Department of Building, School of Design and Environment,
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RESEARCH BRIEF

2004/005

Evaluation of the Displacement Ventilation System in the Tropics

SIGNIFICANCE OF THE RESEARCH

The research has resulted in the development of a handbook on design guidelines for displacement ventilation (DV) system in the tropics. The handbook includes a simple definition of DV, its advantages, limitations and applications (Fig. 1). Building owners who want to install the DV system in their buildings for its benefits will find this handbook useful as the basic principle of DV can be easily understood. This is an informative handbook which will come in handy for designers who are assigned the task of designing DV systems in the tropics. The guidelines are presented in an 11-step approach for ease of understanding and application of the design guide. Such a presentation will benefit designers and in particular those who have limited knowledge and experience in designing DV systems.

The research has also led to a few novel research ideas that are pertinent to tropical conditions.

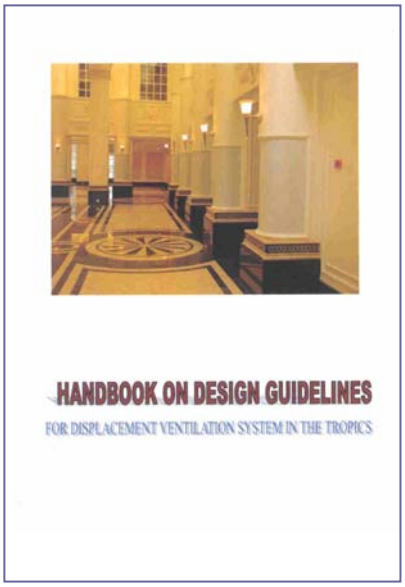

Fig. 1. A handbook was developed from the research.

BACKGROUND

In current practice, most of the air-conditioned and mechanical ventilation (ACMV) systems in Singapore use the mixing ventilation (MV) system where the air is distributed to the entire room via air supply diffusers on the ceiling and exhausted via the return grilles on the ceiling. The MV system aims to maintain indoor environment uniform over space and constant over time. However, in displacement ventilation (DV) system, ventilation air with a lower temperature air than the mean room temperature is supplied at the floor level, while the warm air is extracted at ceiling level. In this arrangement, one obtains two zones in the room, a lower zone with unidirectional flow and an upper re-circulation zone with mixing. This system has several potential advantages, i.e. better air quality and efficient cooling of rooms, over the MV system.

The basic theories on DV system have been developed in the Northern Europe where there is vast climatic difference from the tropics. Hence, results of such research may not be applicable to buildings in the hot and humid climate. The temperature and humidity stratification profiles experienced in the local indoor environment are very different. In addition, the ACMV system in the tropics is designed with substantial re-circulation for the energy-conservation reason. Last but not least, the people in the temperate climate experienced different climatic conditions as compared to the local subjects. The acceptance of the DV system in Singapore can be difficult since most of these systems are not thoroughly demonstrated in the tropics. Hence, the viability of DV system application and its performance in the tropics have to be substantially studied.

MAJOR FINDINGS

The four major findings from this research project are:

1. **Acceptance of the DV system**

   Subjective study shows that there is no significant difference between the DV and MV systems for all the tropically acclimatized subjects' votes for the same given condition.

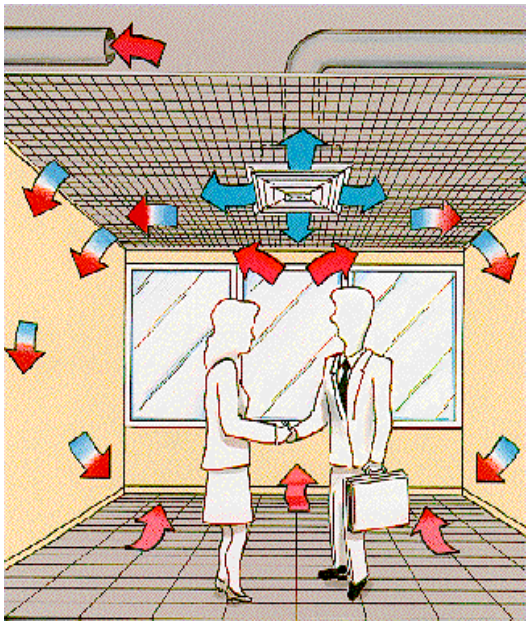

Fig. 2. Mixing Ventilation (MV) system
(Source: Halton Oy Group)

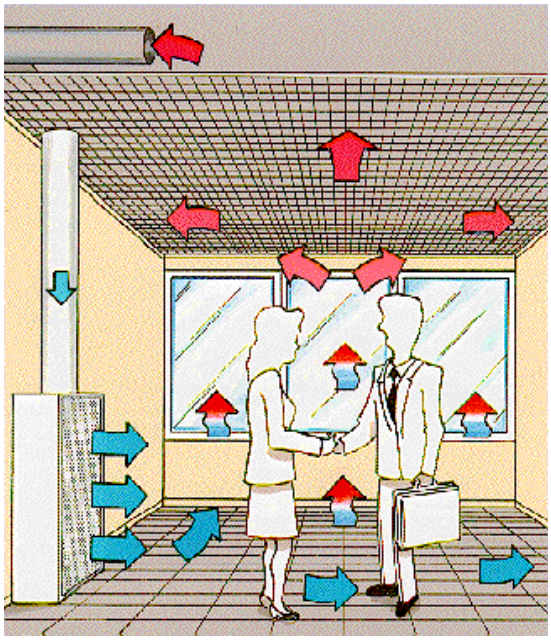

Fig. 3. Displacement Ventilation (DV) system
(Source: Halton Oy Group)

2. Thermal Comfort

The DV system produces cooler thermal sensation than the MV system. Room neutral temperature for DV and MV systems were found to be 23.8°C and 23°C respectively. This shows evidence of energy-saving potential for the DV system in the tropics.

3. Indoor Air Quality

Stratification of carbon dioxide concentration exists in the DV system where concentration increases with height. Better air quality was found in the breathing zone for the DV system even with high air recirculation as compared to the MV system.

4. Energy-Saving Potential

When the conditions for both the systems were the same, i.e. 17.5°C supply air temperature, 62% RH and the same fresh air flow rate, the cooling capacity for DV system was 5% lower than that for the MV system. In addition, due to the temperature gradient, sedentary occupants will receive cooler sensation with the DV system as compared to the MV system. In order to achieve the same thermal sensation as that with MV system, the room air temperature was raised by about 1.0°C. This would lead to the increase in the return air temperature and at last the decrease in the energy consumption by the DV system.

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