibition rooms and could be of help while staging a museum exhibition, or evaluating novel climate control strategies.

Model limitations
- The model is not yet adequately validated for this case study.

- It takes quite some computational effort to perform simulations based on coupled Heat, Air and Moisture transport, even in a simplified situation.

- The simulation results are sensitive to the imposed boundary conditions and solver settings.
Conclusions

Future work

• Future steps in this study will include performing a grid-sensitivity analysis and re-evaluate the validation of the model based on extensive experimental data.

• Influence of solar radiation as short-term fluctuation on indoor climate conditions.

• Couple indoor climate as boundary condition to a stress-strain model of typical heritage objects.
Thank you for your attention

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