fire

Editorial

Active Firefighting Systems Against Flashover Fires in Big Halls

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1. Introduction

The number of big fires in buildings appears to be increasing [1]. People are occupying compartments in buildings in dense urban areas and enclosed spaces such as train cars. As the number of fires—including arson and terrorist attack fires—appears to be increasing in recent decades, compartment fire safety must be carefully considered. Fundamental scientific research on flashovers for different room fires will lead to the development of more appropriate firefighting strategies. The room fire scenarios that lead to more extensive fires and their associated changes in compartment fire characteristics, including the fuel mass loss rate and flame characteristics of the operating system, are exciting topics for further study.

This Special Issue was proposed with an aim of achieving a better scientific understanding of room fires under different ventilation conditions. Different aspects of fire science in the area of compartment fire research, such as burning regimes, flame patterns, flashover, etc., can be updated to match new styles of living and travel. The latest developments in compartment fire and safety, in addition to the possible fire protection implications for associated regulations and standards, are presented.

In this Special Issue on compartment fire and safety, a number of important topics were covered by contributions from colleagues in different countries, including Australia, Cameroon, Mainland China, Hong Kong, Taiwan, France, Korea, and Russia. The topics investigated include the burning of building materials, fire suppression systems, and fire risks in different types of enclosures, including green buildings, high-rise buildings, pressurized buildings, long-term care institutions, and railway tunnels. Parameters of interest span topics such as heat release rates, smoke toxicity, evacuation times, and ventilation velocity.

These research results were obtained using various methods, including experimental, modeling, and simulation, which all add knowledge to the field of compartment fire studies. Topics included the burning characteristics of PE foam blocks used as interior building materials and the effect of coating on retarding fire ignition. The fire hazards of vertical greenery systems were also studied, with the conclusion that in certain conditions, the fire spread could be more rapid compared with external thermal insulation composite systems and double-skin façades. In contrast, the importance of the effect of ventilation was investigated using numerical method. Studies on smoke hazard, a very important factor in compartment fire safety, were reported. Fire detection and suppression were investigated. Compartment fire hazards in specific buildings such as high-rise residential buildings, high-altitude hermetic pressurization buildings, and long-term care institutes were reported.

The results will be applied in drafting fire safety management guidelines for existing buildings with high occupancies. In the long term, fire codes could be drafted for the next generation of buildings. More importantly, fire safety provisions, including fire safety

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management strategies from compartment fire research, atria, tunnels, tall buildings, underground spaces, mini storage units, transport vehicles, airplanes, ships, and submarines, will be affected.

2. Tall Buildings

New challenges arise from storing too many combustibles in rooms of taller buildings, where both the fire load density and occupant loading are high. New materials, such as fire retardants, flammable clean refrigerants, and environmentally friendly fire suppressants have been developed to satisfy older fire tests. New scenarios for big fires and explosions due to electric batteries and power supplies are not yet included in codes that were developed years ago. New lifestyles with more plastic furniture and glass partition areas lead to more fire and smoke hazards [2]. Protection against flashover fires must be carefully considered. Traditional water suppression systems, particularly automatic sprinkler systems [3], are required by fire authorities to reduce the possibility of uncontrolled fires. However, they are installed to meet earlier fire codes, which might not be able to face these new challenges. Sprinklers will discharge water upon activation to cool the burning objects, prewet walls and floors, cool the smoke layer to reduce the chance of flashover, and displace oxygen away from the burning objects. It is necessary to study how to improve their performance with respect to two key performance parameters in sprinklers: thermal activation and adequate water delivery—not too much, nor too little—particularly for tall and big halls.

This Editorial discusses active systems fighting against big flashover fires. Three systems are presented to address the two important problems of thermal activation and water delivery in active water systems in tall halls [3]. These include long-throw sprinklers [4], water guns [5], and positive pressure ventilation (PPV) blowers [6] to handle hazardous environments.

3. Water Gun Systems

Water guns with an infra-red detection and flame sensor system were used in big halls [5]. An appropriate design can dispense adequate, but not excessive, water. However, in many places, including Hong Kong, water gun systems have not been regarded as approved fire protection systems for protecting tall spaces that do not function as storage areas for years. The situation is starting to change because of the availability of new software and hardware. Whether the water gun system can control a fire [7] must be demonstrated experimentally.

The system is allowed in many places, including Mainland China and Taiwan, and many new water gun products are being developed [8]. Fire authorities are starting to consider using such systems with electronic equipment in several areas.

4. Long-Throw Sprinklers

Sidewall long-throw sprinklers at height are allowed [9] for tall halls that are not used as warehouses. Field tests demonstrated an acceptable water distribution density by adjusting the discharge water jet's angle [9]. A small wood crib of 20 kg ignited by a 0.6 m diameter pool fire with 1 liter gasoline was tested [9] in a hall. Water was discharged at 273 s, with the fire extinguished at 460 s. The system worked as expected to suppress small fires. However, the complicated air flow pattern due to sprinklers discharging water with fire-induced movement during a big fire is a concern.

Experiments with bigger fires are required to evaluate the performance of long-throw sprinklers at height. Such sprinklers can provide the required water distribution density in the protected coverage areas to acceptable standards.

5. Water Turbine-Driven Positive Pressure Ventilation (PPV) Blower

Installing active fire suppression systems can prevent or delay flashover fires. The fire can also be controlled. However, a huge volume of smoke will be liberated, because the intermediate reactions are stopped. Smoke and toxic gases must be driven out. Operating positive pressure ventilation (PPV) [6,10,11] is necessary. Water turbine-driven PPV blowers with water suppression or water shielding could serve this purpose and are commonly used by firefighters.

6. Computational Fluid Dynamics

Computational Fluid Dynamics (CFD) has been used [12–17] in fire hazard assessments in performance-based design (PBD) or the Fire Engineering Approach (FEA) [13,17,18]. A workshop focusing on this was held in 2017 [19]. Discrepancies between experimental data and computational results might be attributed to modeling errors. Poor CFD studies might lead to inadequate protection.

There are general concerns on applying CFD to simulate combustion, even for small fires in big rooms [14,17]. Even burning Poly(methyl methacrylate) (PMMA) with simple kinetics of thermal decomposition [20], there are three stages in the combustion process. Thermal radiative feedback from the ceiling was a significant factor in determining the fuel gasification rate [21]. 'Bridge-mixing' of igniting fuel vapors gasified from different combustibles by means of thermal radiation during flashover was observed [22]. The 'bridge-mixing' concept was verified by preliminary simultaneous cone calorimetry.

However, there are many disagreements, and studies are needed to complement the preliminary findings [13,17,18]. Fire safety provisions have to be upgraded, if necessary, as in the above-described cases. Fire safety management must at the very least be reviewed [23].

7. Conclusions

Fire safety in tall or big halls always presents challenges to management and firefighters. There are different types of active firefighting systems, each with its merits and limitations. A proper selection of the system requires professional knowledge and experience, as well as the support of stakeholders. The successful integration of the system into the building structure can only be achieved via collaboration of parties from different professions. It is worth mentioning the employment of CFD in assisting with the design of a system, at least in the preliminary stage, as it saves a lot of time and money, although CFD results have to be carefully applied.

Safety aspects should be watched more carefully by responsible actors and top management of organizations. Fire safety must be provided according to regulations. However, the penalty on non-compliance with safety was previously very low in many places (several thousand US dollars, even with casualty). This type of safety culture has changed recently, with more stringent punishments. The demand for recruiting more safety experts with practical experience is expected to be higher. This might create a bigger market for fire safety personnel.

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