EXPERIMENTAL STUDY
OF VERTICAL AIR TEMPERATURE
GRADIENT IN LECTURE ROOMS WITH
DIFFERENT VENTILATION SYSTEMS

Natalia Lastovets, Simo Kilpeläinen, Juha Jokisalo, Risto Kosonen

Department of Mechanical Engineering

Department of Mechanical Engineering, Aalto University, Espoo, Finland
Motivation – Context of the study

• Complications in the classroom situation: high and intermittent occupancy

• Dearth of results assessing performance of these systems in actual classroom situation

• Vertical temperature gradient affected by the type of air distribution system
  o Mixed ventilation (MV)
  o Displacement ventilation (DV)
  o Hybrids of the above two

• Data gathered can aid:
  o Numerical evaluation of air distribution systems
  o Study of the thermal mass effect on the vertical temperature gradient
  o Making informed choices regarding retrofits
Method – Room description and measurements

Measurements:

Temperature and humidity at 20 heights:
0.1 – 1.7 every 10 cm and three more at 2, 2.5, and 3 m

Using two masts with 20 TinyTag Plus 2 Dual Channel loggers

<table>
<thead>
<tr>
<th>Room</th>
<th>Floor Space (m²)</th>
<th>Seating Capacity</th>
<th>Air distribution system</th>
<th>Max. air supply (l/s)</th>
<th>Supply diffusers</th>
<th>Exhaust</th>
</tr>
</thead>
<tbody>
<tr>
<td>U3</td>
<td>94</td>
<td>70</td>
<td>Mixed + Displacement</td>
<td>260 + 500</td>
<td>24 underfloor, 3 in ceiling</td>
<td>4 grilles</td>
</tr>
<tr>
<td>U4</td>
<td>156</td>
<td>156</td>
<td>Mixed</td>
<td>1500</td>
<td>3 in ceiling</td>
<td>5 grilles</td>
</tr>
<tr>
<td>U135a</td>
<td>108</td>
<td>65</td>
<td>Displacement</td>
<td>600</td>
<td>50 underfloor</td>
<td>5 grilles</td>
</tr>
</tbody>
</table>
Measurement location in the lecture halls

U3

U4
Measurement location in the lecture halls

U135a
Results – Temperature profiles

- U3

- U4

- U135a
IDA-ICE model of the lecture room with displacement ventilation

Room height – 3 m
Floor area – 86.4 m²
Airflow rate – 0.6 m³/s
Heat loads are adjusted from the measurements
Calibration of 2-capacity model

Indoor air temperature (Te = +18°C)

Indoor air temperature (Te = +19°C)

Indoor air temperature (Te = +20°C)
Modelled and measured exhaust air temperatures during 1 day

- IDA-ICE model
- 2-capacity model
- Measured
Conclusions

• Vertical temperature profiles depended on air distribution system, as did the temporal variations
• Temporal variations of temperature tracked the students coming in and leaving in the beginning and at the end of lectures
• The influence of student presence on the temperature profiles highly depends on indoor air mixing
• MV+DV showed very little stratification of air temperature
• The effect of thermal mass is the highest in the DV cases
• The measurement results can be used to validate the simplified dynamic models of indoor temperature gradient