Department of
Building and Housing
Te Tari Kaupapa Whare

Practice Advisory 13

Egress Stairs:
Earthquake checks needed for some

This Practice Advisory is issued in response to concerns about stair collapses in Christchurch CBD in the 22 February 2011 Aftershock

Background

The Lyttelton earthquake (aftershock) of 22 February 2011 caused a number of stair failures in buildings in the Christchurch CBD. Although it is recognised that this earthquake made extraordinary demands on existing designs, the failure of stairs is of serious concern. The Department considers it imperative that the circumstances of these failures are fully understood and the implications for similar buildings around New Zealand examined and acted upon.

The report commissioned by the Department on the collapse stairs in the Forsyth Barr Building [1] illustrates an example of the issues and concerns. A report prepared for the Royal Commission [2] provides further comment on the issues and some considerations that may assist structural engineers to decide on retrofit actions. Design considerations for stairs are offered in the SESOC draft Practice Note [3].

Purpose and Scope of Advisory

This Practice Advisory is to:

- alert practising structural engineers assessing existing multi-storey buildings throughout New Zealand to issues relating to safety of stairs

It applies to all existing multi-storey buildings throughout New Zealand:

- to which members of the public have access, including office buildings, particularly those with scissor stair configuration, and
- have stairs designed to slide under seismic action, particularly those with the gap-and-ledge stair detail.

Key concerns

- If the relative lateral displacements between adjacent floors of a building (the "inter-storey drifts") are sufficiently large, a stair may be pulled off the ledge that supports the sliding end of the stair.
- The seating dimensions allowed in existing designs may not be sufficient to account for movements now expected.
- The maximum inter-storey drift in estimates of building displacement may not adequately account for variability and uncertainty.
- Details that have limited scope to allow closing movement may cause damage to the stair flights. This damage may shorten the flights and make them more likely to fall off their supports.
- Seismic gap details that have been partially or fully filled or are susceptible to being filled because of construction or maintenance errors may restrict or prevent closing movement.
- Heavy finishes, fixtures and fittings in stairwells may come loose during an earthquake and fall and block the stairway or injure people using it.

Main points

1. *Stairs designed to slide*: Check if sliding is the designed intention or not:

- This Practice Advisory applies to stairs that are detailed to slide on the end supports in order to accommodate the relative horizontal earthquake displacements between floors (known as "inter-storey drifts").
- Stairs that are "built in" to the supports/landings at both ends are not covered by this Practice Advisory.

2. *Overall allowance for movement*: Needs to be checked:

- There are a number of loading Standards and material Standards that have prescribed the calculation of inter-storey drifts for NZ buildings (as far back as 1956). Typically, these design displacements are not consistent across the Standards. Therefore it is imperative that relative displacement between floors is calculated to the current Loadings Standard, NZS 1170.5.
- Clearances and seatings for stairs should be capable of sustaining at least twice the Ultimate Limit State (ULS) inter-storey displacements (drift) as calculated in accordance with NZS 1170.5.

3. *Stair movement that closes the gap between the end of the stair and the support*: Check support detail.

- Calculate the inter-storey drifts as per Item 2 above.
- Check if the movement causes the sliding end of the stair to impact against the support (wall, beam or landing) - see Figure 1.
- If the lateral movement of the stair closes the gap, causing impact on the support/landing:
  - Look to increase the gap.
  - Check implications of bracing action as the stair struts between floors, if gap should close:
    - on the stair flight
    - on the supports at each end of the stair
    - on the building, as the stairs can significantly stiffen the building through the bracing action between floors, via unintended load paths. This results in the building attracting seismic forces that may be much larger than originally considered in the design of the building.
- Check gap left for closing movement of the stairs:
  - Check for objects in gap, such as debris or floor levelling compounds that may have occurred during earlier repairs/new fit-outs. Remove these obstructions.
  - Modify detail to prevent further objects in the gap impeding movement. For example, cover plates over the gaps.

