Fire resistance in industrial buildings

BRANZ researchers have been analysing how much fire resistance is needed for external walls in industrial buildings. Results show the Building Code minimum fire-resistance ratings could be reduced for some.

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EXTERNAL WALLS close to property boundaries are commonly fire-rated to help prevent fire spread to a neighbouring property as required by New Zealand Building Code objectives.

Acceptable Solutions for industrial building design

Industrial buildings can be designed to Acceptable Solution C/AS5 if used for low-risk purposes (limited to mostly low-level storage) or C/AS6 if used for high-risk purposes or for higher-level storage. The fire-resistance ratings required in C/AS5 and C/AS6 are in the range 120-180 minutes for unsprinklered buildings and 60-180 minutes for sprinklered buildings.

The Acceptable Solutions give a single fire-rating requirement for a wide range of potential commercial and industrial building designs. These include different building heights, numbers of storeys, floor area, ventilation, amount of combustible contents and materials of construction. The fire-resistance ratings in the Acceptable Solutions are intended to ensure a worst-case fire can be resisted. They are based on worst-case design assumptions for the fuel load, ventilation area and thermal characteristics of the construction.

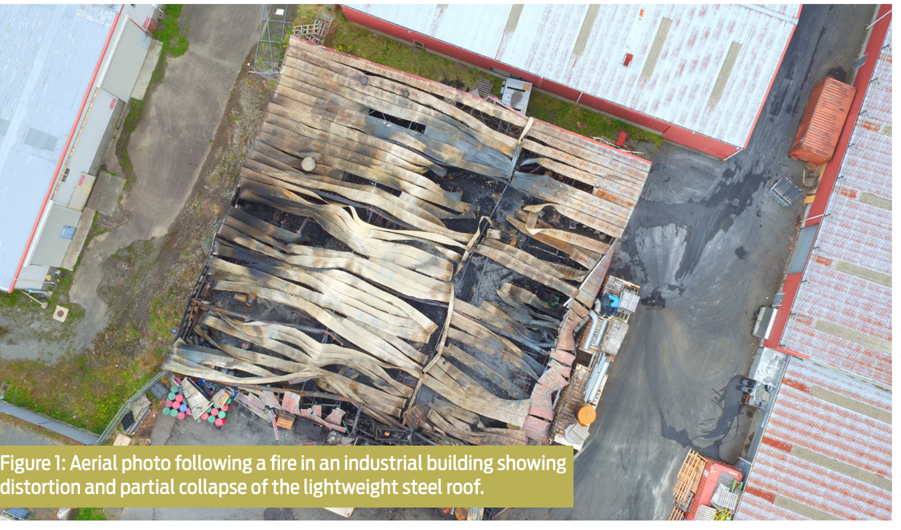

Figure 1: Aerial photo following a fire in an industrial building showing distortion and partial collapse of the lightweight steel roof.

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Potential to reduce fire-resistance rating for some

The construction needed to provide the currently required fire-resistance ratings for boundary walls can substantially increase the cost of common single-storey industrial and storage buildings.

In the case of many of these buildings with lightweight steel roof construction, some of the heat of a fire can escape through the roof since the roof is highly heat-conductive and also usually collapses or distorts early during the fire (see Figure 1). This allows more oxygen-rich air to access the fire, which, in turn, causes the fire to burn out faster.

These effects reduce the overall severity of the fire that the boundary wall is required to withstand as the heat from the fire is not trapped inside the building. This means the fire-resistance rating can be reduced without a large increase in fire spread risk to other properties.

Fire severity in industrial buildings

BRANZ fire researchers carried out a probabilistic analysis of the fire severity in industrial buildings. This considers how key parameters such as the amount of fuel present and size of openings in the walls and roof (providing fire ventilation) can vary in reality and the subsequent effects on potential outcomes.

For this research, the analysis was done by calculating the minimum fire-resistance rating required to keep the wall standing before the fire burns out, for combinations of the key parameters occurring in a given fire. The results were then combined into a probability graph showing the percentage of fires expected to burn out before walls built to different fire-resistance rating specifications would fail.

For each simulated fire, the minimum required fire-resistance rating was calculated using a method based on the Eurocode 1991-1-2:2002 parametric time-temperature equations but modified to account for roof failure and subsequent venting.

The relationship between fire resistance and fire severity was assumed based on comparing the maximum temperature of a protected steel beam in a standard fire-resistance test with that reached when exposed to a fire-temperature history for the simulated fire as determined from the Eurocode parametric equations.

