CROSS Safety Report

Unsafe design of retrofit cantilever balconies

This month's CROSS report concerns a post-fixed residential balcony and shows the value of third-party checking, which prevented a potentially dangerous structure.

Overview

A structural assessment of several new balconies being added to an existing building revealed critical concerns in respect of fixings back into the existing brickwork.

Report

A structural assessment of several new balconies added to an existing building was undertaken by the reporter. The design of the fixings back into the existing brickwork was of great concern to the reporter. The building was of traditional loadbearing masonry with steel-framed balconies being added to upper floors. The balconies were supported only at their junction with the wall by way of a steel channel bolted to the wall and at their ends on a triangulated bracket, again bolted to the wall. The balconies were bolted only to the brick outer leaf of the external walls **(Figure 1)**.

Key learning outcomes

For structural and civil design engineers:

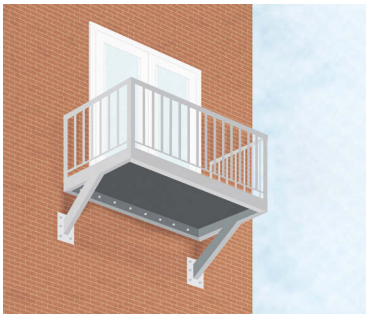
- →| Retrofitting balconies to cavity wall construction is fraught with difficulty
- →| Guidance, oversight and validation are essential to help design talent develop and produce competent designs
- →| CROSS Safety Alert *The management of design related risks: structural civil and fire engineers* considers design risk management
- →| The acceptability of critical fixings should be examined at the design concept stage

The reporter was provided with the design and drawings, which had been prepared by an engineering consultant. Although the designer had calculated pull-out loads in the top fixings, these were not used in the initial bolt design, only the shear loads were considered. Later, in justifying the design, the designer made the assumption that the balcony was infinitely stiff so that tension loading would be distributed to all top fixings. However, the framing was a steel channel bending about its weak axis and although there were intermediate beams, the reporter considered it was arguably not infinitely stiff. The even distribution of tension loads to all top fixings assumed by the designer was therefore considered not acceptable by the reporter. The tension loads would in any event be significant given the size of the balconies and the relatively small end brackets.

The reporter was not provided with any justification for the brickwork, which was obviously subject to new local loadings. Indeed, the reporter was of the view that the brickwork would be difficult to justify given the proximity of the fixings to free edges and openings in the brickwork.

The fixings used also concerned the reporter. The fixings were not stainless steel and only had a thin galvanised coating intended to protect against corrosion in the short term, indeed the manufacturer does not normally recommend the selected fixing for external use. In the finished state, the fixings would be hidden from view and therefore unseen corrosion of the fixings could also lead to a failure.

↓FIGURE 1: Balcony and fixings



The reporter says that a cantilevered balcony is a critical structure and any failure, in this case, would likely have been sudden with potentially life-changing consequences. The reporter confirmed that the design lacked an appreciation of load paths and an understanding of the fragility of the adopted structural solution, which, together with the potential for corrosion, meant that rectifications to the balconies were required. The reporter understands that the design was prepared by a junior engineer and that the design was not adequately checked by a senior engineer.

In conclusion, the reporter is of the view that fixing such structures to cavity brickwork should be avoided. Support should be taken from the floors or other main structural elements. Cantilevers should be avoided on retrofits and ideally the front edge supported by posts, which indeed was the case once the recommended remedial works had been put in place.

RETROFITTING BALCONIES TO CAVITY WALL CONSTRUCTION IS FRAUGHT WITH DIFFICULTY

Expert Panel comments

This is a very worrying report. All involved in the project team, but particularly the structural designer, are fortunate that a third-party check of the design was undertaken. The reported design appears frightening and wholly unsatisfactory.

