Fire protection

An investigation into the performance of fire protection systems in the Christchurch earthquakes produced recommendations for change.

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Several factors reduced the incidence of fires.

THE CANTERBURY earthquakes provided a rare opportunity to investigate the actual performance of fire protection systems in the earthquake events. A collaborative research project involving the University of Canterbury, the Fire Protection Association of New Zealand (FPANZ) and BRANZ has some interesting findings.

Thankfully few fires

Very few fires occurred due to the time of day (reduced ignition sources from cooking), it was summer so there were no ignition sources from space heating and Christchurch has a low level of reticulated gas.

Active fire protection systems

Active fire protection systems were inspected in affected buildings after the September 2010 and February 2011 earthquakes. Fire sprinkler systems had two main issues – water supply had been disrupted or the system damaged.

The mains water supply in the CBD was temporarily disrupted in the September 2010 earthquake and significantly disrupted in the February event leaving areas surrounding the CDB red zone without water for several days, weeks or much longer.

In some cases, the basements housing booster pumps required by fire systems were flooded, and the pumps were inoperable.

Damage to sprinkler systems was observed where non-structural components and systems had collapsed. Roof cross-bracing in low-rise commercial buildings also caused damage to sprinkler fittings. Modern pipe systems performed well.

Several racking systems had collapsed, and where there were in-rack sprinkler systems, these were also damaged.

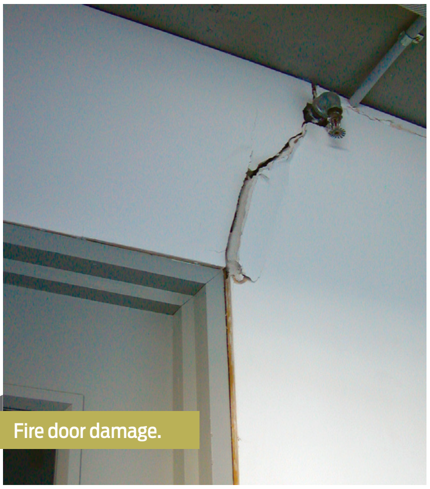
Alarm cabling poorly placed

While only some commercial or industrial buildings require sprinkler systems, most require a fire alarm system.

The most obvious issue found was the poor alarm system cable routing – little attention had been paid to the consequences of seismic movement. There was damage where cabling passed through holes in or around cut edges of structural and secondary steelwork or concrete tilt-up wall panels crushed cabling.

Passive fire protection system damage

Following the February 2011 earthquake, passive fire protection such as fire-rated compartmentation systems, fire doors, fire-stopping systems and fire-rated coatings on structural elements were inspected.



Fire door damage.

In some buildings, the passive fire protection was destroyed. This research focused on structurally safe buildings where the passive fire protection had been damaged.

Damage observed included:

- fire-rated lining cracked or separated from fire door framing
- door leaf movement opening a 4–16 mm gap down the door frame (rather than 2–3 mm)
- a wall-to-wall internal corner junction with a 15 mm gap in a fire-rated escape stairwell
- a precast concrete stair where the junction to the fire-rated wall beneath had been crushed by earthquake-induced motion.

Concrete tilt-up wall panels in low-rise industrial buildings showed separation of fire-rated sealant joints, increasing the risk of fire spread to neighbouring properties.

Structural design for fire

There is a heavy reliance in New Zealand on fire sprinklers - dispensations are given to the level of passive fire protection systems where fire sprinklers are present.

In the February 2011 earthquake in particular, the majority of sprinkler systems had no water since the municipal water supply was seriously disrupted and around 40% of water tanks supplying sprinklers were damaged.

Post-earthquake fires are likely to grow faster and have a greater severity and longer duration than typical fires. At the same time, compartmentation is likely to be breached, allowing rapid fire spread, and the fire service response will be reduced.

Structural elements may have to endure greater severity fire exposures for significantly longer periods than they were designed for, and passive fire protection to the member may be damaged. Examples were observed of damage to protective coatings of structural steel members by earthquake movement.

In a general sense, structural elements in buildings subjected to a design-level earthquake are going to suffer significant damage, weakening the members and making the structure of buildings more vulnerable to fire-induced collapse.

Recommended regulatory changes

From these findings, two changes are recommended to current practice:

- A sliding scale for reducing fire resistance ratings when sprinklers are present - 50% reduction in the lowest seismic risk areas, up to 0% in areas of highest seismic risk.
- Mandate the design of fire scenarios commensurate with the seismic zoning where compartmentation has failed and egress routes have been compromised.

What else can we learn?

Changes needed to support the role active fire protection systems play in post-earthquake fire safety, include:

- alternative strategies to ensure sprinkler water supply from in situ tanks is more reliable after an earthquake
- alternatives to dual mains supply for existing sprinkler systems
- installing fire pump systems to minimise the risk from basement flooding
- improving practice for routing alarm cabling
- reviewing seismic resilience of non-structural components and systems.

Note This article is a summary of the paper, Baker, GB, Collier, PCR, Abu, AK and Houston, BJ *Post-earthquake structural design for fire – a New Zealand perspective*, presented at the 7th International Conference on Structures in Fire, Zurich, Switzerland, June 2012.