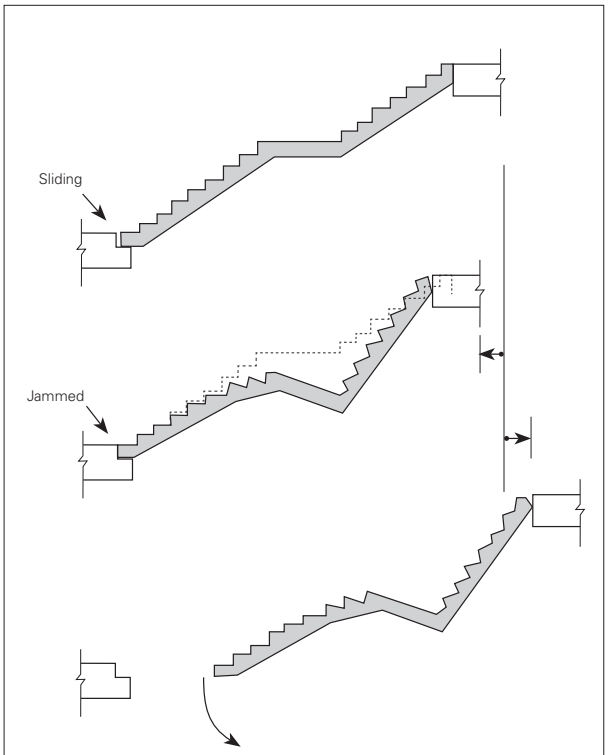

Figure 1 – Inter-storey drift along the stair compresses the stair shortening it.

When earthquake reverses, the stair can now fall off the supporting ledge. [2].

4. *Progressive collapse: one stair falling on to the stairs below and collapsing them all*: mitigate:

- Using the inter-storey drifts from Item 2 above, construction tolerances, residual width of seating, spalling of the concrete ends of the stairs or the edges of the supporting ledge and other factors, determine what should be the width of the seating (contact area) between the sliding end of the stair and the support. If the available width of support is inadequate, install catch-frames or similar safety devices or engineer extensions of the ledge to ensure adequate width of support for the end of the stair.
- Stairs can swing sideways relative to its length. This can either damage the lining to the stairwells causing blockage of the egress path or, more significantly, can overload the connection at the other end of the stair, where the stair is fixed in to the support. This overload can result in failure of the bars or connection details there, resulting in collapse of that stair. The ability of the connections at the fixed ends must be checked and if there are issues, these need to be mitigated by design, i.e. by using NZS1170.5 Section 8, Requirements for Parts and Components.

5. *Wall finishes, fixtures and fittings within the stairwells*: Make these safe:

- Secure or remove any wall finishes that can not sustain the calculated inter-storey drift and could dislodge in earthquake shaking or building movement (particularly under inter-storey drifts).
- Restrain or remove any fixings and fixtures in the stairwells. Restrain in accordance with NZS 4219.

Actions to be taken

The Department advises the following actions from the various parties:

- *Structural engineers*: When undertaking detailed assessments of buildings, strongly recommend to your client that checking of the stairs is included in your brief.
  - Recommend that any necessary retrofit measures be carried out as soon as possible. These should bring the stair earthquake safety performance to as nearly as is reasonably practicable to that of a stair in a new building of similar structural characteristics (see "when designing new buildings").

- *Territorial authorities*: When advising owners of the need to renew their annual Building Warrant of Fitness Territorial Authorities are advised to bring this practice advisory to the attention of owners.
- *Building Consent Authorities*: When building consent applications are made for any work on a multi-storey building with sliding stair details, Building Consent Authorities are advised to bring this practice advisory to the attention of owners.
- *Building owners with concerns*: Owners should contact a chartered professional engineer with suitable qualifications and experience to review the stair design and make recommendations for retrofit work.

References

1. Beca Carter Hollings and Ferner Ltd (2011), Investigation into the Collapse of the Forsyth Barr Building Stairs on 22 February 2011. Report prepared for the Department of Building and Housing, September 2011
2. Bull, D (2011), Stair and Access Ramps between Floors in Multi-storey Buildings. Technical paper prepared for the Canterbury Earthquakes Royal Commission, August 2011
3. SESOC Practice Note: Design of conventional structural systems following the Canterbury Earthquakes, September 2011

When designing new buildings

Do

- Do use details which allow stair flights to slide on landings without restrictions
- Do take into account variability and uncertainty in estimates of building displacement to provide resilience. Clearances and seatings for stairs should be capable of sustaining at least twice the Ultimate Limit State (ULS) inter-storey displacements as calculated in accordance with NZS 1170.5, after allowances for construction tolerances.
- Do take account of disproportionate collapse, i.e. progressive collapse resulting from a stair flight failure

Don't

- Don't use details that restrict closing movement that may cause damage to the stair flights. This damage may shorten the flights and make them more likely to fall off their supports. The freedom of movement may be further restricted by debris or other material in the movement space.
- Don't use seismic gap details, particularly gap-and- ledge stair detail, which are susceptible to being filled by construction or maintenance error and thereby restricting closing movement.
- Don't allow stair wells to have heavy finishes, fixtures or fittings that could come loose during earthquake movement. They may fall and block the stairway or injure people evacuating the building.