CROSS UK

COLLABORATIVE REPORTING FOR SAFER STRUCTURES

The Institution of Structural Engineers

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The Institution of Fire Engineers

CROSS Newsletter

CROSS-UK Newsletter 65 | **June 2022**

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Share knowledge to help create a safer built environment

Editorial

It is now over five years since the fire at Grenfell Tower took 72 lives. The on-going Public Inquiry has revealed failings which created the situation where a fire developed and spread through the tower. Dame Judith Hackitt identified key issues that need to be addressed to help prevent a similar failure occurring in the future, including the expansion of CROSS, to facilitate the sharing of learning and to foster a better safety culture.

The Building Safety Act, part of the legislative response to Hackitt's recommendations, received Royal assent on the 28th of April 2022. The Building Safety Regulator (BSR), previously operating in shadow form, will now enforce the new measures introduced by the Act for the safety and standards of all buildings. The BSR will also establish a new regulatory framework for all higher-risk buildings that are in scope. Not all parts of the Act will come into force immediately and the government has published a **transition plan and associated timeline>**.

Higher-risk buildings (HRBs), currently in scope, are defined as all buildings, existing and new, with 7 or more storeys or that are more than 18 metres from ground level to the floor surface of the building's top-storey and contain 2 or more residential units. It also applies to all care homes and hospitals meeting the same height threshold during design and construction. There is the ability for Government to extend the scope to other buildings.

The framework currently being established for HRBs includes:

- the HSE as a statutory consultee for planning applications
- the BSR becoming the building control authority
- the introduction of Gateways during the design and construction process
- responsibilities and accountability being defined for duty-holders during the design, construction, and occupation of buildings
- a golden thread of building information being maintained through a building's lifecycle
- the mandatory reporting of fire and structural safety occurrences to the regulator.

Each HRB will also require a safety case report to be submitted to the regulator by the accountable person, usually the building owner. This includes all existing in scope HRBs currently estimated at 12,500 buildings in England. The report will need to identify the building's major fire and structural risks and how they are being managed and controlled. The size of this task, and the need for it to be undertaken by suitably qualified and experienced persons, should not be underestimated.

The Act also requires the Regulator to establish a system for the voluntary reporting of building safety occurrences alongside a mandatory reporting system. This follows Dame Judith Hackitt's original recommendation to extend and strengthen CROSS. We look forward to further discussions with the BSR regarding this.

The Building Safety Act arrives almost exactly a year after the Fire Safety Act 2021 and corresponding Regulations, which are being commenced to address some of the recommendations of Phase 1 of the Grenfell Tower Public Inquiry. The Act requires the owners and managers of multi-occupied residential buildings to ensure that the fire risk assessments for such buildings are reviewed and updated to encompass the structure, external walls, and flat entrance doors.

These two Acts, and the secondary legislation they will generate, are the biggest changes to building safety legislation in almost 40 years and they are likely to affect all those working in the construction industry and those responsible for the management of higher risk buildings. They will be the legislative driver for culture change within the industry.

CROSS continues to advocate for culture change and this issue of our newsletter contains fire and safety reports that demonstrate the importance of sharing lessons learned.

Paul Livesey,
Scheme Manager, CROSS

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Reporting to CROSS

Your report will make a difference. It will help us to create positive change and improve safety.

Find out more >

Concerns over robustness of some 20 year old buildings

CROSS Safety Report   Report ID: 1051

A correspondent is concerned about the robustness of several two-storey buildings with which their design team were involved in the early 2000s. It was a stressful time with a high workload and there was pressure on the design team, some of whose members were inexperienced.

Key Learning Outcomes

Owners:

- Ensure design teams are allocated sufficient resource and time

Architects and designers:

- Collaborate closely with structural engineers and understand their recommendations

Civil and structural engineers:

- Do not succumb to time and financial pressures that compromise design principles
- Are encouraged to seek a review of their work by a competent person
- Do not allow yourself to be compromised on quality
- Follow your firm's quality management requirements

R Full Report

A correspondent is concerned about the robustness of several two storey buildings with which their design team were involved in the early 2000s. It was a stressful time with a high workload and there was pressure on the design team, some of whose members were inexperienced.

The structures generally had masonry support walls and precast floors. The architects kept pushing for thin walls, small support piers, and short or no buttressing returns. There was resistance to using steelwork over its cost. Furthermore, the architects sometimes specified floor insulation between the precast floor and the screed. This negated any membrane action the floor topping/screed could have provided.

A large internal review resulted in remedial work to a number of the buildings. However, the dreadful collapse in Miami in June 2021 of a much larger building, has reawakened the correspondent's recurring concerns as to whether they had not done enough at the time.

The correspondent says emphasis should be placed on:

- not succumbing to cost and time pressures
- having a very thorough checking regime
- not always trusting people to follow instructions

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. Stevenage building demolition >

A multi-storey building collapsed suddenly, and badly, during its demolition in Stevenage, UK. Part of the debris fell onto an adjacent road that was still in use. An investigation is underway, but the failure is a warning of risks linked to a lack of knowledge of an existing structure's state.

2. Trooping of the colour >

Part of the temporary viewing stand collapsed during a rehearsal of the annual 'Trooping of the Colour' ceremony in London. Three spectators were hospitalised. In the past, CROSS has issued warnings about the stability and inspection demands for such stands.

3. UK fires

Potters Bar Bus Garage >

Peak District wildfires >

Near London, the Potters Bar bus garage caught fire with the fire load being four busses alight. A reminder of the risk of high fire loads. Meanwhile, the long dry spell raised the risk of regional fires in the UK, especially in the Peak District.

