CROSS UK
COLLABORATIVE REPORTING FOR SAFER STRUCTURES

The Institution of Structural Engineers | ice | The Institution of Fire Engineers

CROSS Newsletter

CROSS-UK Newsletter 69 | **June 2023**

Supporting constructions under fire doors and screens

Collapse of unusual hybrid concrete and steel strand truss on school roof

Fire safety concerns for partially occupied Higher Risk Residential Buildings

Modern methods of construction and robustness

Share knowledge to help create a safer built environment

Editorial

In response to the Grenfell Tower fire tragedy, Dame Judith Hackitt, in her *Independent Review of Building Regulations and Fire Safety*, recommended that CROSS should be expanded and strengthened. With support from the Institution of Fire Engineers and additional Government funding, CROSS relaunched in 2021 and now receives and processes fire safety reports in addition to structural safety reports.

Now, two years on from that relaunch, we are at an opportune moment to reflect on the progress made and consider our future plans.

So, what's happened since the end of March 2021? Well, in our first two years, we've been incredibly busy promoting CROSS to a wide cross-sector audience, embedding the consumption of CROSS in professionals' CPD, and encouraging reporting to us.

As you'll already know, CROSS is a community of professionals who share safety information to allow learning from each other's experiences. We promote an **open, collaborative, no-blame culture. Confidentiality** is also important to us - it is at the heart of our system. Through the cross-sector promotional work we've been involved with, I am struck by just how important this element is. We continue to emphasise how all reports we receive are anonymised before they are reviewed by our **Expert Panels>**. Reporters can be confident that their identity is protected.

Together with colleagues, we have been able to promote CROSS to a wide range of organisations including the Competence Steering Group, Office for Product Safety and Standards, Smoke Control Association, Local Authority Building Control and National Home Improvement Council. We have also delivered a range of CPD seminars for audiences including the Institution of Fire Engineers, Fire Protection Association, and Institute of Occupational Safety and Health, among others.

Early indications suggest that this promotional work is paying off. We are witnessing a 40% increase in website visits, a significant increase in LinkedIn followers and a substantial increase in Newsletter subscribers. I'm pleased that this increase in awareness is also beginning to translate into a steady rise in the number of reports we are receiving. The split between structural safety and fire safety reports is currently approximately 60/40. So, fire safety, from a standing start, is already making a substantial contribution to our work and is clearly an important addition to the scheme. Naturally, higher numbers of submissions are translating into an increase in our report publications too - with a similar split between structural safety and fire safety topics.

These trends are important. Reports provide an opportunity to address shortfalls within the industry. They may identify precursors, or trends, indicating a potential future safety issue. They allow CROSS to share lessons learned and improve competency. They may also help to inform regulatory change or advance industry guidance. Reports can make a difference and promote positive cultural change.

While it's too soon for us to draw statistically relevant trends from the fire safety topics being reported to us, here is a broad flavour of common areas of concern:

- the potential impact of scaffolding on fire safety
- potential dangers in misusing fire safety terminology
- fire spread through balconies
- fire extinguishers in common areas
- the fire performance of light gauge steel framing
- plastic composite fencing and decking boards
- passive fire protection issues
- fire safety hazards with lithium-ion batteries

Contents

Visit:
www.cross-safety.org/uk

Email:
team.uk@cross-safety.org

- testing of smoke control systems
- volumetric modular buildings
- apartment front doors
- compartmentation detailing
- hazards associated with 'green walls'

So, our next steps? We shall continue to build on this successful start to our wider remit. We also look forward to cementing our relationship with the Building Safety Regulator. They have a duty under the Building Safety Act to arrange for the operation of a Voluntary Occurrence Reporting System that facilitates the voluntary giving of information about building safety. We are delighted the Regulator has appointed CROSS to operate the scheme in its first year, and we shall continue to develop this opportunity to encourage the sharing of lessons learned and help drive culture change within the industry.

Peter Wilkinson
Fire Engineering Consultant

Share a safety report with CROSS

CROSS is a confidential system for built environment professionals to share information about fire and structural safety issues.

Submissions are anonymised and deidentified, so learning from each other's experiences can be shared within a no-blame culture.

CROSS' Expert Panels analyse anonymised submissions and provide comments which aim to identify underlying causes, suggest possible mitigations and signpost to useful publications.

Help create positive change and make the built environment safer - find out more about submitting a concern to CROSS.

Find out more >

More from CROSS

Work for CROSS

The CROSS-UK team is looking for a fire engineer to help process fire safety reports and share lessons learned and best practices with professionals across the built environment. Visit **cross-safety.org/uk/workforcross >** for more details.

Request a CPD talk from CROSS-UK

The CROSS Team is available to give presentations to professionals and organisations on the work of CROSS as well as examples of structural and fire safety failures, and the lessons that can be learned from them. To request a CPD talk please **complete the form >** and we will get in touch to make arrangements.

New - Guide to Managing Safety Critical Elements

The CIOB and RIBA have jointly produced **A Guide to Managing Safety-Critical Elements in Building Construction >**. CROSS were part of the team that peer reviewed the guide.

The guide is free to download and has been written with the intention of increasing awareness across all sections of the industry of the need to bring a rigorous and structured approach to the design, construction and inspection of elements identified as potentially safety-critical (elements that, if omitted or installed incorrectly, could cause a serious injury or loss of life to those in and around the building).

Newsletters from other CROSS regions

CROSS-AUS and CROSS-US recently published their latest Newsletters, make sure to take a look to review lessons learned from these international safety reports.

CROSS-AUS Newsletter 9 >
CROSS-US Newsletter 4 >

Supporting constructions under fire doors and screens

CROSS Safety Report   Report ID: 1181

A reporter raised the issue of interpreting test results for understanding the performance of system glazing fire doors and screens in raised access floors or lightweight construction methods.

Key Learning Outcomes

For designers:

- When designing compartment walls using lightweight means of construction, close attention must be paid to the structure supporting fire doors or glazed panels
- Designers may be responsible for the performance of these junctions in a fire
- Desktop assessments of systems against one or more standards, when the materials used may not have been considered in the original test, may result in safety being compromised

For contractors:

- Adhering to design details for supporting structures beneath fire doors and other compartment wall elements is critical

R Full Report

The reporter is concerned that an outdated understanding of appropriate supporting constructions for glazed fire doors and screens, based on steel-framed systems, are still in play in the fit-out industry in the UK.

System glazing is fire tested according to European standards with clearly defined supporting constructions. In these cases, the threshold is typically a concrete block and may be lined with calcium silicate. None of the door systems will have been fire tested on anything other than this firm form of the threshold.

> **The fit-out industry often installs raised access floor systems without breaking them at the threshold of a fire door**

The fit-out industry often installs raised access floor systems without breaking them at the threshold of a fire door. The compartmentation is maintained with a fire-rated batt-type barrier in the floor void, directly below the fire door. The reporter considers this form of construction for a fire door threshold to be of unproven performance because it extrapolates significantly from two other tests.

While a raised access floor may have been the subject of a fire test, it will have been according to the test standard for raised access floors, where the fire is below the floor and may only have been limited to the reduced time temperature curve at

News Roundup

In every interval between CROSS Newsletters, failures of some kind or incidents related to structural and fire safety are reported in the press. Here are some accompanied by a brief comment:

1. Multi storey car park collapses

Wisconsin collapse >
New York Collapse >

Two multi storey car park collapses have been reported in the US (one causing a death). Other multi storey car parks are known to have suffered degradation often allied with poor detailing. Through life inspections are required.

2. Subway station ceiling collapse >

A ceiling partially collapsed on the Massachusetts (US) subway narrowly missing a commuter. CROSS has reported numerous examples of ceiling/ suspended structure collapses. As this further one shows, such collapses can be dangerous.

3. Ship dislodged from holding >

At Imperial Dock in Edinburgh (UK), over 30 people had to be treated after a 3,000 tonne vessel keeled over in its dry dock. All structures, in all conditions, need to be stabilised against gross overturning failures. Attention should be given to the possibility of accidental support movement.

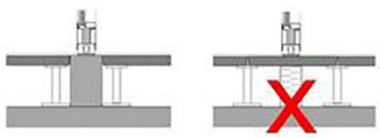
4. Car crash building damage >

In Bradford (UK), two police cars crashed into a row of shops causing significant damage to ground and first floors. Although such accidents are undefined design events, sound building practice requires that designs are robust to assure a measure of survivability.

500 °C. This is out of context with a vertical fire test of a door or screen where the temperature at full term will exceed 850 °C. The raised access floor fire test may have included a load on the top surface but, again, this is intended to simulate the effects of a normally loaded floor, not the behaviour of a steel-framed door under the effects of extreme heat.

The reporter believes the expected performance of that system cannot be properly assessed through the two independent system tests (raised access floor test and fire door test) due to their perceived lack of representativeness of the final application. It should be considered by designers that this form of construction may not have been available, or considered, when the tests were conceptualised. The reporter thinks that without any representative fire testing, there is no way to predict the behaviour of the floor system or its interface with the door, and integrity failure cannot be confidently ruled out.

Limitations - nature and extent of the tested supporting construction



A supporting construction that conforms to the definitions in EN 1363-1, **and is proven by fire test**, should be used with raised access floors broken either side

Unless supported by relevant fire test evidence, a raised access floor with a fire-stop beneath does not satisfy that requirement

Figure 1: raised floor fire screens

The reporter assumes there may be a number of causes for this issue:

- Ignorance of the testing standards and the test evidence behind the door systems
- Programme constraints requiring the raised access floor system to be installed as a blanket without planning the fire door breaks
- Main contractor budget constraints meaning they are unwilling to consider replicating the test threshold configuration while they are using lightweight constructions on the project

The reporter would like to have the assurance that their interpretation of the correct practice is accurate. They have never seen any directive or authoritative narrative that confirms that a raised access floor should not be broken on either side of a suitable threshold construction beneath a fire door, as illustrated in Figure 1. They would also welcome any comments or suggestions about systems that ensure adequate performance without a threshold break. In any case, it is useful to bring the issue forward for the education of the wider community on this, and potentially similar, issues.

C Expert Panel Comments

Testing and standards

This is a serious issue with widespread ignorance of the problem.

Raised floor systems are generally metal-wrapped chipboard, or calcium silicate boards, with pedestals to raise them up and create a void. The Panel are not aware of any tests being carried out on these in conjunction with fire doors. It is critical that the performance of the pedestals is considered part of the system.

This is a relatively new approach, previously contractors would have screeded stair lobbies or installed the doors within blockwork walls, with the raised access floor abutting the solid construction at the threshold. It is understood that contractors wish to remove wet trades from the site and so everything is lightweight plasterboard and raised floor carrying through. People have tried lots of details, and it is challenging to try and take the tested plasterboard wall detail under the door because it is not robust enough for foot traffic.

> **test reports should be carefully reviewed to ensure that the fire tests are actually applicable for the end use**

5. Building explosion and collapse >

In Marseille (France), three buildings collapsed ultimately killing eight people. The suspected cause was a gas leak which is a recurrent hazard initiating many structural failures. Some protection is required by making buildings 'robust'.

