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Comparison of the effect of symmetric and asymmetric heat load on indoor air quality and thermal comfort with diffuse ceiling ventilation

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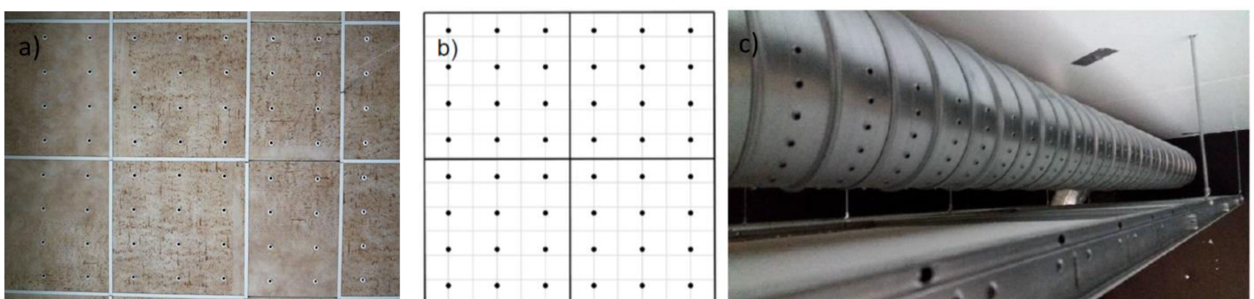
Introduction

- The heat load distribution in the room strongly influences the air flow pattern, so interaction between convection flow and heat load influence indoor air quality
- The heat load distribution influence the mean air temperature, velocity and draught rate

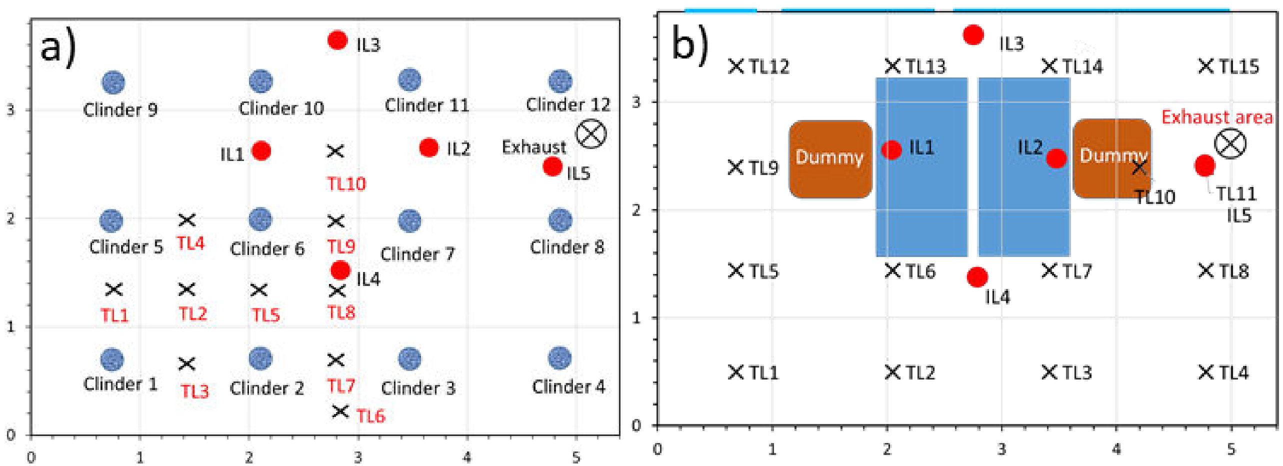
Object:

- Indoor air quality and thermal comfort were studied with symmetric and asymmetric heat load setup under diffuse ceiling ventilation



Method-*Experimental setup*

1. Hot-sphere anemometers:
   - air temperature
   - air velocity
2. Gas-analyzator :
   tracer gas (CO_2)
3. Warm window panels :
   solar heat load



