CROSS Safety Alert

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Safety issues associated with balconies

CROSS UK

CROSS-UK Safety Alert

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Who should read this alert?

Owners of residential and other buildings with balconies, Local Authorities, Building Control bodies, developers, building surveyors, architects, structural engineers, facilities managers and maintenance organisations. Contractors engaged in constructing buildings with balconies or in repairing or re-furbishing such buildings. Fire and Rescue Services.

This Alert draws attention to the safety risks associated with balconies, both new and existing. It draws on confidential reporting experience from the UK, from Australia, New Zealand and from the USA.

1. Introduction

Balconies are frequent features of high-rise buildings and becoming more common as the number of these buildings increase. There have always been safety issues associated with balconies in both design and usage and self-evidently if one collapses, the consequences for life safety are likely to be severe. What is not so obvious, is that the potential causes of failure are varying as new forms of construction and procurement are adopted.

Although this report concentrates on balconies, an allied topic considered in CROSS is of pre-cast concrete canopies. A report (Appendix 1) raises concerns over older canopies which were slender and monolithic over entrance doorways. Such canopies can be vulnerable to sudden collapse.

2. Scene Setting

Location of balcony prior to collapse

Figure 1: CROSS report 341 Balcony collapse at block of flats

Balcony failures have been reported worldwide. For example, in 2016 in Dunedin, New Zealand a heavily cantilevered balcony collapsed during a music concert. 18 students were injured (References 1 and 2). In August 2019, there were two fatalities and more than 17 injuries when an internal balcony collapsed in a South Korean night club. Some other news reports are scheduled in Appendix 2.

In the UK a number of CROSS reports (Appendix 1) have related to balconies and their balustrades. The UK Royal Society for the Prevention of Accidents (RoSPA) website states that in the UK: *"around 10 children die as a result of falls each year - some from windows and balconies and the remainder mostly from stairs"*. Injuries can also be caused by getting heads or limbs stuck in railings, whilst fatalities can be caused by climbing over parapets or falling through excessive railing gaps. Other injuries and fatalities have been reported as resulting from inappropriate adult behaviour, from balustrades/railings giving way, or even total collapse of the balconies themselves as shown in Figure 1.

In Australia and New Zealand, balconies are a common feature on many buildings from high-rise apartments to individual family houses, where they are often referred to as decks. In the latter case, they are commonly of timber and in some cases may have been added by the owner as a DIY project. In 2016, the Institute of Building Consultants (IBC) published a warning on decks and balconies by Archicentre, the building advisory service of the Royal Australian Institute of Architects on the state of Australia's balconies and decks. This noted that around 8,000 balconies in Australia could be life threatening and there was a need for people to inspect their decks and balconies for rotting timbers and rusty corroding steel fittings which could lead to life threatening collapses. In 2017, following several deaths and serious injuries as a result of falls from decks, balconies and windows, or from the collapse of decks and balconies, the Queensland Department of Housing and Public Works issued a guideline **Deck, balcony and window safety** (Reference 3) where it notes that: *In Queensland between 2002 and 2012 more than 20 people have died, and hundreds have been injured after falling from decks or balconies. A small but significant proportion of cases have been associated with structural failure of the deck or balcony*. There are similar documents in other states e.g. in NSW there is: '**Deck and balcony safety** - A practical maintenance and safety guide for your home' (Reference 4).

Similar concerns exist in the US. A 2017 article in the US publication *Structure* entitled *Balcony Issues in High-Rise Buildings* (Reference 5) enumerates many of the common safety issue causes and quotes a 2011 article from the *American Journal of Medicine* noting that there were over 86,500 balcony fall cases in the US from 1990 through 2006 and 5,600 cases in that period involved structural failure. Statistics from other countries are similar.

3. Structural failure

Gross structural failures have occurred, and the following points might be considered:

3.1 Procurement

- It is common for several designers to be involved in balcony design. There can be specialist balcony designers with interfaces to the main structure, and the main supports can include a sandwiched thermal break proprietary item. Frequently there will be a separate designer for the connection of the balcony cantilevers to the main structure. There may also be specialist parapet designers. Thus, what seems to be a single cantilever can include several interfaces. As always, there should be one overall guiding hand to assure that the system as a whole is adequate. A third-party review of the final design is recommended.