6. Train design fault >

In Spain, new trains were procured that could not fit through existing non-standard tunnels. In design it is all too easy to make a gross mistake, to concentrate on small details and miss the obvious. In any work involving existing structures, verify fundamental site information.

7. Cyclone Gabrielle >

In New Zealand, Cyclone Gabrielle caused huge infrastructure damage and some loss of life. Natural disasters threaten us all and cost vast amounts in infrastructure repair. There is a case for re-examining our design criteria to react to the consequences of extreme weather events.

8. US tornadoes

Mississippi tornado >
Illinois tornado >

The tornado season led to devastating events in Mississippi and Illinois (US). Several people were killed, and a theatre roof collapsed during a performance. Tornadoes are extreme weather events and public protection is partly by early warning. This was not effective in these cases since the tornadoes occurred at night.

Compartmentation should not be compromised in such a scenario and the test reports should be carefully reviewed to ensure the fire tests are actually applicable for the end use. One robust solution could be to use masonry or a concrete upstand at the line of the threshold, but whatever solution is proposed, those designing these systems must be aware they are responsible/liable for their performance in the event of a fire.

This may be a case of unthinking extended application of a fire testing standard. It is also potentially a case of a fire testing standard being applied in situations that were never intended - or even envisaged - when the test standard was developed.

Identifying wall makeup

An associated matter is the identification of the makeup of walls. The Panel suggests that there should be labels on all fire compartment walls. This should help prevent future breaches and might ensure holes drilled for cables or other services are suitably fire-stopped afterwards. It could be linked to an asset management system, via bar or QR codes, and added to the building information model (BIM) for the building.

Submit Report

Submit Feedback

9. UK flood risk map >

In the UK, new flood modelling by researchers from Bristol University and Fathom has concluded that the annual damage could increase by more than a fifth over the next century. This could be reduced if pledges to reduce global carbon emissions are met.

10. E-scooter explosion >

Video footage captured the moment an e-scooter burst into flames and exploded while on charge in the kitchen of a London home. There have been 48 e-bike fires and 12 e-scooter fires in the capital so far this year. London Fire Brigade warn they should not be charged in the home and advise that people should check their vehicles meet UK safety standards.

Collapse of unusual hybrid concrete and steel strand truss on school roof

CROSS Safety Report Report ID: 1227

This report concerns the collapse of a school hall roof which resulted from the failure of one of a number of unusual hybrid concrete and steel strand trusses. The trusses consist of a precast reinforced concrete top chord and verticals with a bottom chord of tensioned steel strands. The failure of the truss resulted in the collapse of the supported flat roof local to the failed truss, and damage to the adjacent structure and roof.

Key Learning Outcomes

For owners and persons responsible for the safety of buildings including schools:

- Inspect and assess existing buildings, particularly those that might have been constructed over 50 years ago, to see if they contain unusual forms of construction, including roofs similar to the reported failure
- If so, or if there is doubt, arrange for structural inspections and risk assessments to be undertaken by engineers who are suitably qualified and experienced persons (SQEP) – normally chartered structural engineers

For inspecting engineers:

- Undertake a risk assessment of old and unusual structures where there is a life-safety risk should they fail
- Consider what combination of causes could lead to a structural failure
- Understand where structural elements may be beyond their reasonable service life
- Look out for signs of distress while noting that some of these may be in hidden components or locations

R Full Report

This report concerns the partial collapse of a roof to a primary school hall. The collapse resulted from the failure of one of a number of unusual hybrid trusses. The trusses consisted of a precast reinforced concrete top chord and verticals with a bottom chord of tensioned steel strands. The failure of the truss led to the collapse of the supported flat roof local to the truss, and a partial collapse of the adjacent roof. The failed truss is shown in Figure 1 below. Fortunately, the collapse happened outside of school hours and when the hall was not in use.

These unusual hybrid trusses spanned the 10m wide hall, bearing on pockets in a precast ring beam which capped the external wall of the single storey building. The trusses were set at approximately 3.5m centres along the length of the building. The trusses

More CROSS reports

The following CROSS reports have also been published since our last newsletter:

Failure to grout steel frame bases (Report ID 1190) >

A reporter describes a problem that arose during the construction stage of a project when a steel frame supporting pipe and cable racks was loaded before the frame baseplates were grouted.

Behaviour of phase-change materials in fire when incorporated in linings in buildings (Report ID 698) >

Modifications are being made to the composition of some plasterboards by incorporating Phase Change Materials (PCMs). Such materials may alter the fire performance of the plasterboards.

Overall stability of building proposed to be provided by metal framing and plasterboard (Report ID 468) >

Metal framing and plasterboard was used to provide lateral stability to a building. The form of construction was later deemed to be unsuitable and extensive remedial works had to be carried out.

Incorrectly fixed sheets blow off parapet (Report ID 1180) >

Aluminium coping sheets blew off the parapet of a block of flats under construction. A building and a car were damaged but thankfully no one was hurt, although the potential for personal injury or death was significant.

Figure 1: failed truss and partially collapsed roof

supported precast concrete purlins over which were woodwool slabs, insulation and a felt roofing finish.

The bottom chord of the truss consisted of seven steel strands. The strands extended for the full length of the truss between anchorage plates cast into either end of the reinforced concrete top chord. The strands passed over four steel mounts located at the ends of concrete verticals cast integral with the top chord. Stability of the top chord was provided through diaphragm action of the woodwool slabs, thin screed and purlins, distributing lateral loads to masonry cross walls. A drawing of the truss is shown in Figure 2 below. It is thought that the building may have been constructed in the 1950s.

The reporter, a structural engineer, visited the site soon after the collapse. The roof truss had failed with six of the seven steel tensioning strands lying on the ground. The anchorage fixings for the detached end of the loose strands were found in the bearing pocket of the edge beam. The anchorages for the other end of the strands remained with the top chord endplate. The purlins on either side had collapsed or were damaged and hanging from one end, but the felt roof was still intact and holding water.

The reporter considered that, at the time of construction, the purlins would only have had a bearing of around 20mm and there was evidence that they had been bedded on mortar in

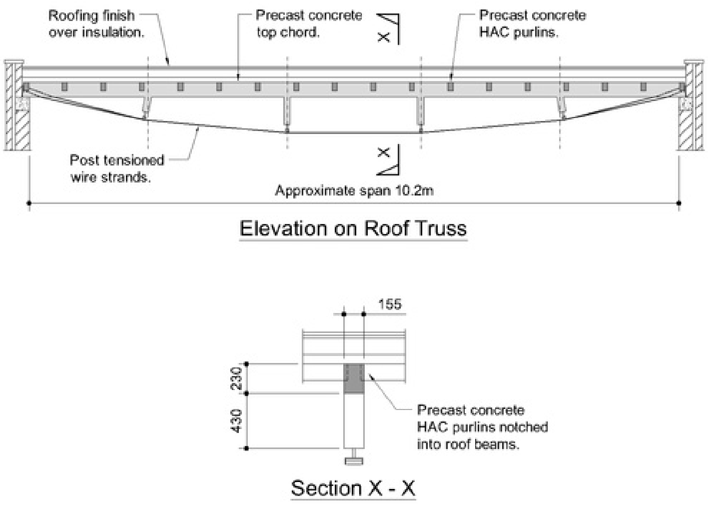


Figure 2: elevation and section through truss

Concern about rebending starter bars (Report ID 1164) >

This report concerns the bending and rebending of starter bars on site during the construction of a multi storey tower. The reporter considered that such a practice could compromise the structure under extreme load conditions.

Dangerous defects in curtain wall glazing (Report ID 762) >

This report concerns a 5m high vertical glazing system in which the fixings for a panel failed after only four years because of a lack of co-ordination between designers and contractors.

Stress fracture on temporary compact stairs (Report ID 805) >

A stress fracture to a temporary access compact stair unit was identified on site by a scaffold manager.

Private Building Control data protection use (Report ID 825) >

A reporter needed details of a domestic extension from a local authority who said that an application had been made for the original work by a private company, but that under the Data Protection Act they could not release any drawings or documentation.

Inadequate bridge bearing pad installation (Report ID 828) >

During the final construction phase of a reinforced concrete bridge deck, the contractor installed the elastomeric bridge bearing pads using a non-approved and potentially dangerous methodology.

pockets on top of the truss. It appears that, probably around the time of construction, a steel angle was fixed to the top chord of the trusses to provide additional support to the purlins, presumably owing to their small bearing width.

The tensioned strands were held at the endplates using a cylinder with two serrated split wedges, as shown in Figure 3 below. The strands were carried over the concrete verticals on support rollers. It was not clear to the reporter how the truss was originally tensioned. The reporter says that there may have been an initial tensioning at the factory, with further tensioning prior to installation using the threads on the steel mounts to lengthen the verticals, thus tensioning the strands. Figure 4 below shows the steel mounts and strand support rollers.

Figure 3: anchoring cylinder with two split wedges

Figure 4: steel mount on concrete vertical carrying tensioned strands

The reporter goes on to say that concrete from the failed truss was tested in a laboratory and found not to have any significant defects. Some surface corrosion of the reinforcement was observed, but this could be expected from a concrete element of this age. The detailing of the reinforcement, however, did not appear optimal; the bars were lapped in the middle of the top chord with a non-standard detail. Furthermore, the reinforcement did not fully extend to the beam end and the bearing appeared to be minimally reinforced. There was also minimal link reinforcement at the end of the beam where the anchorages failed, although there was no shear cracking at the end of the failed truss. There was some surface corrosion to anchor plates and the tensioning strands, but no loss of section was visible. Testing confirmed that the concrete in the purlins was made using high alumina cement. Degradation was apparent in some of the purlins which suggests that conversion had taken place and reduced the structural integrity of the purlins. The reporter's inspection did not identify any significant cracking or distress to the hall structure below the eaves level concrete ring beam.

The reporter believed the failure possibly resulted from anchorages of the tensioning strands slipping suddenly without warning. This could have led to a global failure of the truss in bending, as witnessed by the significant deflection and damage that occurred at the centre of the span. The reporter reasoned that once the anchorages had slipped, tension was lost in the strands and, owing to the poor detailing of the reinforcement at mid span, combined with the reduced capacity of the concrete chord, the truss likely failed in bending at mid span and collapsed. This caused the purlins to become dislodged and the roof structure in the two bays on either side of the truss to fail and deflect or collapse to the ground.

the failure possibly resulted from the anchorages of the tensioning strands slipping suddenly without warning

Punching shear design spreadsheets (Report ID 830) >

This is a technical note from a reporter about the methods their firm uses for punching shear design, because there was concern about punching shear design spreadsheets leading to potentially unsafe situations.

Incorrect fabrication of balustrade connection (Report ID 851) >

A reporter describes how threaded bars were incorrectly used for a balustrade fixing, instead of bolts, which led to failure of the connection.