Visit:
www.cross-safety.org/uk

Email:
team.uk@cross-safety.org

C Expert Panel Comments

The panel has sympathy for the reporter who has clearly been worrying about this for some time. It is reassuring to see that an internal review led to building modifications and it is hoped that this, and subsequent actions, addressed the reporter's concerns and that they are simply reporting to raise the issue so others don't have similar problems.

It was good to see that the potential risks had been identified and an internal review had been instigated. However, it should never have been allowed to get to the point where members of the organisation were so worried about the safety of a project.

The report raises wider issues because we know from feedback to the Institution of Structural Engineers (IStructE) that designers are generally uncomfortable with being able to demonstrate robustness. It is also known that some designers do not grasp the fundamental principles of stability, so there is a key message that robustness for even relatively simple structures can be problematical; indeed many of the reports to CROSS are related to such problems. There should be an overriding expectation on structural engineers to provide resilient and robust structures, irrespective of height and consequence class.

> **there is a key message that robustness for even relatively simple structures can be problematical**

The IStructE publication **Stability of Buildings>** is a helpful guide as to how buildings are engineered to have stability and robustness.

Design validation

This report raises the absolute need to have an experienced engineer review the design before it leaves the office and to stand up to architects, or others, who keep asking for minimum structure as opposed to sound load bearing elements. This is not uncommon, especially with inexperienced teams. Designers should always ensure that designs are properly checked and that any decisions taken that increase risk, as a result of external pressures, are justified and recorded.

There are always going to be cost and time pressures and younger engineers need to learn how to deal with them and act in accordance with their professional responsibilities to themselves, their clients, and the wider community. Some practical considerations are:

- Don't extrapolate beyond ratios and proportions that are known from experience to be safe without very careful consideration. The CROSS recurring theme of scale.
- Don't eliminate unquantified benefits to the stability of a design (i.e. screed laid on floor planks) without careful consideration of what it might mean to loss of hidden factors of safety.
- There is no problem having insulation under screed as long as lateral stability is assured; perhaps by having a structural topping.
- Never rush design work and always ensure independent checking of the overall principles at the very least, as well as the details.
- Thin walls supporting precast units may lead to inadequate bearing due to both the tolerances in the construction of the wall and the length of the plank as delivered to site.
- If an Engineer is being pushed to use thinner walls the potential risk of inadequate bearing needs to be considered both at the design stage and on site.
- With de-carbonisation rightly forcing better utilisation, buildings can become more efficient. However, that should never be at the cost of strength and stability. The need for robust detailing will become ever more prevalent in future.

4. Anniversaries of major events >

May saw the 50th anniversary of the Battersea funfair disaster, which resulted in 5 deaths. That event triggered the statutory need to assess the safety of all theme park rides. May also marked the 5-year anniversary of the Manchester Arena Bomb and a reminder of the need to assess the risk of terrorism on certain structures.

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5. International building collapses

China >

Iran >

There have been dramatic building collapses in China and Iran over the past few months. The collapse of a housing block in Changsha, China killed at least 53. In Iran, a 10-storey block utterly collapsed with concrete floors and steel beams crushing cars on the street below. There have been over 40 deaths reported so far.

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6. Extreme weather events cause damage

Tornado in Germany >

Welsh tornado damages properties >

The weather around the world continues to be threatening. There were extreme heat events in several countries approaching 50oC. And there was severe flooding (and landslips) in some other areas. In Germany, there was a tornado that left one dead and about 40 injured. Structural damage was severe. There was a (lesser) tornado in Wales. Extensive thunderstorms in Canada left 8 dead and resulted in large regional power outages.

Balancing commercial pressures

Remember that whatever the commercial pressures are, if something goes wrong, the law will get involved. If injury is caused or people are exposed to unacceptable levels of risk, there may be a criminal investigation. That part of the law would focus on the duty of the designer to produce a safe design. If shown to be unsafe, the commercial pressure is no defence.

> **If shown to be unsafe, the commercial pressure is no defence**

Designers should therefore always ensure that designs are properly checked. Where decisions are taken that increase risk as a result of external pressures these should be justified and recorded.

Finally, designers should be encouraged to seek reviews of their work by a competent person. Independent reviews are helpful not just in ensuring good practice but assisting with learning and team development. In 2009 SCOSS published a guidance paper **Independent review through peer assist>** which set out the relevant principles and is a useful reference.

Submit Report

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More from CROSS

Request a talk from CROSS-UK >

The CROSS Team are available to give presentations to firms and organisations. These give insight into the work of CROSS on structural and fire safety which include examples of failures and the lessons that can be learned. **To request a talk please complete the form>** and we will be in touch to organise.

Submit a report to CROSS>

CROSS-UK welcomes reports about fire safety and structural safety issues related to buildings and other structures in the built environment. If you have seen a near miss or incident or have knowledge of a safety issue submit a report so we can distribute the lessons learned. Reporting is confidential and all reports are anonymised.

Fire protection to light gauge steel frame walls

CROSS Safety Report   Report ID: 1116

A disagreement between fire engineers and manufacturers on testing for the loadbearing performance of light gauge steel frame walls in case of fire has been reported.

Key Learning Outcomes

For Light Gauge Steel Frame manufacturers and suppliers:

- Provide relevant information to help ensure that designers and builders provide adequate protection to all elements of a structure, including walls that are not separating compartment walls
- Internal loadbearing walls could be exposed to fire on both sides simultaneously and should therefore provide the required loadbearing fire resistance for such exposure

For designers:

- Any design should be tested against the functional requirements of the relevant building regulations, and not only against the provisions of technical guidance
- Internal walls that may not need to be fire-resisting for means of escape purposes (i.e. not separating walls) may need additional fire protection if they form part of the structure
- Light gauge steel frame elements may need additional measures to ensure they remain structurally stable in order to perform their intended function

For fire and rescue services:

- Light gauge steel frame structures that do not have all-round fire-resisting protection may be vulnerable in a fire situation, potentially leading to the progressive collapse of the whole structure

R Full Report

A disagreement between fire engineers and manufacturers on testing for the loadbearing performance of light gauge steel frame walls (LGSF) in case of fire has been reported.

