Flow interaction between diffuse ceiling ventilation and thermal plumes

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CONTENTS OF THE STUDY

- Test chamber
- Literature review
- Measurements
- CFD-simulations
- Results
- Conclusions
FLOW INTERACTION – EFFECT ON THE FLOW FIELD

- Velocity and temperature
- Turbulent motion
- Frequency of fluctuations
- Airflow direction
  - => Flow behavior
  - => Draught rate
  - => Thermal comfort
TEST CHAMBER

- 6 m (L) x 4 m (W) x 3.6 m (H)
- Air handling unit - 0…25 l/s per floor square – cooling and heating – heat recovery
- 3 water circles - air handling unit, room devices and window simulation
- Human manikin, cylindrical and seated test dummies, thermal loads and furniture
EXPERIMENTAL SET-UP

- 12 test dummies produce thermal plumes 40…80 W/m² (floor)
- Air distribution – through suspended ceiling plate at 3.2m (H)
- Anemometers – height 0.1m, 0.6m, 1.1m, 1.4m, 1.7m…2.9m

Ceiling supply ~0.5%
MEASUREMENTS

- Hot-sphere anemometer (7 pcs)
- Ultrasonic anemometer (1 pcs)
- Tinytag humidity and temperature sensors
- Swema 3000 – pressure differences
- Infrared thermography – surface temperature level
- Smoke visualization with led-lighting mast
- Low-weight ribbons – investigate large flow motion
CFD-SIMULATIONS

- RANS, URANS, LES
- ANSYS ICEM CFD and ANSYS CFX 17.0
- Tetrahedron grid and prismatic elements
CFD-DOMAIN - EXPERIMENTS

- Temperature for the walls, floor and ceiling
- Nozzles at the suspended ceiling d~14mm
- Supply air jets – velocity, temp, turbulence
- Heat sources – heat flux from dummies
- Exhaust outlet – mass flow (not opening)
- Small opening for balancing the mass conservation in the domain (near zero)

=> This may avoid over-specification of BC
CFD-SIMULATIONS

- LES initial condition from RANS
  Otherwise start from stagnant situation
- Supply air jets individually => box method
  Otherwise real geometry with nozzles
- Iteration, residuals, grid dependency
- Sensitivity analysis for the BC
RESULTS

- Large scale motion seems to occur randomly
- Flow motion increased while heat load increased
- Flow behavior varies depending on location
- Fluctuation different near dummies and surrounding

![Graph showing airflow speed over time for Case 3, location 5]
Flow interaction – thermal plume
CONCLUSIONS

- Objectives - Airflow interaction phenomena
- Experimental set-up in a test chamber
- CFD-simulations for a generic view
- Results - Effects on the flow field