Accidental partial demolition of a beam (Report ID 855) >

During a site visit, the permanent works design engineer noticed that hydro-demolition of the end of a floor supporting beam had taken place out of sequence. This introduced a pattern of bending moments and shear forces that were not considered in the original design.

Change in use results in masonry wall failure (Report ID 884) >

A room with walls of traditional cavity and single skin masonry was lined with plywood and used for storage of wood chips. No thought was given to the lateral pressure on the walls which eventually failed.

Architectural panel acting as barrier (Report ID 927)

A reporter came across a scenario on site where an architectural decorative panel was acting as a barrier during the construction stage without being designed to act as one.

The reporter goes on to say the inherently defective nature of the truss system, exacerbated by creep and age, combined with poor reinforcement detailing and the poor detailing of bearing notches for concrete roof purlins may have all contributed to the failure. The reporter adds that the roofing felt was proven to be watertight by the fact that it held water that accumulated in the deflected roof structure until the felt was pierced during subsequent demolition. The roof felt held a considerable amount of water, but there was no evidence of an accumulation of water at roof level prior to the collapse, and there was no evidence that the roof drainage was defective in any way.

The reporter wishes the details of the failure to be disseminated so that trusses of this type in schools or other buildings can be identified and appropriate measures be taken.

C Expert Panel Comments

This could have been a very serious incident had the school hall been occupied at the time of the collapse. The construction method is unusual and it is important to share findings to help prevent other similar events.

Unusual structural systems do exist

Variations of the reported concrete structure have been used in bridges, and a similar structural system has also been used in timber trusses. A concrete truss system where precast units were transported to site and then stressed together is also known to have been manufactured. This collapse serves to emphasise that bodies responsible for the safety of buildings must be aware that novel structural systems, as illustrated in this case, may pose safety risks.

Potential causes of failure

The reporter did not know the cause of the failure although they believe it was possibly associated with the strand anchorages. A number of causes could be postulated, and it is likely that a combination of causes led to the collapse. A failure of a tendon or tendon anchorage is one potential cause. Movements at the truss end bearing could be a contributory cause, promoting crack development around the anchorage and loss of anchorage or disruption of the top chord. Creep stretching of the tendons causing sagging of the truss and the potential for rainwater ponding could be an exacerbating factor. Replacement roof coverings could have also had an impact over time.

> **it is likely that a combination of causes led to the collapse**

It should also be borne in mind that a truss of this type would have very low horizontal stiffness and the lateral stability of the top chord could therefore be susceptible to being compromised. The lightweight nature of the roof deck and very small purlin bearings may mean the construction is not particularly robust, and lateral restraint to the trusses could be lost which would have been very detrimental. Although not reported in this case, where woodwool slabs are subject to water damage, their ability to accept and distribute loadings could be reduced.

Suffice to say, a number of different effects, including, creep, thermal movements, load changes and damage, could have been at play and led to a sudden or progressive failure of the truss bearing, tendons or tendon anchorages. It is known that the truss was in the order of 60 to 70 years old at failure and, therefore, beyond reasonable expectations of its service life.

> **the truss was in the order of 60 to 70 years old at failure and, therefore, beyond reasonable expectations of its service life**

SCOSS (now CROSS) published its alert **Tension cable and rod connectors>** in 2012, which concerned the failure of tension cable and rod systems.

Critical details should not be hidden

It is not good practice to have critical details, such as anchorages, in a location where they are not easily inspectable, as appears to be the case with this failure. Any structure which relies on strands or cables for its structural integrity should be designed such that the terminations are visible and easily inspected. The inspection of strand and cable terminations needs an experienced eye as potential issues are often not immediately apparent. Persons inspecting buildings should be mindful that critical parts of a structure may be hidden from view.

Keep robustness in mind

It may be the case that the trusses themselves, and the adjacent decking providing restraint, are not particularly robust. The robustness of the structural system and the nature of any particular modes of failure, particularly those without warning, should be considered during the design or inspection of structures. While not thought to be a contributing factor in this case, the presence of high alumina cement (HAC) concrete should be noted. Its rapid strength development made HAC popular from 1950 to 1970, but, mineralogical ′conversion′ sometimes caused reductions in concrete strength and increased vulnerability to chemical attacks.

Inspection regimes based on risk

Those bodies and persons responsible for the safety of buildings, should understand that these deteriorate over time, and in doing so, the risk of failure increases. Structural elements constructed in the 1950s and 60s may now have reached the stage of being beyond a reasonable expectation of their design life. Inspection methodologies for buildings should take into account matters that influence risk such as age, exposure conditions, usage, construction type and previous inspection and maintenance strategy. Likely failure types and consequences should also be considered; the failure reported here could be considered a sudden failure, the type of failure to be guarded against, as there was no apparent warning. Inspection regimes should recognise such issues, and focus resources using a risk based approach. Inspection and assessment of buildings should be done on a regular basis.

CROSS recommends that responsible bodies or persons arrange for appropriate inspection and assessment of buildings that contain unusual forms of construction, including roofs similar to the reported failure, and take appropriate action following the assessment. Structural inspections and assessments should be undertaken by engineers who are suitably qualified and experienced persons (SQEP). Key points to look out for include the following (there may be others in specific cases):

- Structural forms that are unusual in terms of innovative design or materials
- Buildings that would pose high safety risks to the occupants if they collapsed
- Buildings that are manifestly old and were designed to outdated codes
- Structures with minimal redundancy
- Obvious signs of deflection, leaning, leakage, cracking, corrosion, or damage
- Fixings or bearings that are hidden and may require intrusive investigation

The discovery of such features does not mean there is a high risk but it may mean that a detailed investigation is needed.

SCOSS published the topic paper **ASSESSMENT AND INSPECTION OF BUILDINGS, and other facilities>** in 2003. While some aspects of this paper arguably require updating, it may still be a useful reference to those persons involved in considering inspection methodologies.

The Institution of Structural Engineers' publication, **Guide to surveys and inspections of buildings and associated structures>**, contains general guidance on the subject as does their publication, **Appraisal of existing structures (Third edition)>**.

Submit Report

Submit Feedback

Battery Energy Storage System concerns

CROSS Safety Report   Report ID: 1166

A reporter informed CROSS about issues that emerged, and had to be resolved, in the design and management of Battery Energy Storage Systems.

Key Learning Outcomes

For designers:

- Engage early with the Fire and Rescue Service in the design process of Battery Energy Storage Systems
- A Battery Energy Storage System may not always be a 'common building situation'

For the Fire and Rescue Service:

- Attempt to provide guidance on the design specifications for Emergency Water Supplies within the appropriate jurisdiction

For operators of Battery Energy Storage Systems:

- Consider the necessity of producing an Emergency Response Plan for First Responders
- Review the process of detecting a fire and alarming the emergency services
- Ensure that safety signage complies with the Electricity, Safety, Quality and Continuity Regulations 2002

R Full Report

The safety issue reported relates to a Battery Energy Storage System (BESS) which was built and commissioned in 2018.

Due to the drive to decrease reliance on fossil fuels and limit carbon emissions, renewable energy sources are increasingly being used. This increase in renewable energy comes with several challenges, one of which is that often renewable energy is produced when the grid doesn't require the energy. This means the potential energy being created is either lost or stored for use when the grid requires it. For the latter case, there was a National Grid policy on **Enhanced Frequency Response (ERF)>** which evolved into the **Dynamic Containment system>**. This need for storage means an increase in BESSs to store energy when the demand in the grid increases.

The reporter is of the opinion that the application of Approved Document B (ADB) to meet the functional requirements of Building Regulations is not always sufficient for certain types of buildings, considering that BESSs should be considered as 'complex' situations. They think the technology in relation to BESSs is changing and evolving at a fast pace, and can potentially outpace current fire safety guidance or legislation.

To cater for these cases, the reporter considers it helpful to share some of the lessons learned from the project, so that practitioners can be aware of them and address the issues accordingly should they be encountered. The reporter raised three issues regarding their experience with the installation.

the application of Approved Document B (ADB) to meet the functional requirements of Building Regulations is not always sufficient for certain types of buildings

Emergency Water Supply

Firstly, a fire hydrant has not been provided within 90m of the site, and this was never picked up on in the consultation with the Fire and Rescue Service (FRS). In this case, that means that the nearest fire hydrant is some 1.7km from the site.

Furthermore, there is no Emergency Water Supply (EWS) at the site. It has been suggested that attenuation ponds can be used as an EWS but, in the reporter's opinion, they cannot. This is for the following reasons: the attenuation ponds are seasonal and often there is no water within them, making them an unreliable solution; the attenuation ponds are also not deep enough for a fire appliance to obtain a lift; finally, there is no penstock which means it is not possible to contain water within the pond to provide an adequate depth.

This is of concern to the reporter, because should a fire situation occur at the BESS it is likely the delay in obtaining an adequate water supply could result in the fire spreading to include other electrical infrastructure. This is because it is accepted in the reporter's circles that water is the best firefighting medium for the containment of a BESS fire. Large volumes of water could be required should an incident occur, though it should be clarified that this is not to extinguish the fire but to prevent it from spreading to adjacent installations or buildings.

Signage

The other issue raised by the reporter is that signage is often poorly displayed at the BESS. This means a first responder attending an incident may not be able to identify the message of the sign. In this case, the 'Danger of Death' signage displayed at the access points is not on a yellow background, only the inner portion of the triangle is yellow. Additionally, the signs have been placed on a brush steel effect background. Operators of BESSs, and FRSs, need to be made aware of the **Electricity, Safety, Quality and Continuity Regulations 2002>** in which Schedule 1 - Design, Colours and Proportions of the Safety Sign states:

'The triangle, symbol and text shall be shown in black on a yellow background.'

Detection and Alarm

These sites are often remotely monitored – in the reporter's case the site is remotely monitored in another European country. Initially, however, the Automatic Fire Detection would only raise the alarm abroad and the monitoring company was able to summon the local FRS. This has now been resolved by the Automatic Fire Detection system being linked to an Alarm Receiving Centre in the UK. The Alarm Receiving Centre will contact the Centre in the other European country should a signal be transmitted to confirm a fire or false alarm.

Considerations

The reporter made several suggestions that could potentially resolve many of the issues recognised in this report:

- To avoid similar issues from occurring in other BESS installations, it is crucial that the FRS and proposers of BESS to engage early in their design process. For this engagement to be meaningful, the FRS should acknowledge the BESS should initially be seen as a 'complex' situation (hence the application of only ADB rules for such premises not being acceptable to the reporter)
- Designers of BESSs within the UK should consider the usefulness and appropriateness of any rules found in **NFPA 855 – Standard for the Installation of Stationary Energy Storage Systems>**. In the reporter's experience, some suppliers, developers and designers have recognised the benefits of applying concepts of NFPA 855 to certain aspects of their design
- Operators of BESSs need to produce Emergency Response Plans (ERPs) for First Responders (firefighters). The ERPs need to be developed with the design specification of the BESS, but also in collaboration with the FRS that has responsibility for the BESS
- FRSs in England should provide guidance on the design specifications for EWS within their jurisdiction. This could be similar to the fire appliance access table e.g., the specifications for an above ground EWS to include connections for the FRS to discharge and resupply, a low-level alarm, or trace heating to prevent freezing
- More guidance is needed on the design specification for a BESS within England, considering that a document like NFPA 855 would be a beneficial tool for designers and reviewers

C Expert Panel Comments

The Panel agree that there are significant fire safety concerns related to BESSs. Battery storage is an essential part of society's move towards a zero-carbon future, but it needs to be done in a way that recognises and manages risk.

