Indoor Environmental Quality Benefits of Radiant Systems

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hybrid GEOTABS
Controlling the power of the ground by integration

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Introduction

- We spend most of our lives indoors
- Buildings are built for people, not to save energy
- Comfort, health, and productivity should be achieved with the lowest possible energy use
- Non-fossil energy resources
- Heating, cooling, and ventilation systems
- Three main parts
  - Generation
  - Distribution
  - Emission → Indoor terminal units

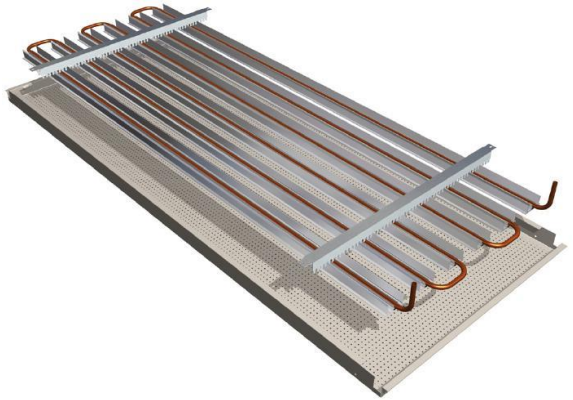
Introduction

- Indoor terminal units: the building elements that use different heat transfer mechanisms and media to emit and remove heat or moisture from indoor spaces
- Possibilities (heating, cooling, ventilation, humidification and dehumidification)
- Methods of heat emission or removal
- Maximum heating and cooling capacities
- Medium of energy distribution
- Total or local volume conditioning
- Indoor temperature and humidity fields depend on the chosen terminal units

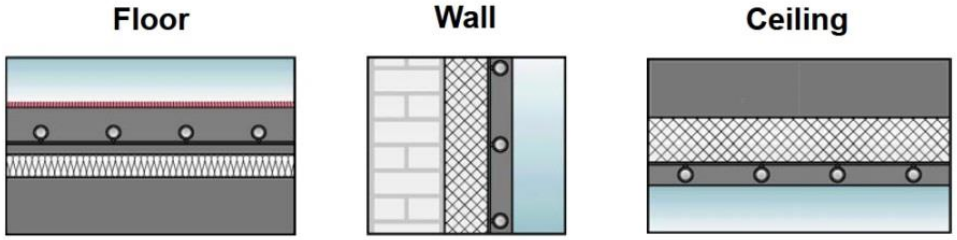
Radiant heating and cooling systems

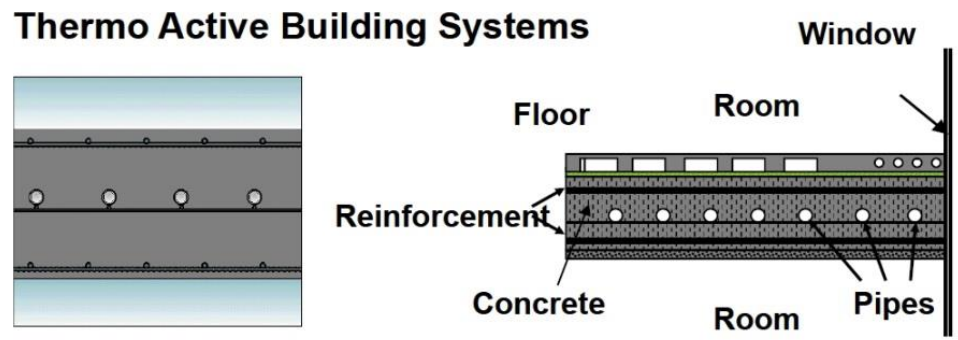
- Low temperature heating and high temperature cooling
- Water-based (mostly)
- Heat emission or removal by radiation and convection (more than half by radiation)
- Three main types
  - Radiant heating and cooling panels
  - Pipes isolated from the main building structure (radiant surface systems)
  - Pipes embedded in the main building structure (thermally active building systems - TABS)

