

Atrium Engineering Research in Building Services Engineering

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Abstract

Atrium Engineering research is active in dense urban areas of the Asia-Oceania regions. Research in Building Services Engineering related to fire and ventilation in atrium conducted by our group in the past 30 years is outlined in this paper. In particular, a joint research project on atrium fire between The Hong Kong Polytechnic University and University of Science and Technology of China was started since 1994. The PolyU/USTC Atrium of 30 m tall was constructed in 1997 to celebrate the smooth reunification of Hong Kong to Mainland as a Special Administrative Region. Key points on full-scale burning tests to address are on smoke filling process in atrium buildings, static smoke exhaust, dynamic smoke extraction systems, performance of atrium sprinklers installed at high ceiling, and fire detection systems in large space. Research activities in ventilation and air-conditioning are also discussed.

1. Introduction

The Atrium, some called “the third-generation structure” in fire safety provision (the first generation was tall building, second generation was shopping malls [1,2]) has become a design feature in big construction projects in dense urban areas in the Asia-Oceania (AO) regions, starting from 1980s in the Hong Kong Special Administrative Region (HKSAR). Many tall atria were constructed in hotels, upmarket commercial centres and the newest shopping plazas. Buildings with atrium are aesthetically appealing, with mentally and visually satisfying additional use of natural and artificial light, plants and water features. However, the fire safety inside is a concern and building services engineering is a challenge. Smoke has been identified to be a major hazardous and so smoke control is necessary.

Joint research on atrium fire [3] was started between The Hong Kong Polytechnic University and University of Science and Technology of China since 1994. An atrium of 30 m tall was constructed for full-scale burning tests. Key points to address are on smoke filling process in atrium buildings, static smoke exhaust, dynamic smoke extraction systems, performance of

atrium sprinklers installed at high ceiling, and fire detection systems in large space. Results were used to work out fire regulations for atria, such as designing atrium hot smoke tests. Atrium fires research and associated studies in fire safety provisions in this long-term project are reported in this article.

2. Atrium Fire

There are technical problems [1] inherent in incorporating fire safety measures into atrium. The risk of fire-spread and smoke movement to the planning of escape routes for occupants should be watched.

The escape process is either part or all of the sequence: fire origin to other compartments and thence to protected stair and finally outside. Occupants tend to use familiar routes for escape. This means using escalators or elevators, which could be disastrous due to a number of factors. It is thus essential to intercept any movement toward elevators by locating the stairs along familiar routes and signing them clearly. There should also be plans indicating escape routes displayed in as many locations as possible. Where escape is via screened internal or external galleries or balconies from which smoke is to be excluded, care must be taken to protect escapees from thermal radiation. Such protection may be given by incorporating an opaque spandrel panel to ceiling height, to allow people to crawl to safety. Alternatively, intumescent laminated glazing can be used, but is very expensive to install. Knowledge of smoke movement in an atrium is as valuable as awareness of the fire hazard.

3. PolyU/USTC Atrium

Although it is well known that an atrium fire is very different from a typical building fire in 1990s, very little research work has been carried out before 1994 regarding atrium fires when compared with other areas of interest, such as cone calorimeter studies or flame spread. Experimental full-scale burning facilities are therefore needed for studying atrium fires and evaluating the performance of the fire protection systems.

The overall size of the PolyU/USTC Atrium [3] is 30.6 m (length) $\times$ 18.4 m (width) $\times$ 30.6 m (height).

Many research projects were carried out and numerous PhD students graduated [4-84].

4. Indoor Aerodynamics

Computational Fluid Dynamics (CFD) [85] can be applied to study the indoor aerodynamics.

Reynolds Averaging Navier-Stokes (RANS) equations were used 30 years ago, Large Eddy Simulation (LES) more. The equations are discretized using finite difference method and pressure-linked equations. The predicted results are particularly useful for comparing the performance of the mechanical system in those big spaces.

5. Aerodynamics of Smoke Management System

Field tests on the smoke control systems in atrium buildings were reported before [86]. There are many studies on indoor aerodynamics and smoke movement in atrium [87-184]. Smoke management systems were assessed by measuring the airflow characteristics and the pressure on operating the fans. The measured results were used together with an empirical formula. Discussion on the limitation of the design and suggestions for improvement are presented. Hot smoke tests are required.

6. Conclusion

Atriums in buildings are now very popular in the AO areas. Many have been built in the HKSAR since 1980, and then in Mainland. With the rapid economic development in China, many atria can be found in many large-scale development projects including shopping malls, luxury hotels, and prestigious office buildings. There are many technical problems associated with the building services systems, particularly the fire protection systems because an atrium fire is very different from a fire in a traditional building.

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