3.2 Loading

- Live loading might well be very high if balconies become crowded, self-evidently there is a likely load case of a concentration of people all along the cantilever tip. Moreover, the effective gravity loading may be amplified by dynamic effects from occupant's behaviour. Risks are highest where balconies are observational locations for events (Figure 2). Balconies might also be used for storage or within an increasing trend to use balconies as green spaces with extensive shrubbery (Figure 3). Dead loads have been known to increase where owners have screeded or tiled over existing surfaces (given balcony slabs are 'thin', the increased load can be significant).

Figure 2: Crowd loading on balconies

Figure 3: Balconies used as gardens

- The total bending at the cantilever support is a combination of moment from vertical loading and moment from horizontal loading acting on the edge balustrade. Both values may peak if users line up along the edge.

3.3 Edge barriers (handrails)

- CROSS has received several reports of balcony edge protection failures (see referenced reports Appendix 2 and Reference 6). Failures can occur as a result of overloading; from the edge protection structure weakening through degradation, or because new types of barriers are adopted. Reports in Appendix 2 refer to failures of glass barriers and here the hazard is two-fold. Firstly, there is the hazard of a barrier failure itself creating a danger to balcony users, and secondly there is the hazard of damaged glass falling onto people below. All balconies potentially create a hazard of 'falling objects' if gaps are left at the base or side of edge barriers.
- Edge barriers are normally vertical cantilevers with an appreciable amount of bending at their base. This bending might be applied directly to the main balcony cantilever or to some intermediate beam in which case that beam will be in torsion (and potentially too flexible). In all circumstances, the base connection is a key interface. Barriers are often anchored by some kind of proprietary fixing. Cases are known of where designs have been inadequate: fittings too close to edges and so on. Main designers should always verify this key detail. Ambiguity of design responsibility is common and not helpful.
- There are recent reports of excessive vibration in balconies which, apart from causing disquiet, raise the possibility of dynamic force amplification. Risks are highest where cantilevers are relatively long. To assure both adequate stiffness and resistance to vibration, checks are required of the rotational stiffness provided at cantilever supports.

3.4 Construction

- Balconies are often short cantilevers and if formed of reinforced concrete, likely to be relatively thin. Hence their bending and shear resistance might be disproportionally affected by tolerance errors in rebar positioning. CROSS has reports of failures being due to misplaced rebar with some rebar in practice being entirely within the bottom part of the cantilever. In effect, cantilever resistance (in any material) might be unduly sensitive to minor dimensional variations.
- Self-evidently, balconies supported on steel cantilevers are only strong and stiff enough if their end connection is adequate. However, cases are known of where beams are shallow and end space limited (the effect of tolerance coming to the fore) so making the insertion of a proper strong, and stiff, connection almost impossible. In this structural form, balcony safety relies almost entirely on the adequacy of a single connection.

3.5 Design

- Debris from any failed balcony may cascade down a façade onto lower units creating a progressive collapse (Figure 1): robustness is required. Putting aside the fact that vertigo and wind may severely restrict the use of balconies on tall buildings (perhaps to be considered by architects) the risk assessment for the potential structural failure of balcony connections on tall buildings needs to reflect the more rigorous design procedures applicable to the main structure. Opportunities for through life inspection are recommended.
- Recognising the practical challenges of connecting shallow long cantilevers to thin floors, increased factors of safety may be appropriate.
- Additional factors supporting the involvement of third-party reviews are; a weak application/monitoring of design and procurement by Authorities; thinking ahead to the UK Safety Bill, 'certification' of proprietary component designs may be required (some have proved severely limited in the detail); a better appreciation of the design of fixings.
- For weathering reasons, there is often a step at the balcony support interface. In concrete cantilevers this makes the detailing of top rebar potentially problematical. Clearly bending capacity is only adequate if top rebar can be adequately continued into the main structure at the rear. This is especially difficult if precast construction (in the rear) runs orthogonally to the balcony. In steel construction, interface steps may complicate the end load path and further reduce space for connections / continuity.
- Balconies might be formed of precast concrete or they might be steel or timber. In all such cases, structure is required at the fixed end to sustain the applied cantilever forces. There are potentially numerous design and construction interfaces between designers and suppliers. Compartmentalised design and construction are commonplace and that leads to ambiguous design responsibility.
- CROSS has received reports casting doubt on the capability of the inner structure to sustain the forces imposed by the balcony (these may be torsion). Assuring the required continuity across the interface is potentially more difficult in precast concrete structures and any design combining hybrid combinations of structural materials. This can lead to a procurement approach that compartmentalises the supply of factory manufactured components from different detailed design/suppliers.
- Where there is a demand for thermal breaks between balcony slabs and adjacent internal structure, proprietary fittings are available. However, their introduction means that achieving structural continuity, plus maintaining support stiffness and overall robustness may be compromised.