Radiant heating and cooling systems



Source: www.zent-frenger.de





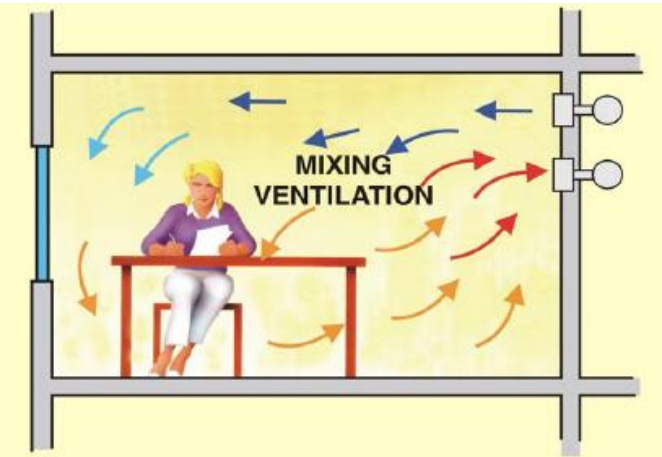
Source: Olesen, 2000

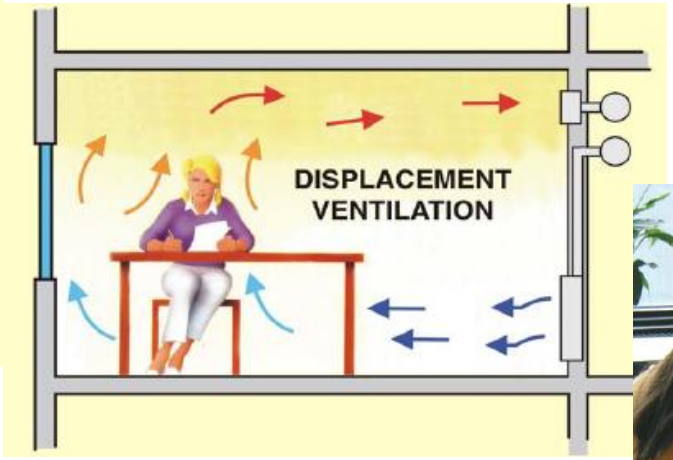
Radiant heating and cooling systems

- Floor, walls and ceiling can be used; large surface area for heat exchange
- Supply water temperatures:
  - Heating: 25 – 40° C
  - Cooling: 16 – 23° C
- The maximum floor heating and cooling capacities are 99 W/m^2 and 42 W/m^2, wall heating and cooling capacities are 160 W/m^2 and 72 W/m^2, and ceiling heating and cooling capacities are 42 W/m^2 and 99 W/m^2, respectively
- Ventilation system required to address the latent loads and to provide the ventilation rates required for indoor air quality

All-air systems

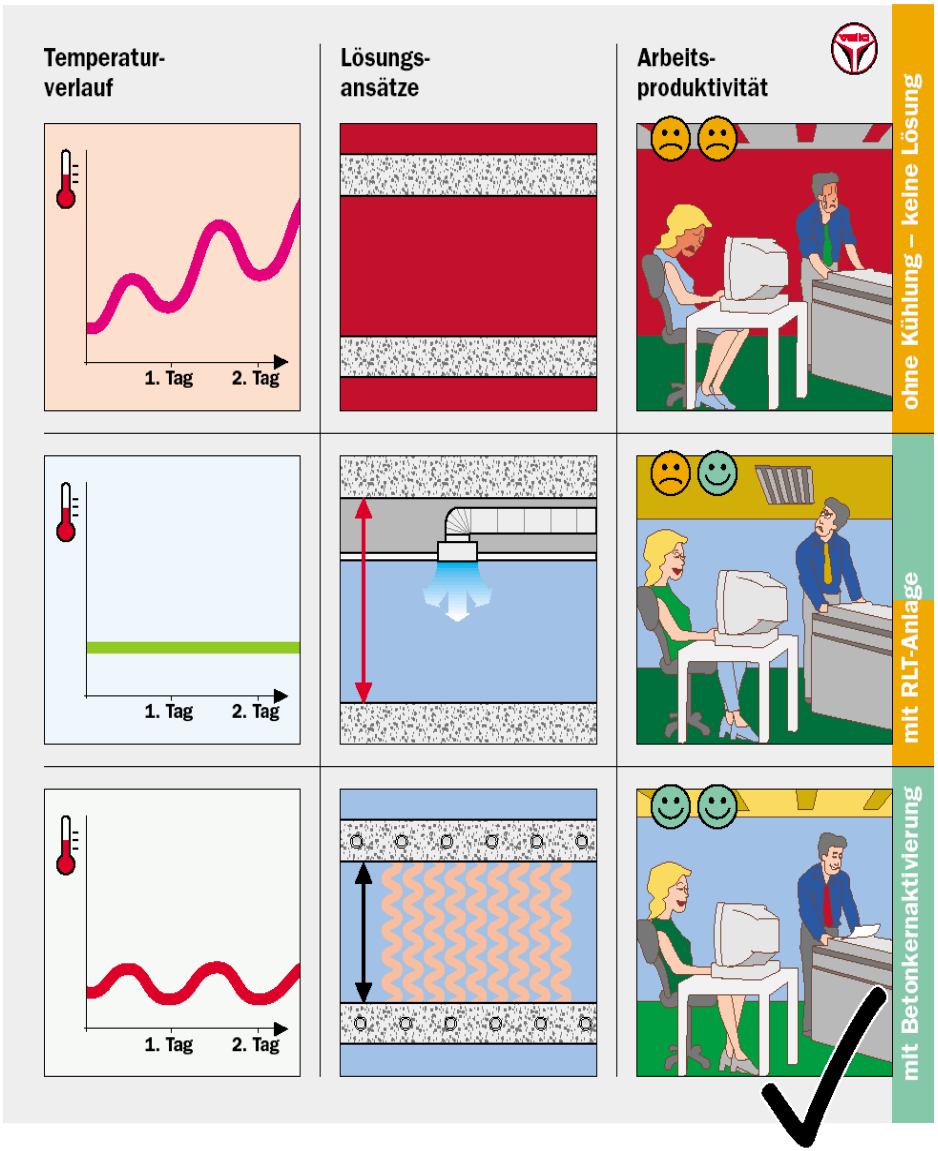
- Air-conditioning systems
- The main method of heat emission and removal is convection
- The medium of energy distribution is air
- Mixing, displacement, and personalized ventilation





