

CAS-Croucher Funding Scheme for Joint Laboratories

Joint Research Center for Large Space Building Fire Safety and Technology

1. Project Title: Active Fire Protection in Supertall Buildings

2. Project Team

Team leader: Professor W.K. Chow

Members: Dr. N.K. Fong, Dr. Gigi C.H. Lui

Research Centre for Fire Engineering, Department of Building Services Engineering, Area of Strength: Fire Safety Engineering, The Hong Kong Polytechnic University, Hong Kong, China

Team leader: Professor W.C. Fan

Members: Professor G.X. Liao, Professor R. Huo, Professor Y. Hu, Dr. B. Yao, Dr. Y. Jiang

State Key Laboratory of Fire Science, University of Science and Technology of China, Hefei, Anhui, China

3. Duration of Project: 1 July 2006 to 31 December 2009

4. Objectives

- To study fire and smoke spread in supertall buildings with wind action.
- To study smoke control systems for supertall buildings.
- To study how the fire can be suppressed by new active protection techniques.
- To study how water mist system can reduce the possible heat release rate.

5. Summary of Research

5.1 Field survey on geometrical aspect ratios of supertall buildings

A survey on 54 supertall buildings was carried out with aspect ratios calculated. Observed aspect ratios of the tall buildings and fire safety provisions were studied. Both passive and active systems specified in the codes for normal tall buildings were compared. The total fire safety concept of implementing software fire safety management to control hardware provisions in passive building construction and active fire protection system was recommended for existing supertall buildings in dense urban areas. Consequently, a fire safety management scheme should be worked out with clear understanding on the fire dynamics in supertall buildings.

5.2 Smoke movement in the stairwell of a tall building

Experiments on the effects of stack effect on smoke movement were carried out in a 1/3 small-scale stairwell model first. Smoke movement in a full-scale six-storey stairwell induced by a fire in an adjacent compartment was then studied experimentally. The smoke flow pattern in the stairwell was observed with vertical temperature and velocity field distribution measured.

5.3 Wind tunnel tests on compartment fires with crossflow ventilation

Wind effect on compartment fire with cross ventilation was studied experimentally in a wind tunnel. Results indicated that the ambient wind would enhance the fire severity to give higher compartment fire temperature and shorter time to flashover. Further, smoke and heat spread of ventilation-controlled fire in a two-vent compartment were studied with wind blowing to the vent at higher altitude. The direction of smoke movement would be dominated by wind rather than by buoyancy.

5.4 Fire detection system for supertall buildings

As supertall buildings would have higher fire risk, fire detection system should be provided. However, fire detection systems are only required for plant rooms for residential buildings in Hong Kong. On the other hand, high false alarm rate of over 70% is reported. The detector response times are delayed with floor fan in operation. Point type detectors response would be delayed due to high air flow induced by strong wind or stack effect in supertall buildings. Video image processing or flame type detection systems are not affected by air speed in the premises and might be more reliable. Associated studies were carried out as a PhD project at PolyU designing appropriate detection system in supertall buildings.

5.5 Water curtain system

Drencher system or water curtain system is required to provide in some parts of a tall building in Hong Kong. To meet these requirements and based on the local building codes, the total opening areas for protection or areas of separation have to be considered. The water curtain system requires a very large amount of water supply for an effective operation of the system. Even though the system is provided according to the codes, the question is how effective it will perform. Investigational works using water curtain in supertall buildings in Hong Kong were studied in a PhD project at PolyU.

5.6 Fire suppression system

Fire suppression of water mist systems and a new dry powder product was studied. The product is denoted as "K-powder" consisted of superfine potassium bicarbonate and some organic and inorganic additives. Performance of the new potassium-based powder in fire suppression was studied by laboratory-scale experiments, which exhibited much superior fire suppression efficacy than that of the commercial bicarbonate powder.

6. Research Students Trained

6.1 Part-time PhD students (minimum 6 years of study) registered at PolyU.

- K.W. Lau (Registered on 1 September 2006, confirmed on 19 June 2009)
- Edgar C.L. Pang (Registered on 30 April 2007, confirmed on 19 June 2009)

6.2 Mainland PhD Graduates at USTC

- Dr. Zhu Jie (Conferred in June 2008)
- Dr. You Fei (Conferred in December 2008)
- Dr. Sun Xiaoqian (Conferred in June 2009)

7. Publications

Y.H. You, W.K. Chow, Y.Z. Li, R. Huo, G.X. Liao, N.K. Fong & Gigi C.H. Lui, "Survey on geometrical aspect ratios of supertall buildings", *Journal of Applied Fire Science*, Vol. 14, No. 4, p. 327-338 (2005-2006).

