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Study of fire smoke movement from building integrated photovoltaic (BIPV) double skin façade (DSF) fires using helium gas

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ABSTRACT

Advanced building technologies such as building integrated photovoltaics (BIPVs) systems have been widely applied in new and existing constructions, in order to reduce energy consumption and electricity demand in buildings. Meanwhile they can cause a new critical challenge, i.e., fire safety issues. On the one hand, plume from the PV panel fires could spread into the buildings through the windows and ventilation openings. On the other hand, the risk of fire can be elevated by affecting the propagation of fire inside and outside the building. Furthermore, interfering with the smoke and venting system, firefighting operation, and electrical shock dangers. Most of the studies on the PV panels are to find the cause of failure, improving the cell efficiency, cost reduction and extracting maximum power, while there is the need to study the mechanism for smoke propagation as well. Applying BIPV on the building cause major changes in the traditional method of using structural components. These changes may include changes in the material, standard distances, gaps, and duties of elements, each of which can bring new fire safety issues.

To overcome the fire safety issues of BIPV and make it resilient, in this research, a case of BIPV application on the building façade is studied. The building uses principles like double glazed storm windows. The ventilation plenum is a good means to trap the generated smoke and prepare enough time for it to enter the indoor area via inner openings. This research aims to observe the physics of smoke spreading from ignited BIPV on the façade to the indoor environment.

A small-scale model is designed using helium surrogate based on the helium-smoke plume similarity and Froud modelling. Firstly, a theory for helium similarity is proposed. Based on this theory the flow velocity is conserved between the model with real fire and the model with helium surrogate. The dimensionless helium concentration is comparable to the dimensionless smoke temperature. Secondly, the mentioned scaling method is verified by comparing similarity of simulation results between the small-scale with helium, small-scale with fire and full-scale with fire cases. The validity of CFD models is observed since the results show acceptable compatibly to the associated experimental measurements (NRMSE smaller than 30%). The coefficients of variation of the results of the simulation cases with helium and fire ranged between 1.6 to 11% which means the associated curves fit perfectly on each other. This compatibility was later supported by the identical snapshots of air flow filling the floors one after another.