3.6 Durability

- Balconies are exposed structures. The capacity of any cantilever will be severely degraded if the top rusts (steel); rebar corrodes (concrete) or timber rots. Yet arguably the balcony location most exposed and most at risk of degradation is the point of support where maximum strength is required. Balconies in coastal environments suffer an enhanced risk of corrosion weakening. Exacerbating this problem is that in some countries balconies are intended to drain water off the outer edge along a downward slope from inside to out but due to many effects, surfaces may not have the intended slope resulting in water ponding at the critical location where the balcony meets the building face. Conversely, if balconies drain towards the building, there is a risk of continual soaking at the interface.
- Timber balconies are framed and exposed to the elements before enclosure and finishes applied. The resulting construction can create and hide active fungal growth, leading to weakened structure and potential structural failure, without any visual indicators.
- Balconies are frequently multiple units. If any balcony fails, it is an indicator that neighbouring balconies are in a dangerous state.

3.7 Older Balconies

- Older balconies (say dating from the early 19th century) which are common in London streets (and other cities with comparable stock) form a special case. The slabs are mostly stone cantilevers, sometimes with iron supports below. Balustrades are often cast iron. Because the slabs are stone, they are prone to weathering and degradation and prone to cracking induced by uneven settlement of the supporting brickwork. Corrosion of embedded balustrade posts can split off parts of the stonework endangering the balcony itself and posing risks to passers-by from falling debris (Figure 5).

Figure 5: Spalled corner of stone balcony

4. Fire on Balconies

Fire on balconies is also a severe risk. In December 2017, a fire on a timber balcony in a multi-storey building in Manchester (UK) spread up the façade balcony by balcony so allowing the fire to spread between fire compartments. This effect had dramatic consequences in June 2019 with a fire on timber balconies in London, apparently started by a barbeque. Very rapidly the whole façade was engulfed (Figure 6). Timber may have been used as structural supports, as decking, or as railings. However, **Changes to the Building Regulations in November 2018>** (post Grenfell, UK) (Reference 7) have banned combustible material on newly constructed facades, including balconies, but self-evidently the risk on existing buildings is high (Reference 8, which relates to fire issues on balconies).

Figure 6: Fire on timber balconies in London (Attribution: @sakukrish)

5. Pedestrian Hazard from Falling Debris

Particularly in urban areas, injury and fatality can occur to pedestrians from:
(1) debris such as falling pieces of concrete from deteriorated structures
(2) large pieces of falling ice from poorly drained balconies, and
(3) unsecured articles such as flower pots.

In a report for the Scottish Government over 1,100 separate incidents of items falling from buildings were recorded over a two year period.

There have been many reports in the public domain of falling materials and items, some of which have caused fatalities.

The UK government has effectively banned the use of laminated glass on balconies (linked to reduced fire resistance), with changes to the building regulations AD B. An alternative of toughened glass is available but has an undesirable mode of failure in shedding fractured parts onto persons below.

Summary

Although apparently simple structures, feedback reveals numerous problems with balconies. Most balconies do not have redundancy. Component failure, whether a parapet or floor connection, can lead to immediate collapse.