Source: Melikov, 2010

All-air vs. TABS



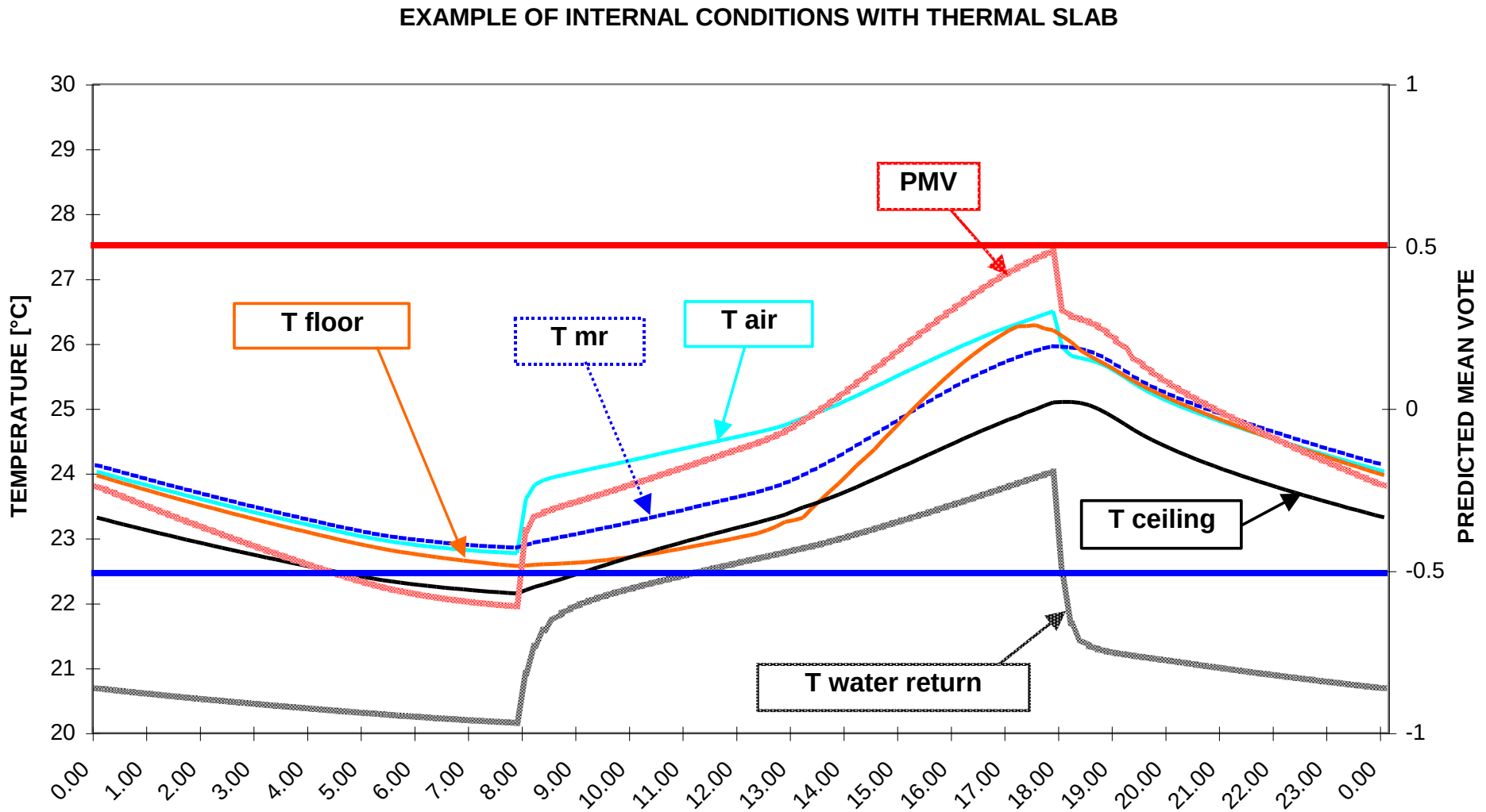
No cooling - decreased performance
Low energy costs
Low operation costs

