ANALYSIS OF THE EFFECT OF WIND ON FAÇADE FIRE PROPAGATION THROUGH COMPUTATIONAL FLUID DYNAMICS MODELLING

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Façade fires are one of the most critical and increasingly frequent hazards in buildings. These fires pose a great risk to the building occupants. The Grenfell Tower fire, which happened in 2017, killing 72 people, is one of the deadliest façade fire incidents. Events like these emphasize the importance of studying the nature of façade fires. Façade fires can spread quickly through the full height of the building. Also, these fires can spread into nearby structures. Researchers have identified several factors that affect façade fire propagation. The main factors include façade material, cavities, geometry of the building, and wind. The focus of this study is the effect of wind on façade fire propagation. Building standards have set requirements to ensure the fire safety of façades. A large-scale façade fire test is one of the methods that building standards have used for this purpose. There are several large-scale façade fire test types in different countries, and the nature of these tests varies significantly from one another. One common theme in all those tests is that they do not consider the effect of wind. Therefore, even though the façades are designed according to the building standards, there is an unforeseen risk in fire situations when the wind is present. This study tries to address that limitation by numerically modelling a large-scale façade fire test and assessing the effect of wind. Fire Dynamic Simulator (FDS) was selected as the numerical tool. FDS is a Computational Fluid Dynamics (CFD) software for fire-driven fluid flows. First, a validation study was performed by numerically modelling a large-scale façade fire test that was conducted in a fire test facility in Melbourne. The experimental setup was 18 m tall, and thermocouples were placed at 10.5 m, 13.5 m and 16.5 m heights to record the temperatures. Wind speed and direction were measured at a height of 10 m. The test specimen consisted of two façade materials: an aluminium composite panel (ACP) with a combustible polyethylene core and a completely non-combustible profiled aluminium panel. The ACP panels consisted of a 4 mm polyethylene core sandwiched in between two 1 mm thick aluminium sheets. These materials were simulated in the numerical model using the material properties gathered from literature and product-specific data sheets. The total dimensions of the numerical domain were 22.4 m x 20.8 m x 19.2 m (length x width x height). This domain was large enough to account for the whole test, the fire plume resulting from the combustion, and the turbulences due to wind. Monin-Obukhov similarity theory was used to model the wind inside the numerical domain. The thermocouple results were extracted from the numerical model, and they were validated using the experimental results. The flame behaviour of the numerical model was compared with that of the experiment for further validation. After the validation, the effect of wind was examined through further numerical modelling. It has been shown that wind has a significant impact on façade fire propagation. The façade fire spread decreases with increasing wind speed when the wind direction is parallel to the main wall of the test specimen. Wind direction also impacts fire propagation. Findings from this study highlight the importance of considering wind in façade fire safety, especially in large-scale façade fire tests.

Keywords: Façade fire, FDS modelling, Large-scale fire test, Fire propagation, Wind

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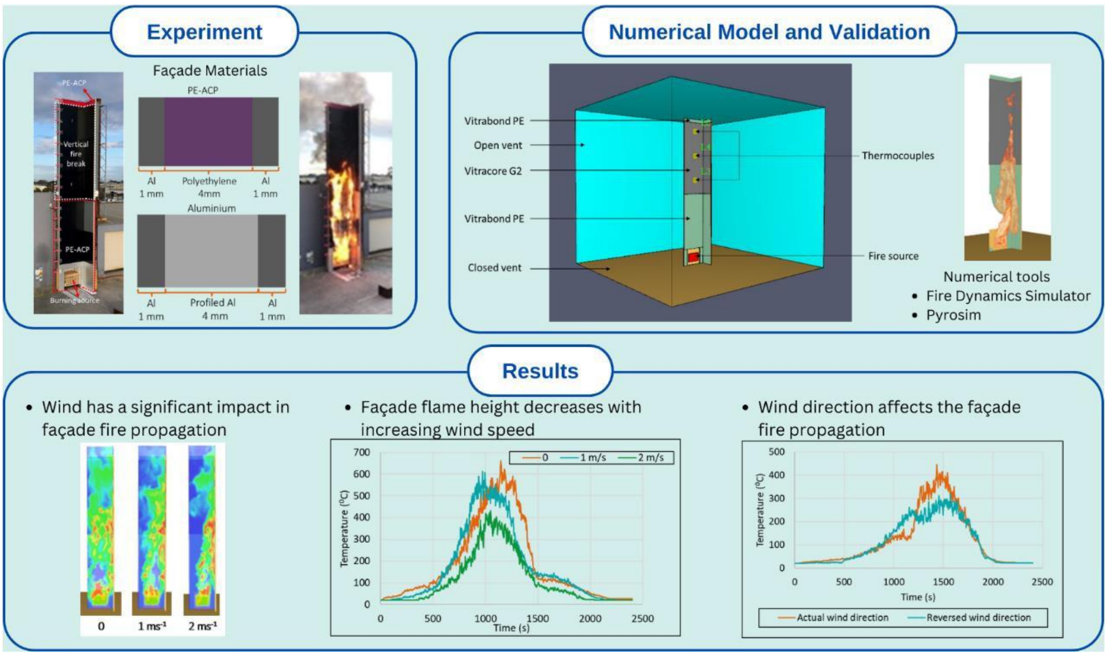
Experiment
Façade Materials
PE-ACP
Vertical fire break
Burning source
Al 1 mm
Polyethylene 4mm
Al 1 mm
Aluminium
Al 1 mm
Profiled Al 4 mm
Al 1 mm
Numerical Model and Validation
Vitrabond PE
Open vent
Vitracore G2
Vitrabond PE
Closed vent
Thermocouples
Fire source
Numerical tools
• Fire Dynamics Simulator
• Pyrosim
Results
• Wind has a significant impact in façade fire propagation
0
1 ms⁻¹
2 ms⁻¹
• Façade flame height decreases with increasing wind speed
0
1 m/s
2 m/s
Temperature (ºC)
Time (s)
• Wind direction affects the façade fire propagation
Temperature (ºC)
Time (s)
Actual wind direction
Reversed wind direction