Firefighting water supplies

As identified by the reporter, containment of a fire is likely to require a substantial volume of water. The example given, where a site was created without consideration of a firefighting water supply, may not be an isolated event, as there is no requirement to inform or consult the FRS during the planning stage and this issue is unlikely to be picked up by any other body involved in the project.

The Panel identify wider concerns regarding domestic (relatively small) and mid-scale (similar in size and appearance to ISO shipping containers) which are being placed into/on top of/underneath/adjacent to premises. Larger grid-scale systems may be classed as infrastructure and may fall outside of the scope of the Building Regulations. From a UK FRS perspective, this limits the opportunities the UK FRS has to even be made aware of the proposal, let alone to be able to comment.

this limits the opportunities the UK FRS has to even be made aware of the proposal

Standards and guidance

The Panel agree that large-scale BESS are likely to be outside of the scope of ADB, are not a common building situation and are not considered in the scope of other widely accepted fire safety design documents in BS 9999/9991. This then requires that a performance-based design from first principles address the risks required.

NFPA 855 (2023 version) is available and has been informed by high profile incidents and learning. Attention is also drawn to the Country Fire Authority's **Design Guidelines and Model Requirements for Renewable Energy Facilities (2022)>**

There is a need to provide future guidance on appropriate fire safety provisions for BESSs based on evidence, research and lessons learned from real fire incidents, to assist a fire-engineered performance-based approach solution.

Consultation at the planning stage

It would clearly be beneficial for early engagement with the FRS to take place but there is no statutory requirement for a consultation with the FRS at the planning stage. Information is required that provides sufficient detail to allow meaningful consideration of the hazards, and to enable an assessment of the suitability of the proposals to manage potential risks. The National Fire Chiefs Council (NFCC) are planning to publish guidance to FRSs on this matter in 2023.

It is noted that some FRSs routinely check planning applications in their areas and follow up on the ones that are deemed significant based on the information provided. This is not a statutory duty, the extent of the practice is unknown, but it gives an opportunity for timely advice regarding matters such as water supplies and access, matters that may be more costly and difficult to provide later on in a building project.

New developments on greenfield sites will be of particular interest because they will be unlikely to have the water supply and access infrastructure. Planning for new towns or housing estates may cover this, but it is less likely on rural/agricultural sites.

Lessons learned from international events

There have been some significant fires involving BESSs, and some training resources and lessons have emerged:

- Fire Safety Research Institute **modules>** on Lithium-Ion Batteries and Lithium-Ion BESSs
- FSRI **report>** into Surprise, Arizona BESS incident
- Fisher Engineering, Inc and the Energy Safety Response Group's **Victorian Big Battery Fire>** report into a Tesla Megapack fire in Australia
- CTIF (the International Association of Fire and Rescue Services) **accident analysis>** of a Beijing lithium battery explosion which killed two firefighters

Firefighter safety - consequences of defensive firefighting

BESSs clearly pose a risk to firefighters, as evidenced by the incidents listed in this report.

Through the FRS information and gathering processes and production of a site-specific risk information (SSRI) record, it is possible that the FRS may adopt a defensive strategy. This could lead, in event of a fire in a BESS, to limiting firefighting to protect surrounding risks and not directly tackle the fire. An uncontrolled fire is likely to lead to the production of toxic and potentially explosive gases entering the environment through the fire plume and contaminated water runoff. Firefighting is challenging when the BESS is in the open air. If it is inside the premises, this introduces further challenges and potential operational decisions that may lead to an uncontrolled fire.

This could lead … to limiting firefighting to protect surrounding risks and not directly tackle the fire

CROSS-UK report 1058 - **Fire safety risks with lithium-ion batteries states>**:

'…this is not only an isolated sector issue but one that society must address together in good time … This issue is not only of concern to the FRS, but the designers, developers and occupiers of these sites also need to acknowledge the risks and evidence of how these systems can be safely integrated into society.'

Submit Report

Submit Feedback

Concerns over corrosion of dissimilar metals in fixing cavity wall tie systems

CROSS Safety Report   Report ID: 1186

A reporter is concerned about corrosion that may occur between dissimilar metals that can be used in cavity wall tie systems. The reporter has noted that stainless steel and carbon steel may be fixed together in wall cavities, which are damp environments, and that corrosion of dissimilar metals in contact may occur.

Key Learning Outcomes

For architects, engineers and other specifiers:

- Corrosion resulting from dissimilar metals in contact in damp environments, can lead to structural failures
- Select the correct fixings for wall tie systems to achieve at least the required design life
- Consult manufacturers regarding the life of wall tie systems and their fixings, taking into account the site exposure conditions
- The whole wall tie system, including fixings, should be shown on the construction drawings
- During site visits, check that the whole wall tie system is being installed adequately

For manufacturers:

- Ensure that the design life for all systems and materials, for varying exposure conditions, is readily available to specifiers

R Full Report

A reporter is concerned about corrosion that may occur between dissimilar metals that can be used in cavity wall tie systems. In particular, the reporter has identified that stainless steel and carbon steel may be fixed together in wall cavities that could be considered damp environments. The reporter cites that, as modern methods of construction evolve, this situation could occur more frequently with metal components, which are likely to be stainless steel, positioned in the cavity and fixed back to framing or other structural elements forming part of the 'inner skin'. The reporter is concerned that the fixings holding the stainless steel components could be more susceptible to corrosion if they are made of carbon steel and are positioned in the cavity. The issue is illustrated in Figure 1.

The concerning matter is the material selection for the self-drilling screws (or similar fixing) that hold the stainless steel component in place. The reporter says that some manufacturers only provide stainless steel fixings, while others offer a choice between stainless steel and zinc plated carbon steel. The reporter goes on to say that zinc plated carbon steel fixings are, in their experience, not offered with a 50 year warranted life, whereas stainless steel fixings in such circumstances are offered with a life that meets the normally specified 50 year design life for buildings in the UK. The reporter argues that such systems are restraining

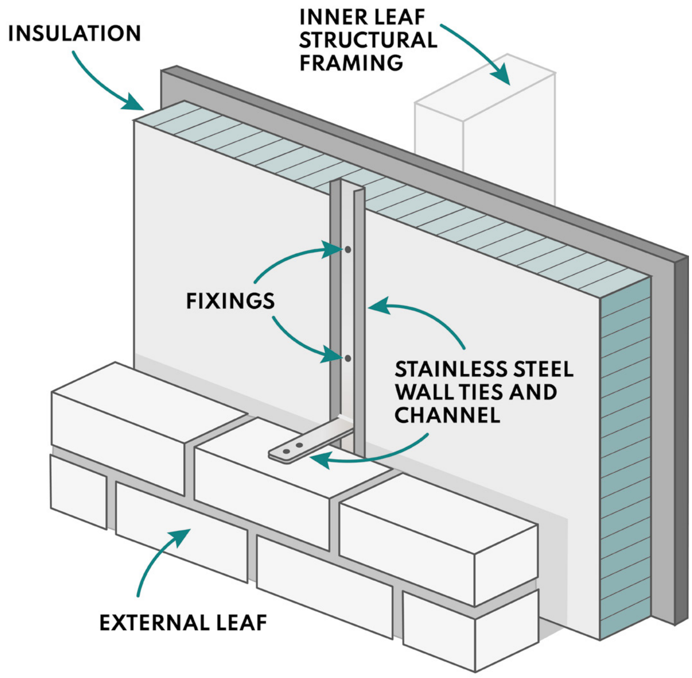


Figure 1: fixings that could be susceptible to corrosion

the full masonry façade of the building and therefore the whole system, including the fixings, must be considered and assessed to meet the required design life of the building.

The reporter says that installations, such as those shown in Figure 1, are gaining in popularity since significant work can be completed before masonry construction starts, with a mason only needing to fit 'twist and fit' ties as masonry construction proceeds. Furthermore, as these products are often procured once the masonry subcontractor is appointed, it may be that the products are just considered from a price perspective.

> **it may be that the products are just considered from a price perspective**

The reporter contends that the cavity space cannot be considered a dry environment and that the presence of water in the cavity can cause bimetallic corrosion between stainless steel components and any carbon steel fixings.

The reporter, therefore, urges specifiers to ensure that all fixings for cavity systems are assessed as fit for purpose, including meeting the building's required design life.

C Expert Panel Comments

The reporter rightly raises the issue of corrosion which may occur due to the use of dissimilar metals in damp environments. Cavity and other damp environments have been known to be prone to corrosion problems since failures of masonry ties in coastal environments became apparent.

Dissimilar metal corrosion is something that may occur when different metals are in electrical contact under moist conditions. For this corrosion to occur, the metals in contact must have sufficient difference in their electro potential. The presence of moisture is also required, to form an electrolyte which enables the corrosion reaction to take place. When this situation arises, it will be the less noble of the metals, the carbon steel in this case, which suffers the additional corrosion. Corrosion arising due to this dissimilar metal effect will be localised to the contact area between the dissimilar metals.

> **Dissimilar metal corrosion is something that may occur when different metals are in electrical contact under moist conditions**

Guidance was published in 1979 by British Standards in **PD 6484:1979 Commentary on corrosion at bimetallic contacts and its alleviation>**. This guidance provides an indication of the additional corrosion of carbon and low alloy steel that may result from contact with other metals including stainless steels. Contact between carbon and stainless steels, in rural and industrial/urban atmospheric exposure conditions, may result in slight or moderate additional corrosion. However, under more aggressive exposure conditions, such as in a marine atmosphere, the additional corrosion may be severe and PD 6484 recommends that either protective measures are required, or contact should be avoided. The level of corrosion will depend upon the duration of wetting, the ratio of the exposed areas of carbon steel and stainless steel at the contact, and the nature of the moisture that is present as bimetallic corrosion is sensitive to the presence of constituents in the moisture.

As in the reported case, where stainless steel channels are fixed back to the structural framing with carbon steel fixings, dissimilar metals may come into contact. The channels are generally fixed to the structural framing of the building by self-drilling, self-tapping fixings which pass through a hole in the channel, through the insulation and fix to the structural framing which could be concrete, steel or timber. Where the fixings pass through the stainless steel channel and a mechanically secure connection is made, this is likely also an electrical connection and where the carbon steel could corrode.