Light steel framing (LSF) is a type of structural system in which thin, cold-formed steel sections, called light gauge steel (LGS), comprise the structural elements which are arranged to build the 'structural frame' in buildings. The reporter was involved in a project where LSF was chosen as the solution and a discussion was had regarding the expected load-bearing performance in a fire of internal non-separating walls. The term 'non-separating' refers to the function of the wall as a fire separating element, and not as an architecturally separating element.

More CROSS reports

In addition to the reports included in this newsletter, the following CROSS reports have also been published since our last newsletter:

Glass removal from façades >

Removal of a glass panel from a building façade left a reporter concerned for the safety of both operatives and the public.

Vegetation damage to railway arches >

Lack of clarity as to maintenance responsibilities leads to degradation of railway arches.

Object rolling into live carriageway >

A disc of concrete rolled from a construction area onto a live carriageway, colliding with a passing vehicle.

Preparation of holes in concrete for chemical anchors >

Reinforcement intended to be resin anchored into concrete was not anchored, because the resin did not cure, due to contamination within the holes.

Accidental concrete infill around a boxed out plunge column >

A problem occurred during a concrete pour to a boxed out temporary column resulting in an area of unsupported suspended concrete slab.

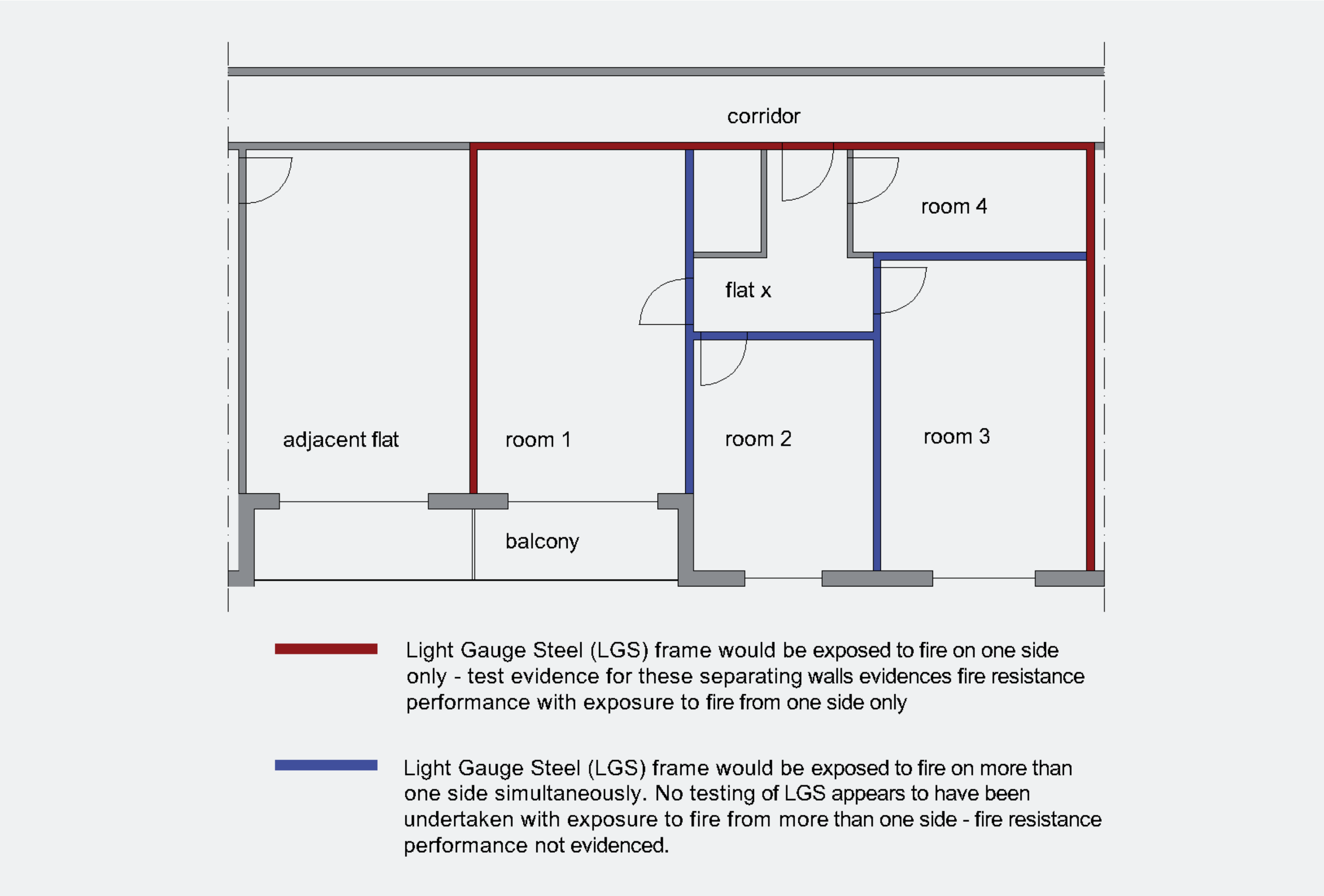

Figure 1: Light Steel Framing Structural Frame – Typical residential layout

Cause for concern

The concern was raised when the solution proposed by a leading manufacturer was considered, by the reporter, to be outside the limits of fire-resistance tests, and in their opinion 'without reasonable skill and care'. This led to further communication efforts with other leading manufacturers and suppliers, who seconded the original position of the LGS manufacturer, making this a common position among the LGS industry leaders. However, the reporter and the other consulted fire engineers disagree.

