Vertical fire spread

BRANZ investigations into the effect of flames projecting from building openings such as windows will result in useful guidelines for fire safety practitioners.

BY KEVIN FRANK, BRANZ FIRE RESEARCH ENGINEER

BUILDING FIRE SAFETY designers typically consider two main hazards with vertical fire spread over external walls of buildings:

- Fire spread through unprotected openings such as windows.
- Fire spread involving combustible façade materials.

While the contribution of combustible façades has received a lot of attention recently due to some high-profile fires, fire spread via unprotected openings is also important.

How fire spreads in a building

Like any fire, a fire in a building requires heat, oxygen and fuel. As a fire starts to grow, the building will begin to affect the fire development. When the building envelope heats up, it radiates heat back to the fire and elements such as windows can start to fail.

The presence of the building also restricts the ability of the fire to access oxygen from the air. The heat in the building will start to produce more flammable fuel vapours than can be burned by the oxygen entering through openings in the building. If enough heat and fuel vapour are escaping with the smoke leaving the building, flames will start to burn outside of the building as it mixes with fresh air.

These flames project vertically upwards and can threaten unprotected openings such as non-fire-rated windows above the fire, with a risk of fire spread back into the building on upper floors. In some specific situations, building design must account for this type of fire spread to comply with the Building Code.

More guidance needed

The New Zealand Acceptable Solutions and Verification Methods for protection from fire both provide some guidance on preventing external fire spread via unprotected openings. In the Acceptable Solutions, combinations of fire-rated spandrels and horizontal projections (known as aprons) are permitted where this hazard is a concern (see Table 1).

The Verification Method requirements are satisfied by calculating the effect of radiation from fire plumes (flames) projected from openings. No detailed guidance on how to evaluate the radiation from the projected fire plume is given.

Table 1

C/AS permitted combinations of spandrel and apron geometry

SPANDREL HEIGHT (M)	APRON PROJECTION (M)
0.00	0.60
0.50	0.45
1.00	0.30
1.50	0.00

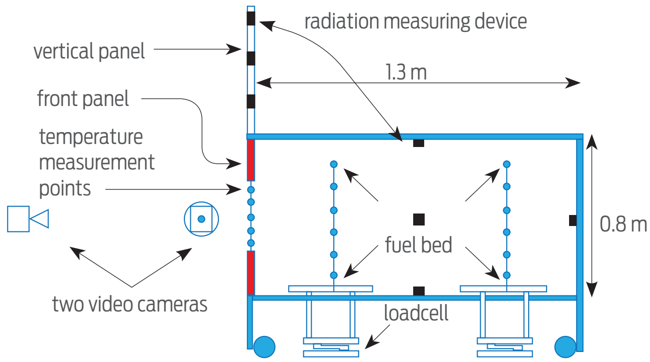

Figure 1: BRANZ reduced scale-test compartment.

BRANZ predicting flame heat

To provide guidance to fire safety practitioners, the Building Research Levy-funded BRANZ project *Limiting fire spread by design* includes an investigation of how to predict the heat from flames projecting from openings. This is being achieved through a review of previous work on this problem, conducting a series of reduced-scale experiments and model validation.

A one-third scale compartment (see Figure 1) was used in the experiments with wood crib and liquid hydrocarbon pool fires. The effects of the position of the fuel package in the compartment and the vertical position of the opening in the wall were investigated. As well, the effects of aprons on the heat intensity received by the external wall above the opening were investigated.

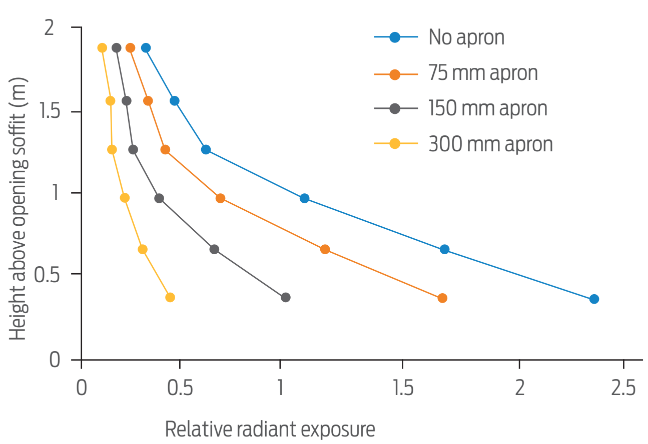

Figure 2: Effects of aprons on peak heat flux above a flame projecting from an opening.

Figure 3: Flame geometry without an apron (left) and with a 0.3 m apron (right).

Process for calculation method

The general process identified for calculating the heat exposure above a flame projecting from an opening was to:

- nominate a fire size - called the heat release rate
- calculate the flame height based on the fire conditions and opening size
- calculate the peak heat intensity on the wall using the flame height and heat release rate.

Predictions from several hand calculation methods and a widely used computer model were compared with the reduced-scale experimental data and other data (both reduced and full scale) from the literature. The computer model provided comparable flame heights to some of the hand calculation methods but had difficulties reproducing the fire conditions and heat intensity above the opening in some instances. Another aspect still being investigated is what is a suitable fire size to use for design calculations.

Figure 2 shows how a progressive increase in the horizontal projection of an apron decreases the received radiation relative to having no apron above the opening. The amount of radiation received decreases over the height of the flame, so not only does the apron physically push the flame away from the face of the building, the building is only exposed to less-intense regions of the projecting flames. The effect of an apron on the shape of the flame can be seen in Figure 3.

Translating to full-scale designs

One of the issues identified in this research is the difficulty of translating reduced-scale experimental data to full-scale design situations, and this is the subject of ongoing research.

Note A BRANZ study report with details of this research and associated findings will be available soon from www.branz.co.nz/study_reports.