NUMERICAL INVESTIGATION ON THE EFFECT OF WIND ON FAÇADE FIRE PROPAGATION OF A HIGH-RISE BUILDING IN SRI LANKA

L.R.W.M.I.M.Lankadhikara [1], T.G.P.L.Weerainghe [1, *], R.M.S.Dananjaya [2]

[1] Department of Civil Engineering, University of Moratuwa, Moratuwa
[2] Department of Infrastructure Engineering, University of Melbourne, Melbourne

The façade is one of the most critical structural elements of a building. It serves as a barrier between the building's inside and the outside environment. Beyond aesthetic appearance, the façade also plays a critical role in providing a protective barrier against external elements, enhancing energy efficiency, and contributing to the overall safety of the building occupants. New energy-efficient lightweight materials with good thermal insulation properties are used for facades worldwide. Poor façade performance may result in catastrophic fire spread, building damages, and fatalities during a fire. Several factors like façade material, design and layout of the building, and external factors like wind can contribute to the fire spread in building façades. The influence can be favourable or unfavourable in accelerating or extinguishing the fire growth. Conducting large-scale testing to investigate various facade fire scenarios might not be possible due to practical limitations and expensive and time-consuming procedures. To overcome these limitations, using numerical simulation has gained prominence in studying facade fires. Numerical modelling of facade fires can be accomplished using the combined capabilities of Fire Dynamic Simulator (FDS) and PyroSim software, which simulates the fire as Computational Fluid Dynamics (CFD) models.

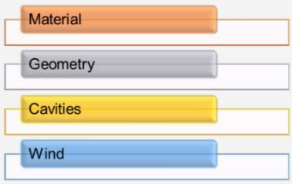
In this study, the primary consideration is given to examining the effect of wind on fire propagation along the façade of a high-rise building in Sri Lanka during windy conditions. The reference building (Height: 127 m with 41 floors) with rectangular shaped building geometry including U-shaped geometry at its shortest dimensional sides, having a combustible façade made of Aluminium composite panels and located in Colombo District in Sri Lanka, is modelled using PyroSim software. U-shaped geometry is critical due to its influence on the chimney effect. In the context of U-shaped geometry, the chimney effect refers to the phenomenon where a U-shaped space or channel within a building acts as a vertical conduit, facilitating the upward movement of smoke, hot gases, and flames during a fire. The fire spread along the façade, the effect of the U-shape geometry of the building, and the influence of wind speed and wind direction (parallel - 0^0, perpendicular - 90^0, angled to the façade surface - 45^0) toward the rapid spread of fire are examined using temperature recordings of thermocouples. The results are compared to a reference case of no wind. Results comparison of the validated models has shown a significant impact from the U-shape façade geometry, wind speed, and wind direction for the fire growth and extinguishing along the façade. The results indicate that the fire propagation is critical when the wind is present. According to the results, the vertical spread of the fire is faster when the wind is parallel to the façade surface, creating a chimney effect, channelling the fire along the open side of the U-shape and potentially impacting multiple floors. When the wind blows parallel to the façade surface, lateral fire spread is significantly accelerated in the blowing direction. When the wind blows perpendicular to the façade surface, the lateral fire spread has been slowed compared to the other two wind scenarios. The wind can push the fire diagonally along the facade, potentially spreading the flames horizontally and vertically. When the wind flows angled to the façade surface, the potential fire spread is high in both horizontal and vertical directions. The windward direction shows rapid lateral fire spread, while the opposite direction shows a slower spread. The findings guide for reducing the rapid spread of devastating façade fires in high-rise buildings during windy conditions.

Keywords: Façade fire propagation, Combustible cladding, Building geometry, FDS modelling, External wind

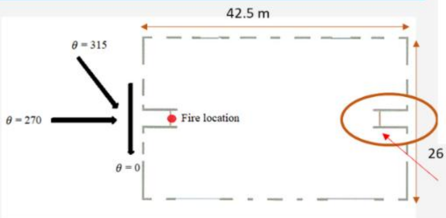
* Correspondence: pasinduw@uom.lk

NUMERICAL INVESTIGATION ON THE EFFECT OF WIND ON FAÇADE FIRE PROPAGATION OF A HIGH-RISE BUILDING IN SRI LANKA

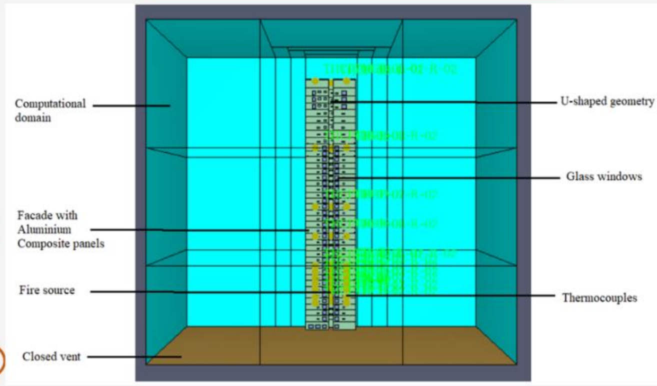
FACTORS AFFECTING FACADE FIRE



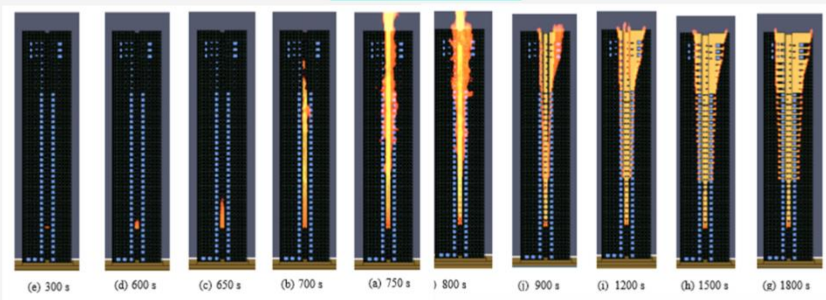
BUILDING GEOMETRY AND WIND EFFECT



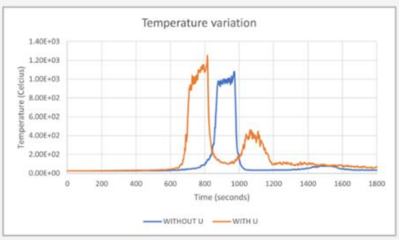
NUMERICAL SET-UP



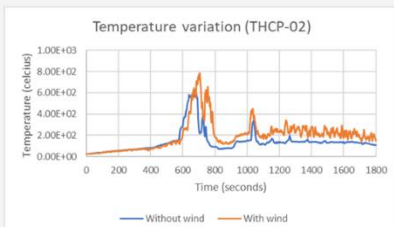
RESULTS



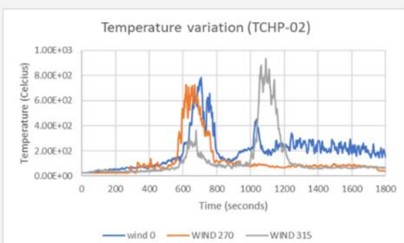
FLAME PATTERN VARIATION



THE EFFECT OF BUILDING GEOMETRY (WITH AND WITHOUT U-SHAPED GEOMETRY)



THE EFFECT OF WIND (WITH AND WITHOUT WIND)



THE EFFECT OF WIND DIRECTION (PARALLEL, PERPENDICULAR AND ANGLED WIND BLOWING DIRECTIONS TO THE FACADE SURFACE)