Constant temperature
Draught
Noise
SBS
High energy costs
High operation costs

Temperature ramps
Reasonable energy costs
Low operation costs

Source: Olesen, 2000

All-air vs. TABS



Source: Olesen, 2000

Why radiant heating and cooling systems?

- Integration of renewable energy resources
- Transferring peak loads to off-peak hours, and peak load reductions
- Favorable operating conditions for heating and cooling plants
- Smaller capacity heating and cooling plants, and downsized ventilation systems
- Reduced total energy use
- Less space requirement, lowered construction heights and saved building materials
- Initial, operational, and energy cost savings
- **Free use of space, no cleaning requirements, quiet operation**
- **Uniform temperature distribution, reduced risk of draught, and reduced vertical air temperature differences**

Current knowledge about radiant vs. convective

- Karmann et al. 2017a and 2017b
  - Thermal comfort in buildings using radiant vs. all-air systems: A critical literature review
  - Comparing temperature and acoustic satisfaction in 60 radiant and all-air buildings
- Bolashikov et al. 2013
  - Thermal comfort in simulated office environment with four convective and radiant cooling systems
- ”Suggestive evidence”
- ”Tendency towards”
- Limited amount of literature available on the direct comparison

IEQ within hybridGEOTABS project

- Demonstration buildings → before and after implementation of Model Predictive Control (MPC)

a. Solarwind office building

b. Infrax office building (NEW)

c. Ter Potterie elderly home

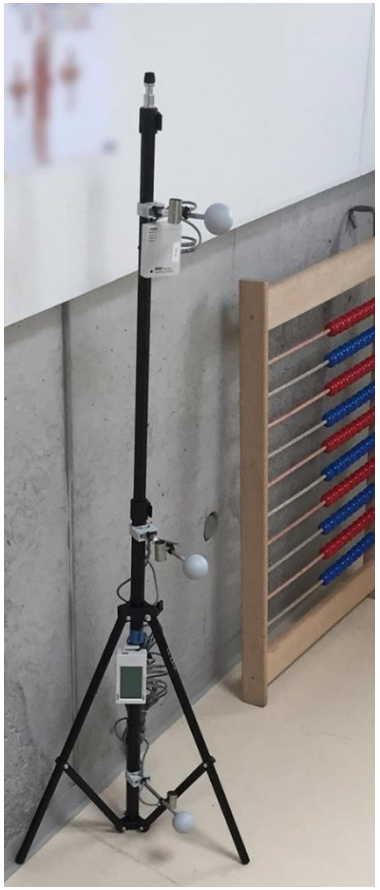
d. Libeznice primary school

Kramer and Kazanci, 2019

IEQ within hybridGEOTABS project

- Objectives
  - Detailed long-term measurements of the IEQ in the demo buildings
  - Quantification of the difference between the "real" and the thermal indoor environment "sensed" by the building management system
  - Periodic questionnaires (subjective - occupant satisfaction with the indoor environment)
    - Comparison of the responses with the physical measurements to identify the correlation and the discrepancies
  - Quantification of the effects of the improved control strategy on IEQ (before and after the MPC)


woonzorgcentrum
Ter Potterie



Summary

- A complete understanding of the IEQ and user satisfaction in hybrid GEOTABS buildings via physical measurements and questionnaires
- Provide suggestions for improving the comfort, health and productivity of the occupants

- Overall + local thermal discomfort
- Effects of the combination of different IEQ factors
- Need for fundamental research on the comparison of the effects of radiant vs. convective systems

Thank you for your attention!

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