Hot Issues in Fire Engineering

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Necessity of Studying Supertall Building Fires ?

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Supertall Buildings

In 2011, tall buildings over 300 m high are classified as supertall buildings by the Council on Tall Buildings and Urban Habitat (CTBUH) in USA [1]. Different reference heights [2] are adopted in defining supertall buildings in different countries. In Japan, buildings over 60 m are classified as supertall. Buildings over 150 m fall into the category of supertall buildings in Ireland. Meanwhile, Hong Kong defines buildings having more than 40 levels as supertall and China categorizes buildings over 100 m and having more than 24 storeys as supertall. Many tall buildings have been constructed in big cities such as Hong Kong, Singapore, Shanghai, Kuala Lumpur and Seoul. The tallest building in the world at the moment is over 800 m high, and it is located in Dubai, United Arab Emirates. As estimated by CTBUH in January 2012 [3], over 20 supertall buildings will be constructed by 2020. In fact, there are two supertall buildings which are over 400 m [4] tall in Hong Kong. Several residential buildings are already 256 m tall with 75 levels. Developers have started to construct supertall residential buildings in other second-tier cities in Mainland China, such as Suzhou and Jiangsu.

Potential Fire Problems

Fire hazards in supertall buildings have been reviewed [2,5]. Some problems are identified in evacuation patterns, means of escape, means of access, fire-resisting construction, upgrading active fire protection systems, use of elevators for evacuation and the onset of big fires due to ambient wind. Very few comprehensive studies have been conducted on the fire dynamics of room fires in supertall buildings. Long-term building fire research in Hong Kong done by the author [5-8] indicates that large amounts of combustibles are stored in tall buildings in cities of high density. Some supertall residential buildings have many openings, such as open windows and balconies. If a fire occurs, the outcome will be disastrous. Upon ignition of combustibles, high ambient wind speed through openings at the upper levels of supertall buildings will supply sufficient air to burn up all stored combustibles. The burning process will be very vigorous under high radiative heat fluxes in a post-flashover fire. The heat release rate will then be very high [8]. Fire safety provisions, particularly for residential buildings, might not work. Consequently, firemen have to go into the site and are exposed to great danger.

Fire Safety Provisions

Most of the fire safety provisions for existing tall buildings [9-13] are only designed to protect buildings against accidental fires when the buildings are not yet in use. It has not been demonstrated whether such fire safety provisions are adequate for supertall buildings. Even so, there are difficulties for some supertall building projects in complying with the current prescriptive fire safety codes. Consequently, performance-based design (PBD) [14,15] has been adopted. However, firefighting and rescue strategies were not thoroughly devised in most PBD design projects, including supertall buildings [16]. The existing firefighting and rescue strategies were designed based on the presumption of fire safety provisions which are for buildings of normal height (say up to 40 levels in Hong Kong). The established requirements are set without support of in-depth scientific research. Consequently, firefighting and rescue strategies in these supertall buildings should be investigated properly.

Current Research on Supertall Building Fires

Very little work has been done in supertall building fire research, and they are limited to elevator evacuation and human behaviour in evacuation. For example, feasibility studies have been conducted on the use of elevators for emergency evacuation in Japan [17]. This issue was also investigated [18] in Taiwan for Taipei 101, the second tallest supertall building in the world. Human behaviour during evacuation of tall buildings by elevators was also discussed by Proulx [19] and some colleagues at the Department of Civil and Architectural Engineering at the City University of Hong Kong. Evacuation in supertall buildings, the necessity of providing refuge floors in tall buildings and aerodynamics induced by wind on refuge floors were studied [e.g. 20]. However, wind effects on supertall building fires, the topic proposed in this project, have not yet been studied.

Many consultancy studies in which PBD was applied have been undertaken to determine fire safety provisions during the construction of supertall buildings [21]. However, such studies only take reference from the fire codes without in-depth studies. The main purpose was to convince the authorities that the fire safety provisions adhere to the specified codes. As research work focusing on supertall building fires is limited, authorities have difficulties in evaluating the PBD adopted by the consultants. It is important to carry out basic fire research [8,22] on supertall buildings and the effects on adjacent buildings, so it is proposed to study these topics in this project. Also, very few PBD reports discussed firefighting and rescue strategies.

Research at PolyU-BSE

PolyU-BSE has been doing building fire research for almost 30 years under the leadership of the author. The department's research focuses on fire models, fire suppression systems and others issues such as performance-based fire safety designs, atrium smoke movement and control and tunnel fires. For supertall building fires [5-8], a research on the upgrading of active fire protection systems was jointly conducted with the University of Science and Technology of China, funded by the Croucher Foundation from 2007 to 2009. Completed research work only focused [6] on the early detection of fires, quick suppression by water mist and dry powder and smoke removal. A PhD research project studied stack effects on smoke exhaust using a scale model in Chengdu, Sichuan; the degree was conferred in 2008.

There is also a General Research Fund (GRF) project financed by the Research Grants Council of Hong Kong on the fire aspects of elevators in supertall buildings [7]. The ways to design fire safe elevator systems in supertall buildings have been investigated. The three key areas of fire spread into the lift shaft, protection of the adjacent lobbies and prevention of water damage due to discharging sprinklers have been studied. A PhD project on fire safe lift shaft and lobby structure in supertall buildings for evacuation is registered at PolyU. Another PhD project, which centers on the stack effect in supertall buildings, is just successfully completed in collaboration with Harbin Engineering University, Heilongjiang, China. This project is also supervised by the author. One GRF project [23] on "Wind action on supertall building fires and spread to adjacent areas" just received funding recently.

In-depth Studies Desired

For supertall residential buildings which are installed with windows and balconies with glass doors, high wind speeds will be induced through room openings at upper levels, and sufficient air will be supplied to burn up all combustibles in the flats. Consequently, a big post-flashover room fire will occur. Room fire dynamics in supertall buildings, which are triggered upon burning combustibles at high air intake rates under high radiative heat flux, must be studied properly to ensure fire safety. Such studies will be useful in the setting up of prescriptive fire safety codes for supertall buildings [24,25] and the implementation of PBD.

The number of fires [5] which are prompted by accidents, arson, terrorist attacks or natural disasters has been increasing in recent years. Fire safety in such supertall buildings is a concern that has not yet been studied carefully. No prescriptive fire codes have specifically been developed for supertall buildings yet. At present, fire safety designs just follow those specifications applied to normal tall buildings. It is not clear whether firefighting and rescue strategies are worked out in those fire safety designs.

The first responder issues are pointed out in the draft SFPE guidelines, which are released for public consultation, for designing fire safety provisions in tall buildings [24,25]. Again, it has not been demonstrated that the proposals were worked out with in-depth research.

It is good that there is support in fundamental research related to supertall building fires [7,23]. Appropriate firefighting and rescue strategies for supertall building fires should be studied by all PBD/FEA approaches. Current practice for existing tall buildings must be reviewed first. Special fire phenomena for supertall buildings, such as wind effects, flashover criteria, heat release rates of burning compartments and materials should be considered in fire hazard assessment.

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