Balconies therefore need careful structural design since experience suggests they might be overloaded and might also be weakened by durability issues at their critical support point. A cantilever is a single point failure item, so as a minimum, high assurance of sustaining cantilever forces is required, this includes assurance that the requisite continuity exists into the rear supporting structure. The nature of balcony structures suggests that their strength might be unduly sensitive to minor dimension variations (such as misplaced rebar, effects of tolerance) or to reduced section sizes linked to degradation. Since all structures are required to be robust, that in turn suggests focussed attention should be given to assuring balcony robustness has the same design rigour to all the failure critical components as is applicable to the main structure's own robustness.

To guard against degradation, proper initial detailing must be followed. A good quality design will account for assuring long term durability from the outset. Thereafter, in service, regular inspections (and potential maintenance) should be promoted. Owners particularly should inspect regularly for water accumulation and leakage at the critical juncture of the balcony with the building face. In turn this implies that designs incorporate opportunities for through life inspection (i.e. any critical fixings normally hidden, ought to be capable of inspection when required).

Similar points apply to strength / stiffness aspects of balustrade design.

The functional aspects of balustrade design in containing people, especially children, and minimizing the risk of dropped objects have to be addressed.

Recent events have highlighted the high risk of fire when timber is used on any part of a balcony. An individual balcony may burn and the flames can then easily spread up an entire façade.

Many of these design issues are covered in a new UK Standard issued in August 2020: BS 8579 Guide to the Design of Balconies and Terraces.

There are risks associated with methods of procurement which introduce multiple interfaces. There should always be one party with a responsibility to assure that the final design, as a whole, is acceptable.

There are many images and reports of balcony failures on the web.

References

1. https://www.mbie.govt.nz/dmsdocument/103-dunedin-balcony-failure-final-report-19-august-2016-pdf->
2. https://www.stuff.co.nz/national/83474768/castle-st-balcony-collapse-subjected-to-grandstand-level-loadings>
3. https://www.hpw.qld.gov.au/__data/assets/pdf_file/0020/5546/deckbalconyandwindowsafetyguideline.pdf>
4. https://www.fairtrading.nsw.gov.au/__data/assets/pdf_file/0017/373310/Deck_and_balcony_safety_guide.pdf>
5. https://www.structuremag.org/?p=12285>
6. https://www.cross-aus.org.au/media/694762/scoss-alert-structural-safety-of-glass-in-balustrades.pdf>
7. Changes to the Building Regulations in November 2018>
8. https://www.bre.co.uk/filelibrary/Fire%20and%20Security/FI---Fire-safety-and-balconies-July-16.pdf>

For general advice see also:

- MHCLG advice: https://www.devonshires.com/publications/new-government-advice-note-on-balconies-on-residential-buildings/>
- https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/869532/Building_safety_advice_for_building_owners_including_fire_doors_January_2020.pdf>
- BRE ‘Fire safety issues with Balconies’: https://www.bre.co.uk/page.jsp?id=3773>
- https://www.designingbuildings.co.uk/wiki/Specify_with_caution_to_new_BS_8579:2020>

APPENDIX 1

CROSS reports

CROSS has received several reports of balcony and balcony edge protection failures.

- **Pre-cast concrete canopies in housing>**
- **Loading on balconies>**
- **Ceiling collapse in an educational building>**
- **Glass panel fixings failure>**
- **More on freezing and galvanised hollow sections>**
- **Modifications to balustrades in a shopping centre>**
- **Balcony collapse at block of flats>**
- **Balcony strengths of blocks of flats – further experiences>**
- **Risks from off-site manufacture and hybrid construction>**
- **Balcony collapse in France (news)>**
- **Steel balconies fixed to precast hollow core floor planks>**
- **Dangerous balcony construction>**
- **Dangerous glass infill panels on balustrade>**
- **AUS-18 High rise balustrade design>**

APPENDIX 2

News reports

Balcony structural collapses

- **Chicago, USA, June 2003>**
- **London - UK, November 2014>**
- **Berkeley - USA, June 2015>**
- **Jakarta - Indonesia, January 2018>**
- **Gwangju - South Korean, July 2019>**
- **North Carolina - USA, July 2019>**
- **Melbourne – Australia, December 2017>**
- **Brisbane – Australia, November 2008>**
- **Highland Terrace - St. Lucia – Australia, April 2017>**

Balcony fires

- **Manchester - UK, December 2017>**
- **London - UK, June 2019>**