Experimental validation of two simplified thermal zone models

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Motivation

- Why to deal with simplified models?

- The more complex a system the less effective the model? (Lofti Zadeh: „As the complexity of a system increases, our ability to make precise and yet significant statements about its behavior diminishes until a threshold is reached beyond which precision and significance (or relevance) become almost mutually exclusive characteristics“).

- Education: ability to explain main features of the problem (target audience – students of architecture)

- EN ISO 13790 – simple hourly method
Scope

- To research suitable simplified description of heat transfer in ventilated zone
- To test if simplified models are capable to produce reliable results

Simplified models should:
- Exclude all factors with negligible influence (i.e. limit number of inputs)
- Provide reasonable accuracy
- Work with short time step
- Be comprehensible for standard users
- Be practical for design process
Problem of accuracy

- Model uncertainty x deterministic criteria?
Process of simplification

- How to change complex structures to simple?

- After several steps (sometimes rather downgrading) one can get

Effective penetration depth model (EPDM)  Effective capacitance model (ECM)

Internal structure („partitions“)

External structure („walls“)

(Jóhannesson)  (Mathews)
Effective capacitance model

- Very helpful for education
- „Climate surfaces“ – Keller, Burmeister

\[ C_{\text{eff}} \frac{dT_i}{d\tau} = \Phi_s + \Phi_i - H (T_i - T_e) \]

\[ \tau_C \frac{dT_i}{d\tau} = \gamma I_s + \frac{\Phi_i}{H} - (T_i - T_e) \quad \text{where} \quad \tau_C = \frac{C_{\text{eff}}}{H} \]

\[ \gamma = \frac{\bar{g} A_w F_g}{H} \]

\[ Q_C = H \cdot \Omega_C (\tau_C, \gamma) \]

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Examination of models

- Goal: to confront EPDM and ECM with measurement
- Comparison with other models (Bestest)
- Comparison with measured data
  - Box on the university roof
  - Real occupied office
Box on the roof

- Room model (1:3)
- Very light structure
- Very good data about solar gains
- Comparison based on ten-day period

![Graphs showing relative frequency of temperature differences for EPDM and ECM]
Office

Heavy structure with light envelope

\[(1-f_s)\Phi_s + (1-f_t)\Phi_t + f_s\Phi_s + f_t\Phi_t\]

- EPDM
- ECM

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<th>T_{ai} - T_{i,EPDM} (K)</th>
<th>Relative Frequency (%)</th>
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Conclusions

- Two simplified thermal models of ventilated zone were comparable with measurement
- It seems they could be capable to predict
  - Heating need and cooling need
  - Thermal comfort

Problems

- How to upscale from one-zone analysis to whole building not to lose information about thermal comfort?
- Dynamics based on longer (ground heat transfer, or castle) or much shorter fluctuation than one day (e.g. technical systems)
Thank you for your attention