4. Mean age of air ($\langle\overline{\tau}\rangle$) and air change efficiency(ϵ^a)

5. Horizon temperature and velocity difference and Draught rate

Method-*Test cases*

Symmetric setup

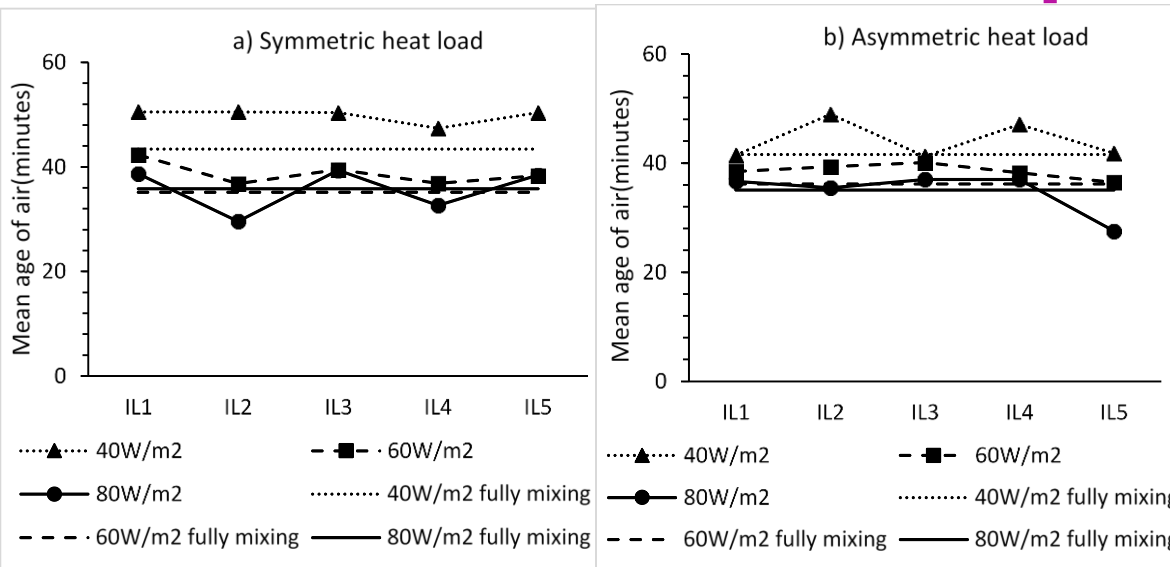
Case	Air flow rate(l/s·m²)	Supply air temperature(°C)	Indoor air temperature (°C)
1	3.7	17	26
2	5.6	17	26
3	7.3	17	26

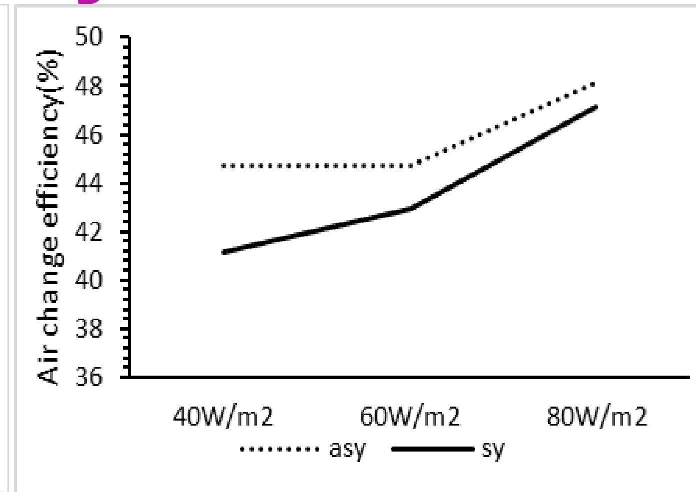
Case	Heat load of dummy (W)	Number of dummy	Total heat load (W)	Total heat flux (W/m²)
1	70	12	840	40
2	105	12	1260	60
3	140	12	1680	80

Asymmetric setup

Case	2 dummies	2 laptops	2 monitors	Light	7 Window plates	Computer at floor	Solar load at floor	Total heat load	Total heat flux
	(W)	(W)	(W)	(W)	(W)	(W)	(W)	(W)	(W/m²)
1	188	75	78	116	693	103	420	1676	80
2	188	75	78	116	381	0	420	1258	60
3	188	75	78	116	381	0	0	838	40

