BUILD SIMUL (2013) 6: 173 – 182
DOI 10.1007/s12273-013-0101-3

Research Article

A network-based smoke control program with consideration of energy transfer in ultra-high-rise buildings, CAU_ESCAP

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Abstract

Ultra-high-rise buildings allow for the efficient use of land, but they are vulnerable to disasters such as fires. Therefore, the development of network models for analyzing the characteristics of smoke movement in ultra-high-rise buildings is necessary for cost-effective design of smoke control systems and operation decisions. A new network-based smoke control program, CAU_ESCAP, is developed in this study, which is a program that can consider the energy transfer. CAU_ESCAP is validated with existing programs, ASCOS and CO SMO, by analyzing the smoke movement. After that, fire in an ultra- high-rise building of 55 stories is applied with CAU_ESCAP for analyzing the smoke movement and the mass flow rate of the smoke control system due to the variation of heat release rate and door conditions of the fire floor. The pressure difference between the fire room and the protecting area does not vary in the closed-door case in the fire room, but vary significantly in the opened-door case. Therefore, the smoke from fire would be spread to other spaces if there is no instantaneous increase in the mass flow rate of pressurization when the door is opened by occupants for evacuation.

Keywords

ultra-high-rise building,
smoke control system,
network-based program,
energy transfer,
CAU_ESCAP

Article History

Received: 14 March 2012
Revised: 26 November 2012
Accepted: 27 November 2012

Indoor/Outdoor Airflow and Air Quality

1 Introduction

Recently, increases in population density due to metropolis-based industrialization have led to high density and the integration of living environments. The construction of various ultra-high-rise buildings has been increasing to accommodate the growing number of people in cosmopolitan cities, as well as to make effective use of land (Ministry of Land 2009). The ultra-high-rise buildings allow for efficient use of the land, but they are vulnerable to disasters such as fires. Particularly, should the exterior of an ultra-high-rise building be broken in a fire situation, the broken area would become a supply route of oxygen, and the stack effect in shafts then becomes stronger because of the characteristics of the sealed exterior. Also, the velocity of the smoke spread would increase through vertical shafts such as elevators and stairwells, and this phenomenon would cause heavy casualties (Park 2009).

Representative examples of fires in high-rise buildings include the MGM Grand Hotel fire, First Interstate Bank of California fire, One Meridian Plaza fire, Cook County Administration fire, and the Parue Central Building fire. These fires resulted in high casualties because the smoke had spread rapidly throughout the entire building via vertical shafts such as elevators, stairways, and the HVAC (heating, ventilation, and air conditioning) systems (Yu et al. 2007). Recently, a huge fire occurred in the Woo Sin Golden Suite, which is an apartment building in Busan, R.O. Korea. The fire propagated through the inflammable outer wall, but the smoke from the fire spread throughout the building via the ducts of the HVAC system, and poisonous gas obstructed efficient evacuation (Choi 2010). It is clear from these cases that effective smoke control system designs are needed for reducing the number of casualties resulting from poisonous gas in ultra-high-rise building fires.

The smoke movement in building fire situations is sensitively influenced by the structure, environmental conditions, pressurizing methods, and the fire conditions. As such, the design of smoke control systems for controlling

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