Five fire hazard cases analysed

Five different fire hazard cases were considered with three cases based on the nominal fire load energy densities (FLEDs) given in the Verification Method C/VM2 for commercial, low-risk storage and high-risk storage. The FLED is a measure of how much fuel energy is available to burn in a fire per unit floor area.

The other two cases were based on the UK fire engineering design document PD 7974-1 recommendations for manufacturing facilities with no storage and low-risk storage, respectively.

All of the FLED inputs could vary on the basis that a fire can occur at any time and the combustible contents of buildings can change from day-to-day during normal use. A fire might also occur when the building is not at full capacity, for example.

The analysis included up to 50,000 simulated fires for each case where the key parameters were randomly chosen from their expected range. It produced probability curves showing the percentage of structurally significant fires for which a wall with a given fire-resistance rating will withstand the fire.

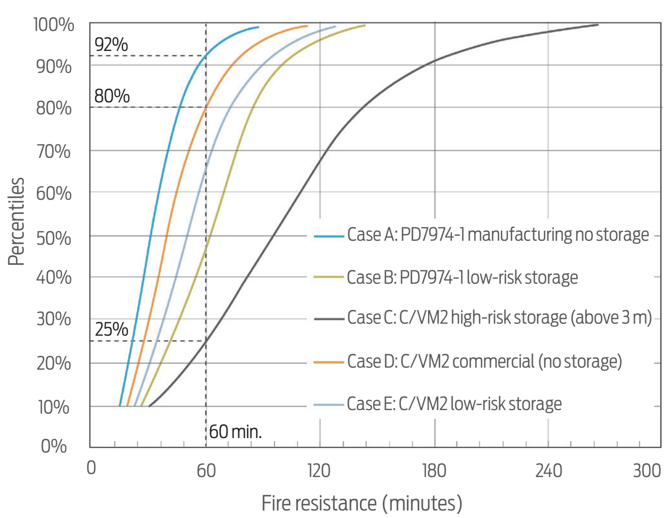

Figure 2: Probability curves for fire resistance (unsprinklered).

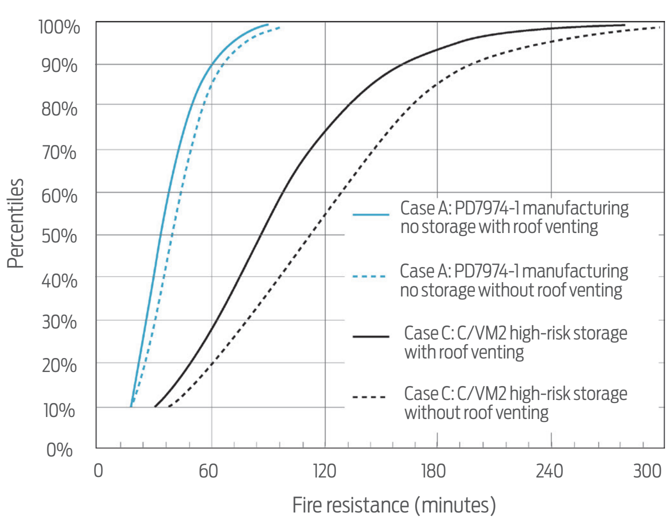

Figure 3: Probability curves comparing effect of roof ventilation on fire resistance (unsprinklered).

Results show differences

The results for the five different cases are given in Figure 2 and show the following:

- For an unsprinklered building design for a Case C building usage (industrial buildings with high-risk storage), a boundary wall with a 60-minute fire-resistance rating would have a 75% probability of failure given a structurally significant fire had occurred.
- In comparison, the same wall in industrial buildings not used for storage (Case A) would be expected to fail in 8% of structurally-significant fires.

The researchers assessed the effect of including roof failure and subsequent venting of the hot fire gases. This is shown in Figure 3 where the effect is relatively small for Case A with the lower fire load but more significant for Case C with a higher fire load. As expected, the 80th percentile fire resistance - that is, the fire resistance that will withstand 80% of structurally-significant fires - is less when allowing for roof venting compared to when the possibility is excluded from the analysis.

Help MBIE to consider changes

The research conducted provides analysis and results that could be used to help inform changes to the minimum fire-resistance ratings required for Building Code compliance in industrial buildings in the future.

However, the findings do not provide all the information required for making such changes. Additional societal risk tolerance and cost-benefit analysis is required to understand the complete picture.

Changes to the compliance requirements can only be determined by the building regulator, the Ministry of Business, Innovation and Employment (MBIE).

For more Further information is available in BRANZ Study Report 417. Download from www.branz.co.nz/study_reports.