Conditions in the cavity

The stainless steel channels and the heads of the fixings are located in the cavity of the cladding system. Since the cavity is vented, daily temperature changes will generate regular airflows. This routine air movement will tend to allow the atmosphere inside the cavity to match the external environment. Therefore, exposure conditions in the cavity will be dependent upon the location and vary from one site to another. Equally, daily temperature changes may lead to condensation from time to time. When condensation occurs on the stainless steel channels it may lead to moisture at fixing positions. Where channels are vertical the condensation may drain to the fixing locations. The geometries under the head of the fixing and between the threads, with very narrow gaps, will lead to moisture ingress to the stainless steel/carbon steel connections, due to capillary action. Once drawn into the narrow gaps, the drying time may be extended due to the small exposed surface area. Levels of condensation will vary, as will the drying times, and therefore, it will generally not be possible to predict metal loss over time due to corrosion.

> **conditions in the cavity will be dependent upon the location and vary from one site to another**

Carbon steel fixings are typically coated with a protective layer of zinc. This zinc coating is very thin and is intended for protection in moderate environments such as inside a building. Thin coatings may not provide protection for extended periods of wetting. Furthermore, the zinc is soft and some of it could possibly be removed during installation of the fixing through the stainless steel channel. Therefore, some of the protection from the zinc in the threads may be lost. Where the zinc is intact, on the head and shank adjacent to the stainless steel, it may be consumed due to the same dissimilar metal effect. The zinc coating adjacent to the dissimilar metal contacts may be consumed more quickly than would be expected for a non-dissimilar metal connection.

Exposure conditions

The atmosphere in cavities of buildings that are located inland may be mild and condensation that forms in them may be low in aggressive constituents. Under these conditions, the additional corrosion due to dissimilar metal connections may be relatively low. In contrast, where buildings are in more aggressive locations, such as marine environments, the atmosphere in the cavities will be more aggressive. This will be reflected in the nature of the condensation, which may lead to more severe corrosion. Exposure also varies with building height and orientation, so facades higher up on buildings and facing prevailing weather may be subject to greater exposure and risk of corrosion. It is important to note that all building types, not just masonry clad buildings, could be affected.

It is important to note that all building types, not just masonry clad buildings, could be affected

Where minimum design life requirements for the cladding systems are expected to match the building, typically 50-60 years, the potential for dissimilar metal corrosion introduces an element of uncertainty with respect to the stability of the outer skin. Due to the progressive nature of any corrosion, this uncertainty will increase with time. It should also be noted that these fixings are hidden from view, are not readily inspectable and, therefore, should be made robustly.

these fixings are hidden from view, are not readily inspectable and, therefore, should be made robustly

One method of avoiding possible dissimilar metal corrosion while still using carbon steel fixings is to isolate the different metals at the point of connection. However, this is not really feasible where self-tapping connections engage with stainless steel channels.

Specify compatible fixings

Structural designers and other specifiers should take the lead in specifying stainless steel systems and compatible fixings for damp environments where corrosion between dissimilar metals may be a concern, unless other measures to avoid dissimilar metal corrosion are taken. These fixings are more expensive, but their use will completely avoid the problem of dissimilar metal contact inside the cladding system. Designers should specify the whole wall tie system on construction drawings. Arrangements should also be made to check installations on site. Manufacturers should be consulted regarding the life of fixings, taking into account the site exposure conditions. Manufacturers should ensure that the design life for varying exposure conditions for all systems and materials is readily available to specifiers.

There may still be dissimilar metal contact where the stainless steel fixings engage with any structural support system. However, when these connections are inside the building, and there are no condensation issues, there should be no potential for dissimilar metal corrosion.

Finally, as suggested by the reporter, it is easy for later value engineering exercises to propose changes to specified cavity wall tie systems, perhaps because their critical nature is not appreciated. All involved with designing, specifying and building cavity wall systems, of all types, should be mindful of the required life of such systems before changes in specification are proposed.

The National Physical Laboratory has published **significant guidance concerning corrosion>** including **Guides to Good Practice in Corrosion Control No. 5 - Bimetallic Corrosion>**.

CROSS-UK report 811 - **Galvanic (bimetallic) corrosion not considered in cladding design>**, published in 2022, concerned corrosion between stainless steel bolts and aluminium cladding. CROSS-UK report 931 - **Masonry panels rock in wind due to missing wall ties>**, published in 2023, dealt with the critical nature of wall ties generally. This report also referenced the Standing Committee on Structural Safety (SCOSS) Alert - **Inquiry into the construction of Edinburgh Schools>**, published in 2017, which reported upon significant structural defects of external walls at a number of schools.

Submit Report

Submit Feedback

Fire safety concerns for partially occupied Higher Risk Residential Buildings

CROSS Safety Report   Report ID: 1169

Fire authority checks found several safety failings in partially occupied Higher Risk Residential Buildings.

Key Learning Outcomes

For inspecting authorities:

- It is advised to closely monitor the development progress for indications that buildings are being allowed to be occupied by residents
- If residents partially occupy a building, it is suggested not to rely on the issuing of final completion certificates before initiating inspections under section 7.2.d of the **Fire and Rescue Services Act 2004>**, or under the Government's High-Risk Residential Inspection programme

For contractors, clients and building owners:

- If the partial occupation of a building is being considered, the areas to be occupied and their full escape route (and any associated systems) would need to be assessed as being in full working order and providing the appropriate level of protection

R Full Report

As a fire authority, the reporters inspected two separate new residential developments under the Government's Higher Risk Residential Building (HRRB) programme which was set up after the Grenfell Tower fire. Both sites came under the same developer and represented similar issues of concern.

Although both developments were incomplete, the reporters had received partial completion certificates referring to individual apartments, but there were no final completion certificates for the whole building. However, the reporters were made aware that the developers were allowing occupation of completed apartments despite the common areas of the buildings and external areas still undergoing works, and without an overall completion sign off.

> **developers were allowing occupation of completed apartments despite the common areas of the buildings and external areas still undergoing works**

Prior to the inspections, the reporters requested documentation from the developers relevant to the partially occupied buildings, including:

- commissioning certificates for all fire safety related systems
- the Fire Risk Assessment

However, none of this documentation was made available prior to the inspections.

On the days of the inspections, the site manager was asked if fire safety related systems had all been commissioned. The manager verbally reassured the inspectors that they had been, but they were unable to show copies of these certificates or a copy of a fire risk assessment.

On inspection, several issues were found:

- At one site, there were access issues for fire appliances to partially completed and partially occupied blocks, because of large planters being sited. This had been done to prevent residents from parking in the central courtyard area, which would obstruct ongoing construction works. However, this also prevented adequate access for the fire service to the occupied high rise residential buildings
- At one site, on a level where apartments were being occupied, the smoke detectors in the communal corridor had not had their covers removed. This would have prevented the automatic mechanical ventilation from activating in the event of fire, potentially putting escaping residents at risk

- At one site, the reporters were unable to locate the override control for one of the firefighters lifts, making it unusable as a firefighters lift. They were then informed that the switch had been installed at basement car park level but had been covered up. An engineer was urgently called to rectify this and re-sited the switch at ground floor fire service access level. However, on inspection by the fire service, it was found the lift still travelled to basement level on activation of the override switch. This again had to be rectified. This issue would have significantly delayed firefighting and rescue operations to occupied flats on the upper floors
- The same firefighters lift was fitted with a smoke curtain at basement level. On activation, this curtain failed to activate due to a poorly installed plasterboard ceiling obstructing its descent
- At another site, the firefighters lift, once activated and under fire service control, would not open its doors when returned to ground floor level. In addition, the original fire strategy drawings showed the firefighters lift being one of two passenger lifts opening on the upper residential floors within 7.5 metres of the firefighting stairs, in accordance with current technical guidance. However, upon inspection it appeared that the installers had configured the wrong one of the two passenger lifts for firefighting purposes, which resulted in the lift further from the firefighting stair being adopted, opening more than 9 metres from the firefighting stairs. This meant that there was a consequent significant deviation from building regulations guidance without any justification or assessment

The reporters' main concerns are:

- The principle of allowing residents to occupy high rise residential buildings that have not been fully signed off and are still undergoing construction works on site. This is occurring because either there is a lack of understanding from the developers of the importance of fire service access and the correct functioning of fire safety-related systems in high rise residential buildings for maintaining the safety of residents, or there is an understanding of the importance of these systems for residents' safety but the drive to generate returns on investment takes priority
- The lack of documentation being made available to demonstrate fire safety-related systems have been commissioned prior to occupation
- The competency of the 'competent persons' carrying out the commissioning, assuming that the firefighting lifts had indeed been commissioned at both sites, given the number and seriousness of the obvious defects the reporters discovered

The reporters would like to advise inspecting authorities that are engaged in building control consultations, particularly in high-rise residential developments, to closely monitor the development progress for indications that buildings are being allowed to be occupied by residents, and not to rely on the issuing of final completion certificates before initiating inspections under section 7.2.d of the **Fire & Rescue Services Act 2004>**, or under the Government's High-Risk Residential Inspection programme, if and when it appears that the buildings are being occupied by residents.

C Expert Panel Comments

This is unfortunately a relatively common occurrence for Fire and Rescue Services (FRSs) to identify, and anything we can do to highlight this issue and educate the sector should be taken. The National Fire Chiefs Council (NFCC), and other sector stakeholders, have been involved in workshops with the Health and Safety Executive (HSE) regarding partial completion under the Building Safety Act (BSA), and this particular issue was raised and acknowledged.

The reporters identify many of the common failings that the UK FRS also identifies where partial completion occurs and can include (not exhaustive):

- Incomplete fire-resisting compartmentation between:
  - Flats
  - Flats and common areas
  - Flats and common areas and areas are still under construction
- Inadequate means of escape
- Inadequate access and facilities for the FRS
- Inadequate/inoperable fire detection (to raise alarm and/ or operate other fire safety measures)
- Inadequate/inoperable suppression systems
- Inadequate/inoperable smoke control systems

places occupiers, and firefighters, at an increased risk

This practice not only places occupiers, and firefighters, at an increased risk that should not exist, it also places an additional regulatory and resource burden on those authorities that have jurisdiction in addressing these shortcomings. This can affect not only FRSs, who are generally the enforcing authority of the Regulatory Reform (Fire Safety) Order 2005 (FSO), but also the HSE and Local Authority Housing/Building Control departments.

From a fire safety perspective, this sees the FRSs having to use the FSO to address failings under the Building Regulations (as amended), something for which it is not directly suitable given the fire risk assessment, as required by the FSO, should be informed by the Regulation 38 fire safety information, under the Building Regulations (as amended), from a premises design that complies with the Building Regulations (as amended). However, this may still result, and has resulted, in formal action being taken under the FSO that can lead to:

- Issuing of article 30 Enforcement notices
- Issuing of article 31 Prohibition notices (which may prohibit or restrict the use of the whole, or part of, the premises)
- The commencement of investigation to ascertain if offences under the FSO have been committed, with the potential to lead to prosecution

This should not be happening and it is imperative all required safety measures be in place to protect those that are occupying the premises, regardless of how many occupiers that may be. It is acknowledged developers and investors wish to realise financial gain for their investment, but this cannot be at the cost of risk to occupiers, and firefighter safety. It is also acknowledged that, in England and Wales at least, there is no requirement for sign off by a Building Control Body before occupation.