W.K. Chow, "Fire safety provisions for supertall buildings", *International Journal on Architectural Science*, Vol. 7, No. 2, p.57-60 (2006).

Kuang Kaiqian, W.K. Chow, Xiaomin Ni, Donglei Yang, Wenru Zeng and Guangxuan Liao, "Fire Suppressing Performance of Superfine Potassium Bicarbonate Powder", *Fire and Materials*, Vol. 35, No. 6, p. 353-366 (2011).

H.X. Chen, N.A. Liu and W.K. Chow "Wind tunnel tests on compartment fires with crossflow ventilation" *Journal of Wind Engineering & Industrial Aerodynamics*, Vol. 99, No. 10, pp. 1025-1035 (2011).

X.Q. Sun, Y.Z. Li, L.H. Hu, R. Huo, W.K. Chow, N.K. Fong and Gigi C.H. Lui, "Studies on smoke movement in stairwell induced by an adjacent compartment fire", *Applied Thermal Engineering*, Vol. 29, No. 13, p. 2757-2765 (2009).

Haixiang Chen, Naian Liu and Wanki Chow "Wind effects on smoke motion and temperature of ventilation-controlled fire in a two-vent compartment", *Building and Environment*, Vol. 44, No. 12, p. 2521-2526 (2009).

Xiaomin Ni, W.K. Chow & Guangxuan Liao, "Discussions on applying dry powders to suppress tall building fires", *Journal of Applied Fire Science*, Vol. 18, No. 2, p. 155-191 (2008-2009).

X.S. Wang, W.K. Chow & M. Wu, "A review on determining water spray droplet characteristics by laser techniques", *Journal of Applied Fire Science*, Vol. 18, No. 3, p. 211-239 (2008-2009).

8. Technology Transfer

Research results were presented in invited talks in China (2007), Hong Kong (2007), Seoul, Korea (2007) and Taipei, Taiwan (2008).

Professor Chow is now advising the Fire Services Department in Hong Kong on drafting fire code for supertall buildings of height over 300 m.

Professor Chow and Dr Fong advised government Buildings Department to approve performance-based design, including projects on supertall buildings.

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- Smoke movement in the stairwell of a tall building
- Wind tunnel tests on compartment fires with crossflow ventilation
- Fire detection system for supertall buildings
- Water curtain system
- Fire suppression system

5. Part-time PhD Students at PolyU

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7. Selected Publications

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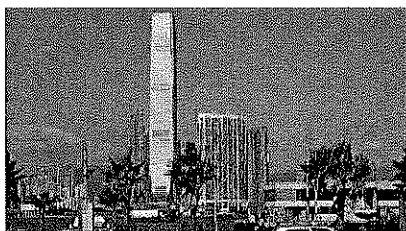
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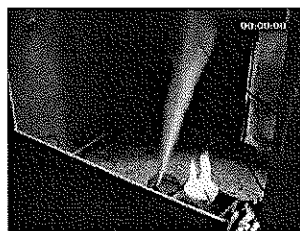
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8. Technology Transfer by PolyU

- Research results were presented in invited talks to architects, engineers and officers in Anhui, Hefei, China (2007), Hong Kong (2007), Seoul, Korea (2007) and Taipei, Taiwan (2008).
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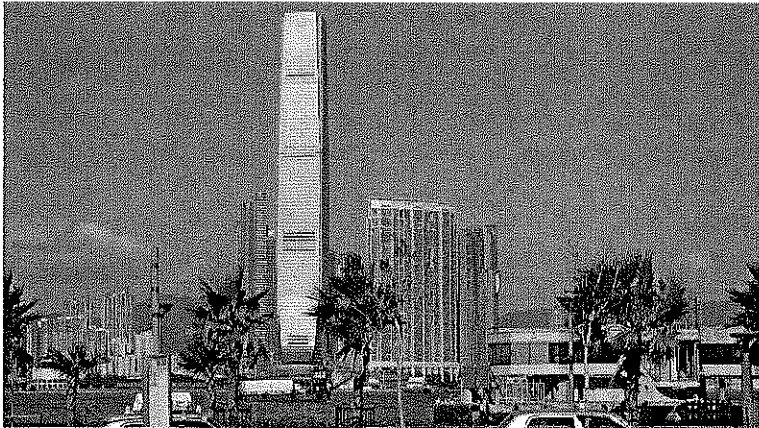


New fire suppressing agent



With PhD student X.Q. Sun at
staircase model

Three photos on project “Active Fire Protection in Supertall Buildings” (2006-2009)



Supertall building- International Commerce Centre, Hong Kong



New fire suppressing agent



With PhD student X.Q. Sun at staircase model