The core of the disagreement is that load-bearing fire-resistance test evidence for LSF assemblies and systems is based on fire exposure to one side only. The reporter considers that the real-world application of LSF includes non-separating loadbearing walls inside apartments which can reasonably be expected to be exposed to fire on more than one side simultaneously. Since these internal walls are part of the structure's loadbearing frame, a certain level of functionality needs to be guaranteed in terms of structural performance.

An example of a typical floor plan in a residential building is shown in Figure 1, in which highlighted in red are the compartment walls that are expected to be exposed only on one side in a fire situation (fire separating elements), whereas highlighted in blue are the internal non-separating walls that can be expected to be exposed to fire on both sides.

Approved Document B employs the performance classification for fire resistance as it is set out in BS EN 13501. Part 2 of this series of documents, covering the '*Classification using data from fire resistance tests, excluding ventilation services*', addresses in paragraph 7.2.2 the issue of classifying loadbearing walls without a separating function; it is stated that '*Loadbearing walls without a separating function shall be tested as columns by the method given in EN 1365-4*'. Columns, when tested in a furnace, are fully exposed to the heating conditions on every side.

Design meeting

During a design meeting between the fire engineers, the contractors (who chose LSF as a solution), and the LSF manufacturer, this issue was raised. The requirement to test according to BS EN 13501-2:2016 based on clauses 7.2.2.1 and 7.2.2.2 was brought forward, but the LSF manufacturer 'did not have an answer' and referred only to the guidance document P424 by the SCI. Subsequently, further support to the argument was found in BS 476-21, which in clause 8 (determination of the fire resistance of walls) states that *'This clause describes a method for determining the fire resistance of vertical walls with or without unventilated cavities, which have both loadbearing and separating functions, and which are required to withstand exposure to fire on one face'*. The reporter's interpretation of this is that single-sided testing is for separating walls only.

The reporter considers it more responsible to test LGS as a 2.5m wide wall (i.e. can fit in a test rig) and then extrapolate the expected performance under each specific field of application. Testing under reasonably expected thermal exposure is for them a defensible approach when compared to just testing to one side. Professionally, they would find it difficult to provide technical defence of a system that relied on validation by virtue of a weaker thermal exposure.

The reporter also considers that the LGS manufacturers '*appear to have a status quo bias', where an emotional bias to maintain the current state of affairs affects human decision-making, due to statements such as 'we've never been asked this before*'.

LSF manufacturers' positions

Insight was also provided on the position and justification of the position by some LSF manufacturers to support one-sided testing. The main argument is that Item 2 on loadbearing walls, in Table B3 of Approved Document B, indicates testing on '*each side separately*' as the type of exposure.

Further justification for one-sided testing was provided on the basis that 'test houses' can only test walls from one side only. The reporter is of the mind that '*a constraint of testing is not a reasonable defence if the consequence is a significant overestimation of the performance of the structure in fire*' and welcomed any comment on the feasibility of undertaking testing with LSF arranged as a column, therefore exposed to fire on more than one side.

One of the LSF manufacturers acknowledged the need to consider exposure to more than one side for loadbearing walls inside an apartment, and indicated that '*they would usually try not to have LSF structural frame in a non-separating wall*'. However, when that does happen, they use a consultant to undertake finite element analysis (FEA) in relation to the load-bearing fire resistance performance.

Finite element analysis as an alternative

The reporter was exposed to some reservations by other colleagues on FEA, and its suitability to accurately model LSF behaviour in a fire event. Any comment by CROSS is welcome on this topic.

Another manufacturer could not provide fire test evidence for 90-minute fire resistance when asked to, and this led them to engage another party to provide finite element analysis to satisfy the request. Again, the reservations on FEA, in this case, were raised by the reporter.

Final remarks

It is the reporter's impression that loadbearing non-separating LSF walls have been, and are being, used frequently in the design of multi-storey residential buildings. However, that is being done with no available fire test evidence using exposure of these structural systems to fire on more than one side, and this needs addressing by both the manufacturers and authors of industry guidance who don't identify this issue with clarity.

A consequence of the LGS being used in loadbearing non-separating walls without testing to more than one side is that structural failure due to fire could occur much earlier than assumed by the manufacturer and designers.

C Expert Panel Comments

This report presents well a very good point. The proliferation of lightweight steel construction is an area of interest, largely because it is not yet as well understood as other forms of construction. Issues like the one brought forward by the reporter need to be investigated further and certainly bought to the attention of the wider sector.

Fire resistance testing

There is still some confusion around fire testing in the construction industry. Fire resistance is a metric for three different things; integrity, insulation, and loadbearing performance. There are cases where some or all three criteria need to be satisfied, depending on the function of the rated element and the nature of the building. However, in this type of construction, almost every single internal and external wall (irrespective of whether they are classified as fire compartment walls) will be containing structural light gauge steel elements and it follows that every wall needs to achieve the loadbearing performance even if they don't need to achieve integrity and insulation.

The panel agrees that these internal loadbearing walls could be exposed on both sides simultaneously and should be designed as such because exposure to both sides by fire is possible. Avoiding such confusion is even more crucial when the structural (resistance) requirements are higher than the separating requirements (insulation and integrity).

Technical guidance and codes

The cited Approved Document B requirements for 'each side separately' is based on traditional forms of construction, and it can clearly be argued that this is a very different situation. Technical guidance is in place to assist designers, not to be followed blindly at the expense of common sense. Concerns have been raised in the past when safety justifications were based purely on literal interpretations of codes. Panelised light gauge steel frame construction is considered a modern method of construction, according to **an MHCLG Joint Industry Working Group>**. Approved documents may not provide appropriate guidance for some buildings that are not considered as "common buildings situations" and incorporate modern construction methods, according to the **MHCLG's Manual to the Building Regulations>**.

