Commissioning of a Coupled Earth Tube and Natural Ventilation System at the Design Phase

Song Pan
Master
Sanko Air Conditioning Co.,LTD.
Nagoya, Japan

Mingjie Zheng
Dr.
Sanko Air Conditioning Co.,LTD.
Nagoya, Japan

Harunori Yoshida
Pro.
Kyoto University
Kyoto, Japan

ABSTRACT

Natural ventilation airflow rate is generally calculated using indoor and outdoor temperature difference without consideration of thermal interaction between the ventilated air and the room in simple analytical method based on pressure balance. However, room air temperature is influenced by natural ventilation airflow rate, and airflow rate is influenced by room air temperature, so it is necessary to perform a coupled analysis taking into account both thermal interaction and ventilation to obtain the correct result. Moreover, when there is marked temperature stratification, as found in large enclosures, or when ventilation airflow rate is small, significant computation error will occur if the set value of room air temperature differs greatly from the actual value.

To solve the problems mentioned above, the authors developed a natural ventilation tool that takes into account indoor vertical temperature distribution and proposed a coupled simulation method using this tool in conjunction with CFD (Computational Fluid Dynamics) to simultaneously calculate indoor air flow/temperature distribution and natural ventilation airflow rate. In this paper, at the design phase of an actual coupled earth tube and natural ventilation system in a gymnasium, natural ventilation airflow rate for four outdoor air conditions have been calculated to perform commissioning and several findings were obtained.

KEYWORDS

Earth tube, Natural ventilation, Coupled analytical tool with natural ventilation and CFD

INTRODUCTION

Natural ventilation not only saves energy, but is also a psychologically and physiologically comfortable method of ventilation. Introduction of outdoor air into rooms passing earth tubes can result in a decreased outdoor air heat load, as outdoor air is preheated through heat exchange with soil. Recently, use of natural ventilation systems with earth tubes as a means of introducing outdoor air is generating a lot of attention in Japan.

For natural ventilation analysis in buildings, the simple analytical method, which is static based on pressure balance without consideration of thermal interaction between the ventilated air and the room, was proposed almost 40 years ago (Ishihara,1969). Several pieces of software have been developed for use in building ventilation analysis based on the airflow network method expanded from the simple analytical method in the Case of multi-zone,. Commonly used software includes COMIS (developed by Annex 23 of IEA (Haas, 2002)) and VENTSIM (developed by Building Research Institute (Utumi, 2005)). By using these ventilation analysis tools, natural ventilation airflow rate can be calculated according to the temperature difference between fixed room air points and the outdoor air, or between adjoining rooms, taking each room as one node; however, the thermal interaction calculation can not be performed.

Room air temperature is influenced by natural ventilation airflow rate, and airflow rate is influenced by room air temperature, so it is necessary to perform a coupled analysis taking into account heat and airflow balances to get the correct calculation result. Therefore, coupled analysis of COMIS with TRNSYS (Hensen, 1995) and EnergyPlus (Huang, 1999), were developed respectively. Moreover, an airflow analysis model based on airflow network method is included in DeST (Jiang, 2005), which is an energy simulation program of building.

NETS (developed by Okuyama, 1998) is ventilation analysis software based on the airflow network theory. When the indoor air temperature distribution and airflow distribution are known roughly, air temperature of division sub-zones and airflow between adjoining division sub-zones can be calculated simultaneously by using NETS depended on the appropriate division sub-zones of indoor and outdoor space. Unlike using CFD, which is based on heat, movement, and continuity equation of fluid, ventilation calculations carried out using NETS are essentially calculations of total pressure. Thus, NETS is not appropriate for use in the prediction of indoor airflow and temperature distribution.

As a result, the ventilation calculation tool mentioned above cannot reproduce the driving force of the buoyancy ventilation which originates from indoor temperature stratification because each room or sub-zone is handled as one node. Therefore, a ventilation analysis tool that considers the indoor