Moving forward, for those new (and altered/extended) premises that will fall within the scope of the new BSA regime under the Building Safety Regulator via the Gateways, specifically Gateway 3 Occupation, it is expected this practice will not be permitted to arise. It is hoped these lessons will be applied to the wider built environment for all premises, those in and out of the scope of the BSA, and this dangerous practice will cease.

Submit Report

Submit Feedback

Modern methods of construction and robustness

CROSS Safety Report   Report ID: 1179

This report relates to the design of a low rise modular building and the requirement, or otherwise, for positive fixings between the superstructure and the substructure.

Key Learning Outcomes

For structural and civil design engineers:

- Approved Documents are guidance
- Eurocodes and institution guides are good practice, albeit that Eurocodes, as listed in Approved Document A, are the UK national standards
- Designers could consider making a case on merits, rather than endeavouring to comply with ill-fitting guidance
- It may be appropriate to consider the aims of the robustness rules and carry out a systematic risk assessment
- Further guidance on fixing superstructures to substructures when considering modern methods of construction would be helpful

R Full Report

A difference of opinion occurred between the reporter, a checking engineer working on behalf of the project's client, and the designer of a building. The building in question was a large two storey building to be constructed using some 100 modular units placed and connected together. The completed building would be approximately 100m long by 20m wide. The building was required to meet Consequence Class 2b requirements of the Building Regulations. The minimum required design life of the building was specified as 60 years. The detailed design of the building was undertaken by a contractor. The reporter undertook a check on the structural adequacy of the contractor's proposals.

The design showed the superstructure, comprised of connected modular units, supported on a substructure of reinforced concrete ground beams and piled foundations. Each modular unit was to have a loadbearing vertical column located at its four corners. The columns were to sit on, but were not fixed to, raised concrete plinths formed as part of the ground beams. The ground beams were not to be connected orthogonally to form a grid, but were discrete parallel concrete beams across the width of the building, under the line of the loadbearing structures over. There were no positive fixings proposed between the superstructure and the substructure.

> **There were no positive fixings proposed between the superstructure and substructure**

The reporter noted the substructure design was extremely efficient with the separate parallel foundations running under the wall of each modular unit. Lateral stability in the vertical plane was provided through the racking resistance of a number of internal walls. Stability in the horizontal direction relied on the continuity of the connected steel modular frames at the ground floor level, since there were no foundations running laterally for the length of the building. The piles, however, had been designed for a lateral load and an eccentricity of vertical load.

The reporter accepted that the ground floor construction acted as a connected stiff diaphragm, however, they queried the lack of a positive fixing between the superstructure and substructure for the following reasons:

- It was unclear how uplift and lateral shear forces were transmitted to the foundations to ensure lateral and overall stability
- The lack of positive fixings could mean the structure would not have adequate robustness to comply with the Building Regulations
- With a lack of positive fixings, the completed building could want to 'wriggle' (move from its plinth locations) due to either temporary construction issues, creep, thermal movements or unforeseen effects

The designer went on to show that there was sufficient dead load at primary supports so that uplift did not occur and that the lateral resistance, through friction generated from the dead load, was greater than the lateral force applied at the supports. Adequate factors of safety were therefore shown for global and local lateral stability.

Robustness requirements

The reporter considered that fixity to foundations was a requirement for robustness as required by the Institution of Structural Engineers publication, **Practical guide to structural robustness and disproportionate collapse of buildings>**. The designer disagreed and was also of the opinion that the concrete plinths satisfied the 'key element' provision of the Building Regulations. The reporter, however, considered that the plinths were not a 'key element' as, in their view, this is a requirement for more significant loadbearing elements potentially subject to accidental loading from larger surface areas. The reporter considered that the plinths should be considered minor elements in terms of overall stability, a view not accepted by the designer.

The designer did not consider that any post-construction issues, such as creep and thermal movement, were a risk to the project, although they did not provide any examples of similar completed projects to justify their case.

The designer did, however, propose a limited number of positional restraint fixings between the superstructure and substructure at both ends of the building. These were accepted as sufficient to show compliance by the certifying building control body.

Nevertheless, the reporter remained concerned. The reporter noted that Requirement A3 of the Building Regulations does not specifically require superstructure fixity to foundations but considered that fixity to foundations was a requirement for robustness as required by the Institution of Structural Engineers' publication, *Practical guide to structural robustness and disproportionate collapse of buildings.*

The reporter also noted that Appendix 6 of **BS EN 1991-1-7:2006+A1:2014 Eurocode 1. Actions on structures - General actions>** - Accidental actions, states:

(1) – Each column and wall should be tied continuously from the foundations to the roof level.

(2) - In the case of framed buildings (e.g. steel or reinforced concrete structures) the columns and walls carrying vertical actions should be capable of resisting an accidental design tensile force equal to the largest design vertical permanent and variable load reaction applied to the column from any one storey. Such accidental design loading should not be assumed to act simultaneously with permanent and variable actions that may be acting on the structure.

In the reporter's opinion, the design did not appear to comply with the Eurocode or the Institution's guide, and further guidance is required regarding the connection of superstructure to substructures for modular building design.

C Expert Panel Comments

The reporter raises an interesting concern where consideration of the regulatory framework may be helpful. It should be remembered that requirements relating to buildings in England are generally laid down in the **Building Regulations 2010>**. Most building works carried out in England must comply with the Building Regulations, other parts of the UK may have differing requirements. The **Manual to the Building Regulations>** published by HM Government describes the regulatory framework.

Available guidance

The Building Act allows the government to publish Approved Documents for guidance alongside the regulations. These give detailed advice on how to meet the legal requirements of the Building Regulations for common situations in domestic projects but may not be relevant for all situations. Following the advice in Approved Documents is not mandatory but adherence does tend to demonstrate compliance with the regulations.

Approved Document A>, generally refers to the relevant parts of Eurocodes for material dependent rules to satisfy the requirements. Eurocodes, as listed in Approved Document A, are the national standards. While engineers can design to any applicable standard, there may be an expectation that a structural design should meet the Eurocodes as a minimum or, where they do not, it be robustly demonstrated why an alternative approach is acceptable.

However, building types such as 'modular construction' are not wholly considered. For example, Eurocode 2 for the design of concrete structures, distinguishes between frame structures and panel structures. In addition, the Approved Documents are written for common building situations and the Manual to the Building Regulations highlights that the guidance may not apply to *'some buildings that incorporate modern construction methods*'. This may mean there is more of an onus for the designer to consider the aims of the robustness rules, and potentially could be a reason to treat the building as a class 3 structure and carry out a systematic risk assessment.

> **the Manual to the Building Regulations highlights that the guidance may not apply to 'some buildings that incorporate modern construction methods'**

The reporter raises requirements of a Eurocode and an Institution of Structural Engineers guide. These suggest something as good practice that is beyond the legal minimum. That is not an unusual circumstance. The question that arises is, would a failure to follow guidance lead to an unsafe structure?

A rationale for vertical tying is to hold the structure together in cases of internal blast where floors are lifted, reducing gravity compression, and allowing loadbearing walls to be pushed out. That concern might be overcome in masonry buildings if the loads are heavy enough (the gravity providing the tensile resistance) or might be intrinsically overcome with modular units where the whole structure just shifted up, and came down without disintegrating, and the structure said to be 'robust enough'. The task is to show the building will 'not collapse' and, in the example reported, a case might be made for that, without positive fixing between the substructure and superstructure. In some cases, designers should be making a case on merits, rather than endeavouring to comply with guidance that may not wholly cover the case in hand.

Stability must be assured

Clearly, stability must be assured. If the foundation mass is required to ensure stability, then the superstructure must connect to the substructure. There is, however, as the reporter concluded, no reason not to rely on friction to prevent sliding. It is interesting to note that other sources of guidance (**NHBC Standards 2022>**, **SCI P302: Modular Construction using Light Steel Framing: Design of Residential Buildings>** and **SCI P284 Modular Construction in Building Extensions>**) generally require that lateral movement and uplift are prevented, but do not explicitly require framing to be tied to substructures.

While many designers, in cases such as the one reported, will feel there should be a positive fixing between substructure and superstructure, it is difficult to state with certainty that it is wrong not to provide positive fixing. The merits of each case need to be understood and it demonstrated that the requirements, including disproportionate collapse requirements of the Building Regulations, are achieved, either through adherence to relevant guidance or other methods.

As suggested by the reporter, further guidance and clarity on the need to fix superstructures to substructures when considering modern methods of construction would be helpful.

Submit Report

Submit Feedback

Thatched roof fire during renovation

CROSS Safety Report   Report ID: 1174

A reporter is concerned about construction practices after a Grade 1 listed church was lost to fire following renovation works on the lead roof.

Key Learning Outcomes

For contractors and thatched property owners or managers:

- Hot works, i.e. work that involves the use of a naked flame, should not be carried out in the vicinity of a thatched roof
- Guidance is available, failure to manage the risk of fire may result in total loss of a property and potential enforcement action

R Full Report

The reporter describes how a Grade 1 listed church's lead roof was being renewed following the earlier theft of lead from the roof. The lead was placed adjacent to a thatched element of the roof. The work was undertaken by a sub-contractor.

As the weather was cold, the sub-contractor used a blowtorch to warm the lead to allow it to be unrolled. During this process, the thatch caught alight, which led to a fire that substantially damaged the church.

The thatch was completely lost to the resulting fire, along with most of the roof structure and the contents of the church, including the stained glass windows. There were also serious concerns about the structural integrity of the church tower following the fire

> **bodies have introduced a policy of removing hot works from the buildings where possible**

Following fires like the one at Uppark in 1986, where the roof was set on fire during renovation works, the Lead Sheet Association and other bodies have introduced a policy of removing hot works from the buildings, where possible, to prevent these issues. A simple alternative is to have a scaffolding platform placed remotely from the roof, upon which hot works can be undertaken.

Fire Risk Assessment

In the case described by the reporter, a simple fire risk assessment should have concluded that using a blowtorch next to a thatch was not a safe thing to do, especially as it had been very dry for the previous months. The thatch was also quite old and dusty. While a hot work permit had been granted by the church inspector for this incident, it is not clear if any conditions made were passed on to the sub-contractors.

The reporter suggests that where hot works which use a naked flame are to be carried out on heritage buildings, the potential consequence of fire needs to be taken into account before a hot work permit is granted. This needs to be addressed, at the very minimum, by a fire risk assessment of the hot works on the roof to be undertaken and a hot work permit should be granted for each instance and use.