The issue reported also shows some of the limitations when applying common guidance to new methods of construction, and **there appear to be commonalities with other reports published by CROSS>** in the literal application of an Approved Document, when the method of construction may well sit outside the scope of the Approved Documents.

There are ways to demonstrate fitness for purpose, and there are organisations that will give independent validation. When innovating it is good practice to seek an independent opinion from experts and to challenge ideas and solutions from many perspectives - this instance is no exception.

Finite Element Analysis

When it comes to the reporter's request for comment on the suitability of Finite Element Analysis (FEA), a point that is reiterated in CROSS reports is that FEA is only a tool and the results it gives depend on the input parameters. To improve confidence in the approach, an industry agreed methodology that at the very least covers inputs and the confidence with which they are known is a prerequisite. Additionally, a number of FE analyses are needed to establish a sensitivity assessment when employing the method.

Conclusion

The reporter is to be thanked for raising the issue and presenting it with such a very good understanding of the situation. It speaks highly of the fire engineers who seem to be considering this properly and pushing in the direction of safer structures by applying common sense to this situation.

This is an abridged version of the full report. ***The full report>*** *is available on the CROSS website (report ID 1116).*

Submit Report

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Rotting plywood decking on grandstand

CROSS Safety Report   Report ID: 1092

This report is from a firm that undertakes visual structural inspections of temporary demountable grandstands for a number of sporting venues in the UK. During an inspection of a grandstand, a decking board failed when it was walked on.

Key Learning Outcomes

For clients, event organisers, suppliers and inspectors of temporary grandstands:

- Inspection regimes should take into account how long a structure has been standing, or has been in storage, since it was last dismantled and checked
- Consider the potential for degradation of all elements and check for hidden defects, particularly in timber decking
- **Temporary demountable structures: Guidance on procurement, design and use>** provides significant guidance
- Stand suppliers should be aware of the potential for hidden degradation at the edges of plywood decking

R Full Report

This report is from a firm that undertakes visual structural inspections of temporary demountable grandstands for a number of sporting venues in the UK. Although temporary in nature these structures can remain standing for a number of months exposed to the elements. In some cases, it is known that venues utilise them as permanent structures.

Whilst there are several providers of these stands, the structural form is largely similar. In general, they are found to comprise of aluminium raking beams spanning between a proprietary scaffold framing system. Spanning horizontally between the raking beams are further aluminium sections that act as the riser and support both the seat modules and terrace decking. Of the stands inspected, the terrace decking comprised of coated plywood deck sections.

During an inspection of a temporary grandstand in the summer of 2021, a decking board (as illustrated in figure 1) failed when it was walked upon. On closer inspection, the board had failed in shear as a result of it being rotten. It is believed that this occurred because moisture had become trapped within the ends embedded in the aluminium edges and over time the plywood had degraded.

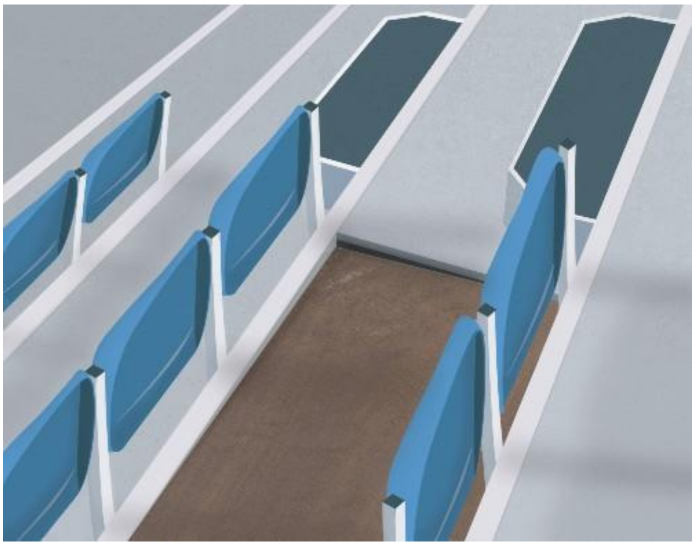

Figure 1: Damaged ply boarding

Other boards failed to a lesser degree during the inspection. The reporter noted that a single person walking over the boards provides significantly less load than they are subjected to in service. The reporter was therefore concerned there is a risk that defects could go undetected during pre-occupation inspections, only to manifest themselves once the boards are fully loaded, potentially with serious consequences. Indeed, the reporter's firm found defective boards at other venues in 2020 and 2021 and was also aware of further incidents where boards had failed in service.

The reporter notes that once the boards have been installed it is very difficult from a visual inspection to check the condition of the plywood embedded within the trim. Adequacy of the deck boards was therefore almost totally reliant on pre-inspection procedures of the installers, which on the stand concerned had apparently failed, leaving the stand not safe for use.

The reporter concludes that it would be beneficial if the various stand suppliers/installers could work together to develop a coordinated approach to the management of these types of structures. Robust pre-inspection regimes or indeed insitu tests need to be developed which are backed up with comprehensive audit trails that clients and event organisers can rely on.

C Expert Panel Comments

In procuring a demountable structure the client will more than likely have specified the use of the structure and the duration of such uses. Demountable structures are usually designed to be easily erected and dismantled, and are capable of adaptation to different situations. This often means that they are relatively lightweight, made from slender components and need to be erected and inspected before each use by competent persons. Demountable structures may be designed to be in place, or in use, for a short time (generally no more than 28 days) and erected and dismantled regularly. When the structures are dismantled and next erected, an inspection of all elements is possible. Demountable structures are by their very nature intended to be demountable and are designed as such, potentially for differing loadings to permanent structures. Leaving a temporary structure permanently erected may mean it is used in a manner not envisaged by the designer/manufacturer. Proprietary temporary systems should be used in accordance with the manufacturer's instructions.

