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Special Issue on Facade Flammability and Fire Engineering

*Xinyan Huang**, *Department of Building Environment and Energy Engineering, The Hong Kong Polytechnic University, Hong Kong, China*
Yi Wang, Research Division, FM Global, Norwood, MA 02062, USA
Eric Guillaume, Efectis France, Espace Technologique, Route de l'Orme des Merisiers, Saint-Aubin, France

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The building facade is one of the most important aspects of an architectural design, taking up around 15%–25% of the total construction cost. From the engineering perspective, a facade performs multiple objectives, e.g. shielding the building from harsh wind, rain, sunlight, and sound; and it also has a significant role in energy saving and keeping the building temperature at a comfortable level. Today, the energy consumption associated with buildings has reached nearly 40% in Europe and more extremely 80% in Hong Kong. Therefore, developing an energy-saving building facade has been a topic of enormous interest globally over the last 50 years. Many buildings have installed facade systems with excellent thermal insulation performance, but they are unfortunately not ready for the associated fire hazard.

Over the last decade, tall building fires involving facades are increasing in worldwide frequency and occurring almost every month. The 2017 tragic fire in Grenfell Tower, London (Fig. 1a), was one of the most devastating fires that caused 72 deaths and raised the profile of facade fire hazards. Unfortunately, large facade fires in tall buildings are continuously occurring globally, especially in fast-developing countries and cities in Asia (Fig. 1b, c). These fires are not only responsible for many deaths and billions of dollars in losses but also cause fear for residents who live with these fire-danger facades every day. Therefore, it is vital for the fire research community to address pending issues related to facade fires and to develop tools for façade fire safety assessment from the material level to the real-scale system.

Improving the fire safety of facades in existing or planned tall buildings is a global effort that requires scientific, engineering, social, and economic considerations. This special issue of Fire Technology is devoted to scientific studies of facade fires, including experiments, computer models, design, technology, and regulations. It includes 11 papers with multidisciplinary contributions from different aspects of fire science and technology. Unique flammability tests on facade samples are conducted in the material scale, small bench scale, large scale, and real building. The

*Correspondence should be addressed to: Xinyan Huang, E-mail: xy.huang@polyu.edu.hk

Figure 1. Typical facade fires in the high-rise building, (a) Grenfell Tower fire, London, UK, 2017, (b) Communication Tower fire, Changsha, China, 2022, and (c) Boulevard Walk Tower fire, Dubai, UAE, 2022.

new technology of measuring fire hazards, numerical simulations, and firefighting practices involving facade fire are also explored.

The 1st paper in this special issue, from *The Hong Kong Polytechnic University* found that the ease of ignition and fire hazard of sandwich facade panels or Aluminum Composite Panes (ACPs) highly depend on the failure of connection between the external non-combustible layer and the internal combustible core. If the external aluminum layer peels off earlier, the internal core, rated as lower combustibility in the material-based test, can be ignited faster and burn more intensively in the bench-scale test. The 2nd paper, from *Wuhan University of Technology* and *BRANZ* explored this issue from a unique perspective of the adhesive layer in the insulated panels. They found that the intumescent flame-retardant epoxy resin adhesive can significantly increase the ignition time of the internal core and even lead to self-extinguishment.

The 3rd paper, led by *University of Science and Technology of China* conducted small-scale laboratory experiments on the flame spread between the combustible facade and the parallel curtain, as well as the chimney (stack) effect. They found that by increasing the separation distance, the flame height first increases and then decreases before reaching a stable value. The 4th paper, from *Southwest Jiaotong University* and *Sichuan Fire Research Institute* performed multiple full-scale facade fire tests on a 12-story building that was covered by the expanded polystyrene (EPS) foam and a plaster layer. The U-shape parallel facade structure introduced a strong chimney effect that accelerates the flame spread.

The 5th paper, led by *China University of Mining and Technology* and *Building Research Institute (Japan)* compared the EPS facade fire performance from small-scale tests to intermediate- and large-scale tests. They demonstrated the nonlinearity in scaling up the fire heat release rate and the effectiveness of masonry cover and mineral fire barrier in reducing facade fire hazards. The 6th paper, from *Tech-*

nical University of Munich tested various types of wooden facade claddings and fire stops under the DIN 4102-20 full-scale test standards. They found three decisive influencing factors, the type of the wooden cladding and substructure, the depth of the rear-ventilation void cavity, and the reaction-to-fire rating of the outer wall layer. The 7th paper, from *Indian Institute of Technology Gandhinagar* studied combustible (ACP and medium-density fiberboard) and non-combustible (glass) facades on a full-scale three-story structure under the compartment fire scenarios. Their study highlighted the large heat flux on the spandrel area, different facade fire performances caused by the test scale, and the importance of the firestop installation method.

The 8th paper, from *Imperial College London* and *Instytut Techniki Budowlanej (ITB)* proposed a novel algorithm (Visual Fire Power) to measure the fire heat release rate with two cameras. By visually determining the time-averaged fire volume, it could measure the power of facade fire and be applied to measure other large-scale fire tests. The 9th paper, from *Efectis* performed detailed numerical simulations on the BS 8414 full-scale tests. They found that the heat flux on the facade is sensitive to the variation of heat release rate inside the compartment. Their work also highlighted the wind effect on changing the patterns of flame shape and fire exposure of the facade. The 10th paper, led by *Universiti Putra Malaysia* looked into the photovoltaic (PV) panels on the building facade. After reviewing the current firefighters' practices in the event of PV fires, they identified the gap in building fire safety regulations and nine hallmarks for safe firefighting practices.

Understanding the fire dynamics, reducing material flammability, and improving overall fire resilience is the everlasting mission and responsibility of fire safety scientists and engineers. Nevertheless, we have to recognize that achieving facade fire safety is a complex sociotechnical challenge. It requires more research in the following areas:

- Facade fire experiments and modelling related to structural failures, detection, suppression, and firefighting.
- The strategies of smoke control and evacuation in case of a facade fire.
- The cost–benefit analysis and performance-based design of the fire resistance facade system to help upgrade the codes and standards scientifically, and
- The forensic investigations and lessons learnt from past facade fires, as well as how to embed them into the education in fire engineering and training of fire services.

It is essential that fire scientists and engineers work together with different stakeholders to solve the complex fire safety concerns and create a safe built environment. This special issue helps shed some light on these critical needs and aims to inspire future work on this vital issue of facade fire safety.