The likelihood of an outer leaf being tied to sufficient structure to support these balconies is very low, even if the bolted connections into the brickwork could sustain the applied loadings, which is also very unlikely. In addition, bolted connections into the brickwork may well degrade over time due to thermal or other stresses, weathering or the effects of dynamic loadings. At some point in time, the balcony, with or without the supporting brickwork, would have been likely to simply peel off. Structural safety relies not just on adequate strength but also on controlling modes of failure such that they are ductile, do not cause harm and give warning of impending collapse. Rapid brittle type failures of any kind, as would likely be the case if a balcony peeled away, are to be avoided. As is illustrated with this example, retrofitting balconies to cavity wall construction is fraught with difficulty and indeed is not normally to be considered. Fixing back to, or introducing new primary structure, is a normal solution for retrofitting balconies.

The reporter was right to consider the stiffness of the deck. If the deck was not able to act as a stiff diaphragm, prying forces in the channel would increase the tension in the bolts at the ends of the channel. The potential for corrosion in hidden structural components is a wider concern, particularly where there may be little visible distress before complete failure. Critical fixings, as in this case, should be 'inspectable' during the life of the structure. Any fixings selected should, of course, be suitable for the intended use and exposure conditions. At the concept design stage, engineers would normally recognise where a solution requires critical fixings and assess acceptability before the concept is developed further. The long-term management of the structure is thus considered at this concept design stage.

Guidance, oversight and validation

For designs that appear unsafe to be developed and constructed is not acceptable. An inexperienced engineer might come up with poor concepts but that is exactly why guidance, oversight, and validation must be in place. Junior staff can be allowed to explore options but ultimately may need guidance on feasible solutions. Overviewing supervision should ensure design resources are used wisely while design validation processes provide gateways to ensure all design is competent and meets expectations. Guidance, oversight and validation are essential to help design talent develop and produce competent designs. Any failing, in this case, appears down to the design firm's senior staff and not any junior involved. CROSS recently published a Safety Alert, *The management of design related risks: structural civil and fire engineers*, which provides deeper consideration of design risk management including how people, process and product impact – all of which appear very relevant to this report.

Duties under regulations

A project of this type would normally be subject to the requirements of the Construction (Design and Management) Regulations 2015 (CDM 2015). Under the regulations, Designers and the Principal Designer have responsibilities that should prevent unacceptable designs from being implemented. It is one of the duties of the Principal Designer to work with any other designers on the project to eliminate foreseeable health and safety risks to anyone affected by the work and, where that is not possible, take steps to reduce or control those risks. Obviously, the Designer also carries duties to eliminate foreseeable health and safety risks to anyone affected by the project where possible. The implementation of unacceptable designs, on any project, may suggest that duties under the regulations have not been adequately met.

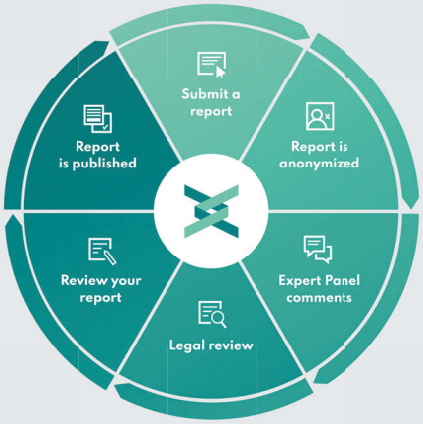
CROSS Safety Alert *Safety issues associated with balconies* concerns the structural failure of balconies. The alert includes consideration of design, loadings, adequacy of connection and weathering, all of which are relevant in this case.

The full report, including links to guidance mentioned, is available on the CROSS website (report ID: 1128) at **www.cross-safety.org/uk/safety-information/cross-safety-report/unsafe-design-retrofit-cantilever-balconies-1128**.

What is CROSS?

Collaborative Reporting for Safer Structures (CROSS) helps professionals to make structures safer by publishing safety information based on the reports it receives and information in the public domain.

CROSS operates internationally in the UK, US, and Australasia. All regions cover structural safety, while CROSS-UK also covers fire safety.



How reporting to CROSS works

The secure and confidential safety reporting system allows professionals to share their experiences to help others.

Professionals can submit reports on safety issues related to buildings and other structures in the built environment. Reports typically relate to concerns, near misses or incidents. Find out more, including how to submit a safety report, at **https://bit.ly/cross-safety**. Your report will make a difference.

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