The reporter goes on to say that the principles to follow are to remove the work from the roof if possible and to not allow any hot works on the roof. If this is not possible, where repairs are to be made, then individual works need to be risk assessed. Suitable fire extinguishers should also be provided, with the reporter's opinion being that the provision of a CO_2 or Dry Powder extinguishers are unlikely to provide suitable cover on a roof and that aqueous extinguishers are likely to be best. Finally, if hot works are to be undertaken where there is no option other than to do it in situ, then the works should be planned to be done earlier in the day to allow the material to cool and a check, possibly with a thermal imaging camera or similar, should be done before the end of the working day.

C Expert Panel Comments

This event could have been prevented with sufficient planning and the application of simple control principles. The National Farmers' Union Mutual Insurance Society (NFUMI) guidance referred to in this report covers hot works so should be used as the default reference document for all works involving thatched on or near thatched properties. It should also be remembered that works of this nature would come under the CDM Regulations 2015. The Health and Safety Executive provide **guidance>** on compliance with these regulations. In particular, the creation of a **Construction Phase Plan>** would reinforce the NFUMI guidance.

> **many thatch properties are located in remote, hard to reach locations, with limited water supplies**

It should also be noted that many thatch properties are located in remote, hard to reach locations with limited water supplies, so involving the local fire and rescue service in consultation when planning works could give reassurance (Construction Phase Plan) and allow for additional operational risk information planning.

Regulatory Reform (Fire Safety) Order 2005

Although the information is limited, it appears the Regulatory Reform (Fire Safety) Order 2005 may apply to some extent, depending on the nature of occupation and use at the time, which would inform who would be the enforcing authority. These works should have been considered in a review of the Responsible Persons fire risk assessment, and where there were multiple Responsible Persons, they should have shared the findings of their respective fire risk assessments to ensure there was no conflict etc.

Additional resources

- The Fire Protection Association's guidance - **Fires in thatched properties with wood burning stoves>**
- The NFUMI's guidance - **Fire safety guide to hot works within thatched buildings used for commercial purposes>**
- The **Thatch Advice Centre>** has a dedicated section on thatch fire safety that may also be of assistance

Submit Report

Submit Feedback

Incorrectly installed tension control bolts could have led to serious consequences

CROSS Safety Report   Report ID: 1196

A reporter finds incorrectly installed tension control bolts during a site inspection of a new highway bridge over a railway. The incorrectly fitted bolts could have had major structural implications, and led to other safety risks, if the installation error had not been spotted.

Key Learning Outcomes

For the contractor's site team:

- Connections can often be the weak link in structures and attention to detail is required
- A procedure should be followed when critical fixings, such as tension control bolts, are used
- When using tension control bolts, plies must be brought together as the first part of making a joint
- If you are uncertain about technical information provided by the fixing manufacturer, seek clarification from their technical support team
- Quality control and competent supervision on site help to ensure the correct fixings are installed in accordance with the manufacturer's requirements
- Critical connections must be checked after or during installation, as prescribed in the inspection and test plan

R Full Report

During an inspection of the site assembly of large steel plate girders for a highway bridge over a railway line, as shown in Figure 1 below, a reporter observed a bolting operative incorrectly installing 24mm diameter tension control bolts at a joint.

Figure 1: a bolted joint in a plate girder

The reporter explains that a joint with tension control bolts should be made in two stages. Firstly, drawing the joint plies together using a bedding torque (often with a simple spanner or torque gun) and, secondly, tightening the bolts to their final preload. In the case of tension control bolts, this is done using a special wrench that reacts against a sacrificial spline on the end of the bolt which shears off when a certain torque is achieved. Each stage involves tightening in sequence from the most rigid to least rigid part of the connection, usually from the centre outwards.

In the case observed by the reporter, an operative was tightening in one stage using a specialist wrench and working in no particular order. After completion of the joint, a bolt that was supposedly fully tightened was observed to be loose, as shown in Figure 2, and could be easily unscrewed by hand.

Figure 2: a loose tension control bolt after completion of joint

The reporter considers there were two potentially significant consequences:

- The connection clearly contained bolts without the designed preload. This may have had major structural implications if it had not been spotted
- The bridge was over a mainline railway. If the bolt had worked loose, it could have fallen onto the railway with potential risk to the railway

The reporter says that the bolt installer must not have been following the correct bolt tightening procedure and that the site team, it appears, was not inspecting and signing off at each stage. Site bolting of preloaded connections should be adequately controlled through all stages. The reporter adds that responsible persons on contracts with large bolt arrays, such as this one, should consider periodic verification of bolt preload using torque wrenches, lift off jacks, or other appropriate equipment.

The reporter concludes that tension control bolts are simple to install and are the choice of many specifiers. Their simplicity of installation may, however, lull installers into cutting corners as appears could have happened in this case.

C Expert Panel Comments

The reporter raises an important subject and makes a number of very appropriate suggestions to help prevent similar occurrences. The tightening of high strength friction grip bolts (HSFG), the forerunner to tension control bolts, received much attention in decades past but has perhaps now been off the horizon for some time. Many procedures are involved but they all start with plies being in contact which necessitates a sequential process of tightening, starting from the middle and progressing out. Not much strain is required to create the tension in a HSFG, and that small amount cannot be used in just pulling plies into contact.

Tension control bolts are no different, as the reporter says, plies must be brought together as the first part of making a joint. The manufacturer's requirements will show this and must be strictly observed. BS EN 1090-2:2018 **Execution of steel structures and aluminium structures - Technical requirements for steel structures>** provides guidance upon the use of tension control and other preloaded bolts.

> **plies must be brought together as the first part of making a joint**

If a tension control bolt is inadequately tightened, as it appears it was in the case observed by the reporter, its shear strength will not be adversely affected. However, the attributes of slip resistance (in bolt clearance holes), fatigue resistance, and resistance to loosening will all be lost, the latter being especially important in structures supporting moving loads or subject to vibration as with bridge works.

Maintaining the lubrication condition is paramount

While these bolts are looked upon by some as *tension* controlled bolts, they should be looked upon as *torque* controlled bolts. The tension in the bolt is critically dependent on the coefficient of friction achieved between the threads on the nut and bolt, which can be significantly affected by changes in lubrication conditions during transport, storage and use - a lesson learned on a number of projects. That said, there are many advantages to using tension control bolts but they must not be seen as a 'simple' solution. They require similar checks and balances as applied to their, more labour intensive to install, competitors and predecessors.

Follow an installation procedure

Fixings are critical and often the weak point in any system. Contractors should have a procedure to follow when critical fixings, such as tension control bolts, are used. Technical information should be sought from the manufacturer's technical support team as required, to assist in developing appropriate procedures.

Competent installation by trained operatives, and effective supervision by competent supervisors, should prevent occurrences such as those reported. A robust inspection and test plan (ITP) should be in place to ensure that structural components, particularly fixings, are suitably and sufficiently designed and installed.

CROSS-UK report 1185 - **Wrong length blind bolts lead to unsafe bridge structure>**, published in 2023, considered inspection and test plans for bolted connections on a bridge.

Submit Report

Submit Feedback

Design criteria for firefighting lifts

CROSS Safety Report   Report ID: 1182

A reporter is of the opinion that the design criteria for firefighting lifts should be re-evaluated.

Key Learning Outcomes

For designers and specifiers:

- Ensure the lift is specified correctly for the intended purpose
- Be aware of the difference between lifts that facilitate firefighting and those intended to be used to assist in evacuation

R Full Report

The reporter has worked for a main contractor for over 30 years and helped deliver large commercial, and some residential, buildings in the UK.

The reporter is of the opinion that the compliance criteria and design intent for firefighting lifts are flawed. They base this claim on the fact that the quantity of firefighting lifts is not dictated by the number and capacity of the occupants in the refuge areas of a building, whereas believe consideration for that is crucial.

They are concerned the refuge areas are inadequate as an approach to assist the evacuation from a building of Persons of Reduced Mobility (PRMs), such as people with disabilities, the elderly, small children, and people who cannot walk down the stairs perhaps due to a recent injury or an illness during the time of the emergency. The reporter is also worried about the impact of an ageing population and whether the current design approach accounts for that.

The reporter describes how they think firefighting lifts are, by and large, very small and can only accommodate two firefighter along with their firefighting equipment. Considering risk assessments are not carried out as frequently as the reporter thinks they should be, they worry about how long two firefighters would take to bring these people down to safety from refuge areas, especially as they have to consider their own safety too. This leads the reporter to support the argument for making it compulsory for at least the goods lift, and possibly one passenger lift, to be designed as a firefighting lift too.

C Expert Panel Comments

Terminology

While the reporter has raised concerns of interest and value, the Panel are keen to point out that the reporter may have highlighted a common misunderstanding of the purpose of a firefighters lift, and all other versions of lifts provided for the use by the Fire & Rescue Service (FRS), as use of terminology here is key. *Firefighters lift* indicates a minimum level of protection compared to the standard, which is what was installed in the reporter's case. We also have *firefighting*, *firemen's*, and *evacuation* lifts, and those with some specifically described (but limited) levels of protection.

The primary purpose of a firefighters lift is to provide access for the FRS to the scene of operations i.e., a compartment on a higher level (normally, but could be lower). The lift allows the FRS to establish sufficient resources and levels of control to fight a fire and/or effect a rescue quicker than would be experienced without such access. This also reduces the physiological impact on firefighters in establishing those resources, facilitating a more efficient and effective response. This is why the firefighters lift is one of the required methods established in statutory, and other, guidance provided in support of meeting the functional requirements of the Building Regulations (as amended), specifically *B5 - Access and Facilities for the Fire Service*.

> **A firefighters lift is not primarily provided to evacuate persons who require assistance in evacuation**

A firefighters lift is not primarily provided to evacuate persons who require assistance in evacuation, nor is this the responsibility of the FRS. It is the responsibility of the Responsible Person under the Regulatory Reform (Fire Safety) Oder 2005 (acknowledging devolved UK administrations may differ), and should be recorded in their fire risk assessment. However, if the incident in question, acknowledging every operational incident will be different, allows for the firefighters lift to be used for evacuation under the direction of the FRS who must remain in control at all times, where prior consultation with the FRS has taken place, this may be appropriate. However, if the lift is then needed operationally by the FRS its use as an evacuation aid will be removed.

Standard under development

Currently in development is **BS EN 81-76 Safety rules for the construction and installation of lifts - Particular applications for passengers and goods passenger lifts>**. - Part 76: Evacuation of persons with disabilities using lifts, with all comments from members states currently being considered by the overseeing European working group. Given the rules surrounding drafting, comments, resolution and publishing etc., it is unlikely this will be published before well into 2023. It is anticipated that the sizing, capacity and number of evacuation lifts required will need to be considered in each individual building's strategy, including fire, as it is not possible to set prescriptive rules in a standard given the needs will be dictated by the proposed, and reasonably foreseeable, occupancy of every premises.

It is also acknowledged the current version *BS EN 81-72:2020 Safety rules for the construction and installation of lifts. Particular applications for passenger and goods passenger lifts*. Firefighters lifts, has a minimum sizing and capacity for a firefighters lift. This is not the recommended size but is seen by many as the default. When the current version undergoes a review, there will be an opportunity for everyone to pass comment on any existing text or proposed changes, which may include the need to consider current firefighting practices and equipment to ensure the provisions remain fit for purpose. An interesting paper and presentation on the development of this standard, **Challenges to Drafting a Standard for the Evacuation of Disabled People Using Lifts>**, was given at the Lift and Escalator Symposium in 2022.