Inspection and testing methodologies

In any structural system where degradation is a risk, as it clearly is with exposed timber, the features at risk should ideally be 'inspectable' and not hidden. It is after all not possible to assure safety if degradation can progress to become dangerous without becoming obvious. It appears the immediate cause of the floorboard failure, in this case, was the rot eroding the board's resistance to shear at the supporting edges. Metal trims on plywood boards can promote water ingress and the retention of water which enables fungal attacks of the plywood. Such degradation of the plywood may not be readily discoverable. In inspecting a stand, the engineer should assess areas of potential weakness; design documentation may be helpful to identify areas of potential concern. A visual inspection may be insufficient since as in this instance, the area of weakness was not obvious. Deflections can be used to predict a potential failure due to bending, however, shear failures would be sudden with minimal deflection. Simply walking over boards to assess deflections may therefore be insufficient.

However the inspection and testing are undertaken, it must be sufficient to find the areas of concern highlighted by the reporter and other potential faults. Those inspecting grandstands could consider if their testing and inspection processes are adequate taking account of pertinent factors such as local weather, exposure, time since last dismantle and full inspection, manufacturer's recommendations, usage and potential for material degradation including hidden defects. The potential for degradation of materials that have been stored damp, wet or externally should be taken into account.

Stand suppliers should be aware of the susceptibility of plywood edges to hidden degradation. Where short life elements including timber deck boards are concerned, it may be that an 'element life' marking system could be implemented if not already put in place by the grandstand manufacturer. Whilst it was the decking board that failed in this instance, clearly, inspections should assess all elements of the structure.

The Institution of Structural Engineers has published a guidance note **Procurement and use of demountable structures>** that provides a brief overview of these structures and also directs people to where further detailed information and advice can be sought. The guidance note reminds people of their legal responsibilities when procuring and using temporary demountable structures for events. It is a requirement that competent persons are employed to design, erect, inspect and dismantle any such structure. Fuller and more detailed technical guidance is available through the Institution's publication **Temporary demountable structures: Guidance on procurement, design and use>** which also addresses testing and inspection of temporary structures. It should however be noted that this guidance is primarily aimed at demountable structures which are designed as temporary structures for short-duration use.

> **competent persons are employed to design, erect, inspect and dismantle any such structure**

General advice is also given in the HSE publication: **Temporary demountable structures (TDS) - stages, seating, marquees etc>** and more recently the Advisory Group on Temporary Structures (AGOTS) has put together brief guidance for landlords, local authorities and event organisers: **Temporary demountable structures - Winter 2020/21 considerations>**.

The use of a structure on a more permanent basis is a different proposition and requires an appropriate assessment to appropriate standards by competent persons.

It will normally be the case that public liability insurance at the venue will at least be contingent upon adequate schemes of design, erection, maintenance and inspection.

Submit Report

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Intumescent paint application

CROSS Safety Report   Report ID: 1113

A report has been received regarding issues of detailing by following the relevant advice provided from an intumescent paint supplier. The reporter was incorrectly advised by a supplier that the paint would still be effective if it was applied to steel and then closely covered, leaving no gap for the expansion of the intumescent material.

Key Learning Outcomes

Structural and Fire Engineers:

- Engineers should give consideration to and understand the limitations of the materials, products, and systems they specify

For manufacturers and suppliers:

- Ensure that the people providing advice and guidance to clients are operating within the limits of their knowledge
- Give thorough consideration to how the product might be used and provide appropriate guidance

For the construction team:

- Be aware that passive fire protection components should be installed in accordance with the manufacturer's specifications
- Consider introducing a quality assurance process that covers the correct use and installation of fire protection products and components

R Full Report

Intumescent coatings

Thin film intumescent coatings are paint-like materials used on steel sections to provide fire protection to the structure. At ambient temperatures they are inert, but at elevated temperatures they follow a series of chemical reactions that leads them to expand, forming a layer of low conductivity char that has the ability to insulate the steel section. This insulating function protects the structure by "keeping it cool", ensuring that the degradation of material properties that occurs at higher temperatures is reduced and the structure can carry its design load successfully during and after a fire.

It follows that for an intumescent paint to be successful in its role, it needs space to expand when heated in order to form that protective layer. If the boundary condition is such that facilitates a local or global increase in the steel section's temperature, then its ability to carry the design load can be compromised.

Cause for concern

Engineers need to consider infill solutions between steel frames and eventually detail how these may be connected to the intumescent painted steels. A reporter informed CROSS that an architect sought advice on detailing from a supplier who claimed that an intumescent paint does not need space to expand. The supplier responded to the architect confirming that (a) the steels will start to intumes[ce] up at 70 degrees and be fully active at 120 degrees, and (b) there is no scientific evidence to suggest a space between the steels and a covering is relevant.

It should be highlighted that the supplier incorrectly stated that 'the steels' will intumesce, however this is a property of the paint. The reporter is also of the mind that this is inaccurate and incorrect advice, citing **a publication from the Steel Construction Institute>** which has the highlighted statement that '*finishes must be detailed to allow room for expansion of the intumescent coating*' (page 22). Any seller 'guidance' can only be given on the basis of appropriate technical justification or physical testing, otherwise any answer is 'poor advice'.

The reporter considers that this example should be picked up by structural engineers, who need to be aware of this issue. They should then be advising and clarifying to architects why the intumescing zone should remain free of infill materials, except when a formally recognised heat sink, protective board, or any other tested solution of proven efficacy is present. This way, any careless detailing that could render the intumescent non-operational will be avoided early on in the design process and highlight areas where a combination of fire protection solutions can be more appropriate.

