Numerical Study of the Effect of Air Terminal Layouts on the Performance of Stratum Ventilation System

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Introduction

- **Stratum Ventilation**
  
  Supply terminals are positioned at the side-walls or columns slightly above the height of occupants.
  
  It performs well in providing good indoor air quality; maintaining thermal comfort and saving year-round energy.
Introduction

- Effect of air terminal layouts on traditional ventilation performance

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<th>Mixing ventilation</th>
<th>Displacement ventilation</th>
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<td>Effects of inlet and exhaust locations and emitted gas density on indoor air contaminant concentrations [1].</td>
<td>CFD study on effect of the air supply location on the performance of the displacement ventilation system [3].</td>
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<td>Experimental and numerical study of influence of air ceiling diffusers on room air flow characteristic [2].</td>
<td>Experimental study factors that affect thermal comfort in an upward-displacement air conditioned room [4].</td>
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- Objective:

  Investigate the effect of air terminal layouts on the stratum ventilation
Methodology

- Four Air Terminal Layouts

(a) 

(b) 

(c) 

(d)
# CFD simulation

## Details of the Numerical Method

<table>
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<td>Standard scheme for Pressure; Upwind second order difference for other terms; SIMPLE algorithm</td>
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<td>Floor, ceiling, side walls, tables</td>
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<td>Supply</td>
<td>Velocity inlet, Supply temperature: 20$^\circ$C, Supply airflow rate: 10 ACH</td>
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<td>Radiation heat</td>
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</tr>
<tr>
<td>PD and local mean age of air</td>
<td>User defined function.</td>
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Model Validation

Experimental and simulated results for cases with Layouts a and c

Measured Velocity
• Simulated velocity
△ Measured temperature
▲ Simulated temperature
Evaluation Criteria

- Airflow pattern
- Temperature distribution
- Effective draft temperature (EDTs)
  \[ \theta_{eds} = (t_x - t_c) - (v_x - 1.1) \]
  where, \( \theta_{eds} \) = effective draft temperature for mixing ventilation, K; \( T_x \) = local airstream dry bulb temperature, °C; \( T_c \) = average room dry-bulb temperature, °C; \( v_x \) = local airstream centerline speed, m/s

For stratum ventilation, the thermal comfort condition is **good** if \(-0.6 \, \text{K} < \theta_{eds} < 0.6 \, \text{K} \), and **satisfactory** if \(-1.2 \, \text{K} < \theta_{eds} < 1.2 \, \text{K} \) when the velocity is less than 0.8 m/s.

- Percentage of dissatisfied people due to draft (PD)
  Requirement of class C indoor thermal environment for PD is **25%** according to CR 1752 1998 [5]

- Local mean age of air
Airflow Pattern (m/s)
Temperature Distribution (K)
EDTs (K)

(a) (b) (c) (d)
PD (%)
Mean Age of Air (s)

(a) (b) (c) (d)

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Conclusion

- Exhausts location can affect the airflow pattern and temperature distribution indoor.

- In the case with exhausted located at ceiling level, lower temperature distribution of occupied zone was observed, which leads to relative low EDTs. Occupants have higher risk of draft.

- Compared with other cases, case with exhausts located at the low level of the same wall with supplies performs better. Good air diffusion performance, comfort thermal environment and fresh air of occupied zone could be provided. It also helps to save system installation space. It is therefore a better choice for stratum ventilation.
References


THANK YOU!