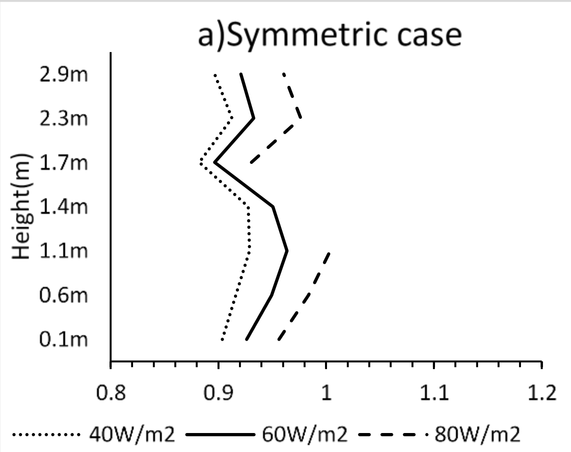
Result-Indoor air quality

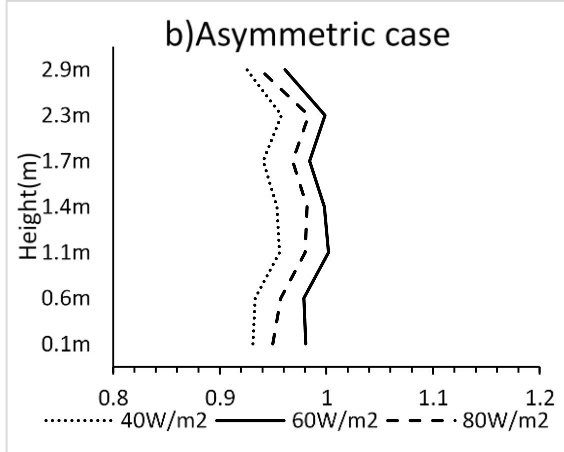


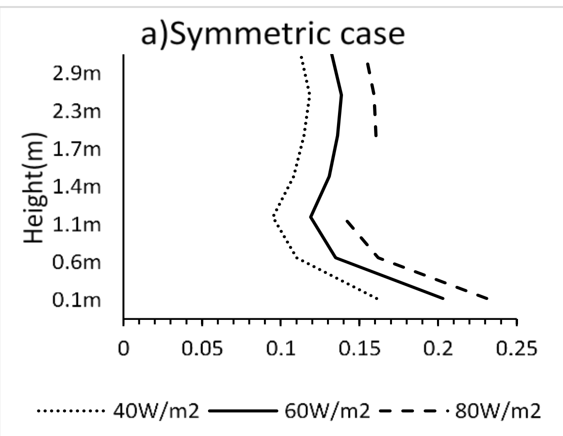


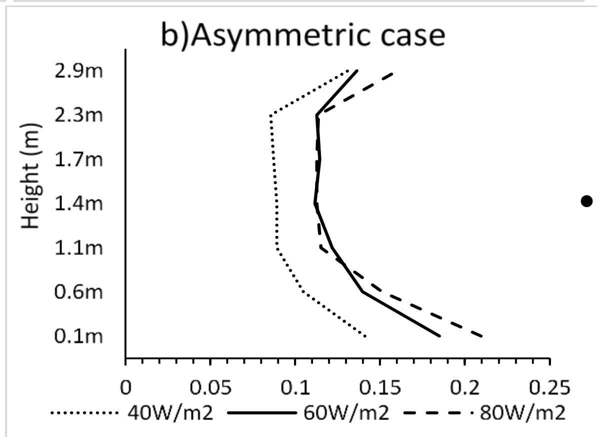
- The highest values for both setup was obtained for the heat load of 40 W/m²
- The difference between the cases of 60 W/m² and 80 W/m² was insignificant
- The difference between symmetric and asymmetric heat load conditions was very small
- Air change efficiency increases only little bit when the heat load increase
- The performance is similar to mixing ventilation