C Expert Panel Comments

In the panel's experience, it is considered common knowledge that an intumescent paint must have room to expand significantly in order to be effective in insulating the structural element. One such description of an intumescent coating is that it is 'swelling up when heated, thus protecting the material underneath in the event of a fire'. If anything stops it from doing so, it will be ineffective. Such remarks are also commonly found in the market literature.

Covering boards, and any kind of secondary structure, need of course to connect to the primary structure in some way. Brackets of many forms may be connected to the primary steel member, and their effect on the intumescent paint expanding will depend on the nature and size of the clip fittings. It is expected that any responsible manufacturer should have a tested detail for this scenario, and sharing that information with clients will allow the design team to give appropriate consideration on how products can be used. The manufacturers' guidance needs to be clearer than what is presented by the reporter, and it seems challenged when the logic seems at fault.

A similar issue which also is encountered frequently is where there is a junction between, for example, a boarded fire protected column and a beam protected through an intumescent coating. Testing of assemblies that incorporate different manufacturers' products is rare, and common practice is to overlap the protection systems; this also requires careful detailing to ensure that every solution performs its intended function successfully.

The panel also has recent experience in which the uncertainty around a specific chosen solution was resolved through testing, since no other form of information on its expected performance was available.

In parallel to this case, a very common issue seen in the retrospective use and application of intumescent paints is that they are very often seen as an easy solution and an easy way to achieve the necessary fire resistance requirements. However, their application can often be misunderstood in regards to:

- The prescribed application method e.g., number of coats, base layers, mid coats, topcoats, and drying times.
- Humidity and moisture levels that dictate when intumescent coatings can be applied.
- Suitable substrates of application.
- UVA/UVB degradation and any required reapplication times.
- Physical damage and the need to reapply a coating.
- What any test certification means and what an intumescent coating's performance in fire actually is.

Good practice comes down to following manufacturers' instructions and ensuring the correct product is specified. There is, however, a need for the supplier to sell responsibly as well.

Once in situ, there is a need for the Responsible Person to be provided the Regulation 38 information under the Building Regulations (as amended). This will assist in the production of a suitable and sufficient Fire Risk Assessment under the Regulatory Reform (Fire Safety) Order 2005, with these products identified and managed appropriately.

Submit Report

Submit Feedback

Water ingress to cross-laminated timber structural frame

CROSS Safety Report   Report ID: 1124

In an eight year old building that included cross-laminated timber construction, it was found that water penetration had caused parts of the structure to rot. This was not apparent from external inspection.

Key Learning Outcomes

For construction professionals:

- Design in 'inspectability' of key building components including structure
- Be aware of the risks associated with moisture build-up, particularly where timber is a main component
- Good detailing can be key to controlling water ingress
- Beware of the potential for condensation within external walls
- Ventilation requirements must be considered to control condensation in buildings

For contractors:

- Consider the knowledge and experience required to sign-off compliance of specialist packages such as CLT

R Full Report

A reporter had been involved with remedial works on a project that was built about 8 years previously and included cross-laminated timber (CLT). The external walls had insulation covering CLT panels and it was found that due to quality issues with the original wall construction, there had been water penetration which caused parts of the CLT to rot in localised areas.

This was a serious concern because the rot was hidden behind the insulation and so was only identified when significant amounts of intrusive investigations into the external wall construction were carried out. Visual inspection from outside the building would not have identified this issue. This means that if the investigations had not been carried out, over a longer time period (e.g., 10 to 20 years) the rot might well have become much more extensive.

When CLT is used it typically forms the structural frame and so there is a risk that poor waterproofing could cause the frame to deteriorate over time with no outward sign of the deterioration. The reporter considered the cause of the water ingress was likely poor workmanship, poor design, or a combination of both.

For new buildings that include CLT, says the reporter, it is vital to emphasise the importance of effective waterproofing through good design and construction. It is much more important for a CLT building than it would be for buildings with more conventional types of structure, for example, reinforced concrete.

The reporter considers that for existing buildings that include CLT, the owners and anyone surveying them, should be aware of this issue and ensure that adequate checks are carried out, although in practice it is a difficult issue to investigate without extensive intrusive investigations.

C Expert Panel Comments

This report highlights the importance of understanding a structure, and knowing where there are hidden critical components. Where unseen deterioration could lead to a failure and components cannot be inspected then 'beware'.

A theme that occurs in many CROSS reports is 'inspectability'. The object of an inspection is to detect a problem before it progresses far enough to become structurally dangerous. In this case, it looks as if there was no way of knowing that the timber was rotting. With a trend for increasingly greater use of CLT in buildings, including tall buildings, it is critical to ensure protection of susceptible materials from water and from other potential hazards.

Unfortunately, poor detailing which allows water ingress can badly affect all building types, causing failures in different ways including providing environments that are damp and hazardous to health. These issues are often difficult and expensive to resolve. CROSS report **Rotting of cross-laminated timber (CLT) roof panels>** published in 2019 similarly concerned hidden structural members which had deteriorated due to an ingress of water. This report also considered the subject of internally generated condensation in buildings which can be really problematic and again lead to deterioration of structural elements including timber as well as causing all manner of unacceptable non-structural effects. **BS 5250:2021>** gives recommendations and guidance on avoiding problems with high moisture levels and condensation in buildings.

> **good detailing and construction of weatherproofing systems are essential**

Water and moisture generally are contributing factors to much deterioration and failure of buildings. Good detailing and construction of weatherproofing systems are essential. A lack of routine maintenance may also play a part and lead to deterioration.

