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Research Article

Indoor/Outdoor Airflow and Air Quality

Comfort and airflow evaluation in spaces equipped with mixing ventilation and cold radiant floor

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Abstract

In this work the comfort and airflow were evaluated for spaces equipped with mixing ventilation and cold radiant floor. In this study the coupling of an integral multi-nodal human thermal comfort model with a computational fluid dynamics model is developed. The coupling incorporates the predicted mean vote (PMV) index, for the heat exchange between the body and the environment, with the ventilation effectiveness to obtain the air distribution index (ADI) for the occupied spaces with non-uniform environments. The integral multi-nodal human thermal comfort model predicts the external skin and clothing surfaces temperatures and the thermal comfort level, while the computational fluid dynamics model evaluates the airflow around the occupants. The air distribution index, that was developed in the last years for uniform environments, has been extended and implemented for non-uniform thermal environments. The airflow inside a virtual chamber equipped with two occupants seated in a classroom desk, is promoted by a mixing ventilation system with supply air of 28 °C and by a cold radiant floor with a surface temperature of 19 °C. The mechanical mixing ventilation system uses a supply and an exhaust diffusers located above the head level on adjacent walls.

Keywords

air distribution index,
thermal comfort,
air quality,
heat removal efficiency,
contaminants removal efficiency and numerical methods

Article History

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1 Introduction

The air distribution index, ADI (Awbi 2003), is based on the thermal comfort level, the indoor air quality level and the ventilation effectiveness. In the thermal comfort level the predicted percentage of dissatisfied (PPD) people concept is used, in the indoor air quality level the percentage of dissatisfied (PD) people concept is used and the ventilation effectiveness concept is used for the contaminants and heat removal. The air distribution index provides useful information on the ventilation system performance and provides a comparison among different systems, different airflow rates and different airflow characteristics.

In order to evaluate the thermal comfort level the predicted mean vote (PMV), based on a seven- point psychophysical scale, is used. The predicted percentage of dissatisfied which is correlated with the predicted mean vote is that due to Fanger (1970). The acceptable thermal comfort limits can be found in ISO 7730 (2005) or in ANSI/ASHRAE 55 (2010). In accordance with both standards the acceptable thermal comfort levels are verified for PPD lower than 15 % or for PMV between −0.7 and 0.7.

Fanger (1988) proposed an expression for assessing the percentage of dissatisfied associated to the indoor air quality that is based on studies using subjective assessment of the indoor air quality. The expression correlates the percentage of people dissatisfied with the indoor air quality with the ventilation rate in L/s per olf (olf being the bioeffluent emitted by a sedentary occupant). For indoor air quality levels, the recommendations of ANSI/ASHRAE 62.1 (2004) and of the Portuguese standard presented in D.-L. nº 79/2006 are used. In both standards the acceptable limits of carbon dioxide concentration in indoor occupied spaces are 1800 mg/m^3 (1000 ppm).

The coupling of different kinds of numerical models has been developed in recent years. Coupled computational

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