Result-Thermal comfort



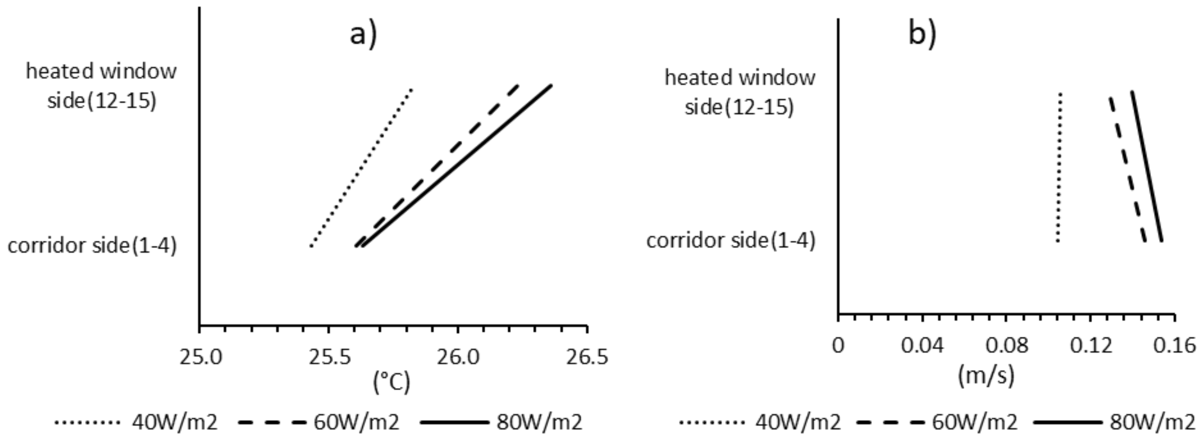






- The mean air temperature and velocity increase with the heat load
- The indoor temperature were quite uniform across the room
- The average indoor air temperature was lower than the exhaust air temperature, and vertical temperature gradients was small
- The mean air velocity was higher on at the floor level but low on at the head level

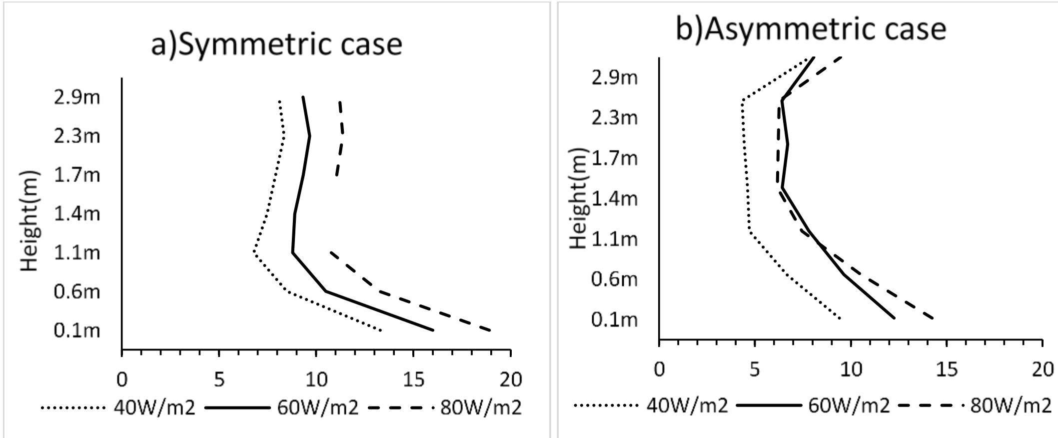
Result-Thermal comfort



a) temperature difference   b) velocity difference

Horizon difference from corridor side to window side with asymmetric setup

Result-Thermal comfort



- The average draught rate increased with heat load in both setups
- The average draught rate was higher in the symmetric setup than in the asymmetric setup
- The values of lower space is higher than upper space for both cases, which corresponds well to the relatively higher velocity found at the lower part of the room.
- The maximum draught rate was 13–18% , the category B was achieved

Discussion

- The equipment heat load and the increasing density of workspaces have provoked a significant rise of the internal heat load in offices, which also results in high ventilation demands

- The heat load distribution in the room strongly influences the air flow pattern.

- The marker smoke visualisation showed that the asymmetric heat load distribution generated a large-scale circulating airflow pattern from the window side to the opposite corridor side

Conclusion

- When the heat load changed from 60W/m² to 80 W/m², the age of air is not improved, indicated a specific threshold value of heat loads where the flow structure changed.

- Diffuse ceiling ventilation performance like mixing ventilation , and the load distribution does not have much effect on air change efficiency.

- The heat load had a limited effect on temperature level, however, the mean air velocity and draught rate increased with heat load.

- The thermal conditions at the investigated heat load of 40–80 W/floor-m2 were not able to fulfill the category A.

Thank you