Number of lifts

The Expert Panel also agree there is an issue regarding Design Teams not adequately considering the number of lifts needed. While the reporter doesn't appear to be indicating whether the type of building they are referring to is commercial or residential, as each would come with different challenges, the Panel support the inference that evacuation of mobility impaired occupants is currently poorly accounted for within the design development stage. More should be done to practically support the Responsible Person in fulfilling their duties once the building becomes occupied. This concept of refuges and assisted egress is changing very rapidly, at least in London. The London Plan, policy D5, requires at least one evacuation lift at each core in addition to any firefighters lift, and the quantity should be justified by the number of people who may need to use them, as the reporter suggests.

Submit Report

Submit Feedback

Incompetent design of simple steel beams

CROSS Safety Report   Report ID: 1183

This report concerns designs for simple steel beams submitted to building control bodies under Part A of the Building Regulations. The reporter, a checking engineer for a building control body, was not able to accept the effective length and restraints assumed in a number of submitted designs. Most originated from individuals who used proprietary structural design computer packages without, in the view of the reporter, a sufficient understanding of the subject.

Key Learning Outcomes

For property owners, clients and commissioning architects:

- Steel beams and other structural elements should be designed by suitably qualified and experienced (SQEP) civil and structural design engineers
- All structural design should be signed off by an appropriately experienced chartered civil or structural engineer
- Be aware that the adequacy of a structural design submitted to a building control body is the responsibility of the originator - do not rely on the building control review

For structural designers:

- Designers must understand the principles of the problem at hand (and relevant design codes) before using software
- Structural design should be undertaken in accordance with the design standards as stated in Approved Document A in England and Wales, and the equivalent in Scotland and Northern Ireland
- Be aware that health and safety legislation places duties on all designers to ensure they do not put people at risk of harm

For building control bodies:

- Assess compliance of structural designs against the design codes stated in Part A of the Building Regulations in England and Wales, and the equivalent in Scotland and Northern Ireland

R Full Report

A reporter, who is a structural engineer checking building regulation applications submitted to a local authority in a UK city, has become increasingly concerned about the number of designs, submitted to show compliance with Part A of the Building Regulations, that they have judged as inadequate. Over the last year, the reporter's attention has been drawn to the number of issues they have had to raise in respect of steel beam designs for low rise domestic extensions, loft conversions, flat conversions and similar projects. The reporter's main concerns are that:

- some users of computer programs 'fill in boxes' without a sufficient understanding of structural design
- the effective length of steel beams designed under BS 449 and BS 5950 has been incorrect
- steel beams have been designed as fully restrained when they should have been designed as unrestrained

The reporter has assessed calculations for steel beams supporting timber floors and roofs that have shown the beam as fully restrained between supports, however, when the reporter has assessed the effective length based on the full span, the beam is judged as inadequate. The reporter has also had instances of beams supporting masonry walls being designed as fully restrained when, in the reporter's view, they should be designed as unrestrained.

The reporter says most of these issues have arisen when designers have incorrectly used proprietary structural design packages. The reporter believes a significant driver is the use of structural design programs by unqualified designers, and that it is very easy to purchase a software program and, with little training, prepare and submit design calculations. In the experience of the reporter, these concerns do not apply to steel elements designed under Eurocode 3, as there is greater guidance in this code, and it is not commonly used by unqualified designers.

The reporter goes on to say some local authorities do not deploy checking engineers and some approved inspectors only check larger schemes, and that this lack of checking could lead to incorrect designs being accepted. The reporter finds at least one incorrect design each week and considers that a similar picture across other regions would suggest many incorrect designs could be progressed every week and, ultimately, structures built in accordance with those designs.

many incorrect designs could be progressed every week and, ultimately, structures built in accordance with those designs

The greater number of issues the reporter has noticed concern designs to BS 449, which they believe is a simple code that lends itself to being used by unqualified designers. Although the reporter has also found that some experienced engineers are unaware of the revision to clause 26a of BS 449 in November 1995 concerning loading to top flanges and beam end fixity. The reporter understands that BS 449 is no longer supported by BSI and that, although not cited under Part A of the Building Regulations, building control bodies are unable to refuse its use. Nevertheless, the reporter suggests that BS 449 could be 'deleted from use'. The reporter has found fewer issues relating to applications designed under BS 5950 as they believe Table 13 (in that code) gives clearer advice regarding the effective lengths of beams.

The reporter believes that around 30 to 40% of structural applications originate from designers who are not members of any professional engineering body and, therefore, do not become aware of design issues through journals or other related information sources. Communicating with this group of people is difficult.

The reporter makes several suggestions that they consider could improve the situation:

- The new Building Safety Regulator could consider a requirement that only qualified engineers should submit calculations
- Software packages for single beams designed under BS 449 and BS 5950 should use a default effective length of 1.2L and treat beams as unrestrained
- There should be more guidance relating to the lateral restraint of beams. The only material the reporter could find regarding lateral restraint to steel beams was **P360 Stability of Steel Beams and Columns>** published by the Steel Construction Institute. This document provides details of how beams can be restrained but the reporter believes good site supervision is required to achieve the details on site
- The reported issues should be raised with all engineers checking building regulation applications
- CROSS should consider how the reported issues could be communicated to the wider industry beyond its readership

C Expert Panel Comments

The reporter is right to be concerned about the use of structural design software by persons who are not suitably qualified and experienced. Those undertaking structural design must be competent to do so. Incompetence can cost lives; the capacity of an unrestrained beam can be significantly less than when restrained, meaning that in the cases described possibly dangerous under-design could be taking place.

the capacity of an unrestrained beam can be significantly less than when restrained, meaning that possibly dangerous under-design could be taking place

CROSS receives many reports about structural designs being undertaken by persons who appear not to be competent, particularly in respect of work undertaken in the domestic residential market. CROSS-UK report 1132 - **Inadequate design for basement works>**, published in 2022, considered issues of designer and checker competency for structural alterations to a townhouse. Persons who issue designs that are incompetent not only risk lives but are likely also not meeting their legal obligations.

The reporter suggests a requirement that only qualified engineers should submit calculations; CROSS agrees with this suggestion and once again recommends that all structural designs be signed off by an appropriately experienced chartered civil or structural engineer. Clients, and other persons appointing structural designers, must satisfy themselves as to the competency of proposed designers prior to appointment. As a minimum, a structural designer should be expected to be a member of a professional body that regulates structural designers, normally the Institution of Structural Engineers or the Institution of Civil Engineers.

a structural designer should be expected to be a member of a professional body that regulates structural designers

Some of the reporter's concerns relate to designs undertaken to BS 449 and BS 5950. Steelwork designers should note that neither BS 449 nor BS 5950 appear in any of the lists of Codes, Standards and References in Approved Document A. BS 449 is not maintained by BSI and BS 5950 has been withdrawn by BSI. Approved Document A does however state: 'There may be alternative ways of achieving compliance with the requirements and there might be cases where it can be demonstrated that the use of withdrawn standards no longer maintained by the British Standards Institution continues to meet Part A requirements.'

Whilst BS 449 and BS 5950 are still used by some designers, CROSS recommends that structural design be undertaken in accordance with the current design standards as listed in Approved Document A. Superceded codes (such as BS 449 and BS 5950) are useful when assessing existing structures designed to previous codes, but new structures should be designed to the current codes since these represent best practice and are updated as required. Designers should also note that professional indemnities may only cover designs carried out to codes and standards stated in Approved Document A.

Use of software by persons who are not competent

The use of software to produce designs for simple steel beams may, in some cases, be happening because the user is not competent in structural design. Persons who do not know how to design a simple beam may be thinking an automated design process will take all matters into account. However, inputs determining effective lengths and buckling parameters must be determined by the user, and unless the user is suitably qualified and experienced then, unknowingly to them, their design may be unsuitable. Designers using structural design software should have enough experience and knowledge to anticipate the software outputs, for example, beam sizes, and recognise any outputs that do not 'feel right'.

> **Designers using structural design software should have enough experience and knowledge to anticipate the software outputs**

Inappropriate use of software by persons who are not competent has been reported to CROSS on a number of occasions, including, for example, CROSS-UK report 989 – **Dangerous design of a retaining wall>**, published in 2021. This report concerned what would have been a dangerous structure, liable to failure during or soon after construction, designed using software.

Restraints and lateral torsional buckling

The concepts of buckling and restraint are actually quite difficult and require sound engineering judgement. Competent structural engineers know that stability relies critically on restraint conditions. Some codes use words to describe different types of restraint, whereas some designers argue that pictures would be far more helpful and intuitive. For example, BS5950-1: 2000 Table 13 does not include illustrations, although Table 14 for cantilevers does.

As the reporter has rightfully noted, this gap is 'plugged' by guides, including **P360 Stability of Steel Beams and Columns>**. The reporter has suggested that default settings for effective lengths and restraints in software should be set at values that would produce more conservative designs; this may be helpful in some cases but is no substitute for competency. Competent designers will also know that deflection, or other criteria, may be the overriding matter determining final beam selection rather than bending stress.

Ensure all designs are checked before submission to Building Control

Structural engineering is a safety-critical profession. Structural design, regardless of the use of software or not, must go through appropriate checking processes, either within the design organisation or an independent organisation, as part of completing validation of the design.

> **Building control bodies have a responsibility to review all designs for compliance with Part A and its equivalents across the UK**

As very clearly illustrated by the reporter, the checking of engineering designs submitted under building control processes has many benefits including, not least, the prevention of unsafe structures being erected. Building control bodies have a responsibility to review all designs for compliance with Part A and its equivalents across the UK but, nevertheless, this does not absolve the designer from any of their responsibility to produce an adequate design.

The Institution of Civil Engineers published **Submission of structural engineering data for approval under Part A of the building regulations>** in 2015. The paper offers guidance to structural engineers to ensure they maintain an adequate standard, examining the components of an acceptable submission to building control bodies. It looks at essential competency standards that should be followed to help engineers protect the health, safety and welfare of those in and around buildings.

CROSS will continue to take opportunities to communicate to relevant parties its wider concerns about unsuitably qualified and experienced people undertaking structural design.

Submit Report

Submit Feedback

About CROSS-UK

We help professionals to make structures safer. We do this by publishing safety information based on the reports we receive and information in the public domain.

We are a trusted provider of free safety information for the built environment.

Visit the website>

Contact CROSS-UK>

How we are structured

The Institution of Structural Engineers

ice Institution of Civil Engineers

IFE The Institution of Fire Engineers

Sign up for our emails

If this Newsletter has been forwarded to you, please **sign up>** for email updates from CROSS-UK.

Email updates are the best way to receive the latest safety information and news from us, including our Newsletter.

CROSS on social media

CROSS UK