Deterioration can contribute to the collapse of structures. The ice rink roof collapsed onto skaters in Bad Reichenhall, Bavaria, Germany, in 2006 killing fifteen people. There was not a single cause of the collapse but a series of several defects and damage. The design capacity of the failed elements was found to be inadequate and this capacity was further reduced over the life of the structure due to deterioration in the timber box girders. The structure was about 34 years old at collapse.

> **not a single cause of the collapse but a series of several defects and damage**

CROSS published an important article **Cross-laminated timber (CLT) in multi-storey buildings>** in 2021 concerning interpretation and application of the Building Act 1984 with respect to the use of CLT in multi-storey buildings.

A checklist of water damage> published in the Institution of Civil Engineers publication 'Forensic Engineering' overviews the wide range of causes of damage from water in the built environment and provides further information that can be considered during design or to help investigate problems.

Submit Report

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Change of use to care home

CROSS Safety Report   Report ID: 1078

A report has been received relating to the intended change of use of a large building. The reporter is concerned that there is an increase in the risk factors, while the protection levels remain unchanged.

Key Learning Outcomes

Lead designers:

- Changing the use of a building may require a revised approach to fire safety
- Changing from a hotel to care premises will require consideration of the mobility and other health issues that will impact the evacuation strategy

Authorities Having Jurisdiction:

- Change of use from a hotel to a care home may be subject to planning consent requirements, however Building Regulations and in-service fire safety requirements should be considered at the earliest opportunity

R Full Report

A report has been received relating to the intended change of use of a large building. The reporter is concerned that there is an increase in the risk factors, while the protection levels remain unchanged.

This building is currently used in part as a hotel, and part as private residential flats. Each is served by a single stair core. In order for the original design to be approved and built, a fire engineering solution was sought; part of that solution was a sprinkler system in the hotel occupancy.

A recent change in ownership was followed by a planning application with a council to change the existing use of the hotel to a care home. This application is supported by a report from a fire engineering firm and it is stated that the change of use to a care home is similar to the current use as a hotel. Additionally, the application also includes a section where it is argued that the sprinkler system would not be required if the change of use is to move forward.

However, the reporter is alerted to the fact that there are no alternative means of escape from the hotel, proposed to be a care home, and is also of the opinion that there is a significant difference in the proposed change of use; so, it is not similar to the previous occupancy. This stems principally from the characteristics of the occupants:

- In a hotel, they would be short term occupants, fully mobile, and any persons with disabilities would be cared for by appropriately trained staff who would follow the hotel's fire safety procedures and any Personal Emergency Evacuation Plans (PEEPs), among others.
- In a care home, the occupants are normally elderly, of reduced mobility and alertness, potentially unable to escape unassisted, and can also be bed-bound due to medication or health support mechanisms. Night shifts are usually lower in staff numbers, so that would make this the time that the occupants are at a higher risk.

There is concern that the application may potentially be approved because, according to the reporter, the local authority overlooked that a fire engineering solution was required for the original build. Additionally, the reporter is of the opinion that when the occupancy risk increases, the safety precautions should increase respectively; while they could remain the same, they should not, in any event, be reduced.

The fire engineering report supporting the application may navigate the complexity of the issue in such a way as to influence the local authority to proceed with the change of use, causing a general misgiving to the reporter about the safety of the care home residents in the event of a fire.

C Expert Panel Comments

The panel agrees that, in terms of the occupancy profile and the means of escape requirements, a care home is not equivalent to a hotel. It can be quite hard to assess this situation, given the lack of details, but the reporter is correct in their uneasiness about the proposed solution with a reduction in safety measures. Sometimes, however, this difference in risk may be offset in some way by higher levels of staffing and management in conjunction with other measures. From the available information, it would appear this case relates to a planning application rather than a Building Regulations (as amended) application, which adds to the confusion. It is also unclear whether this is part of the information being provided under a Fire Statement in support of Gateway 1 of the new regulatory regime (which went live on 1 August 2021).

It is assumed that the issues highlighted in this report would be identified by the Building Control Body and by the Fire and Rescue Service during **the consultation process>**, as the fire safety issues identified indicate the proposed measures might not be suitable, as the indicated layout would not support Progressive Horizontal Evacuation which is commonplace in most care settings.

From the available information, which is limited, it could potentially be presumed that the fire engineering team was brought into the project at a later stage, facing many constraints and unchangeable decisions. It can be challenging for a fire safety engineer to oppose or alter these decisions, especially when considering the differing levels of 'status' amongst the disciplines involved in the design process. There is a subtle difference between engineering a design to be safe from the start of the project, and proving that an existing, nearly finalised, design is safe. It might appear counterintuitive, but holding back in the face of uncertainty can be a sign of professionalism, which ultimately serves rather than impedes the design objective of fire safety.

holding back in the face of uncertainty can be a sign of professionalism

In a worst-case scenario, and an example of the lack of the much needed culture change, if the care home was to open and fire safety deficiencies were identified by the enforcing authority of the Regulatory Reform (Fire Safety) Order then there would be a realistic potential of formal action that may involve the prohibition of the use of part of, or all of the premises.

Submit Report

Submit Feedback

Poor quality design leads to failure for a small design and build contract

CROSS Safety Report   Report ID: 1088

An example of a small design and build contract where poor design and management led to an inadequate structure being built.

Key Learning Outcomes

For clients and owners:

- Require that all structural design is signed off by a suitably experienced chartered civil or structural engineer
- Consider appointing an independent chartered building professional whose role is to monitor the design and build processes
- Be wary of a quotation that is significantly lower than others

For contractors' site staff:

- Request detailed drawings and specifications for any aspects of the build which are not clear

R Full Report

A reporter shares their concerns about a design and build project which they have appraised for the owner of a domestic property; the design and build contractor having produced a structurally unsound building.

The property was a Victorian two storey building split into ground and first floor flats. The project concerned a loft conversion to the first floor flat. The owner appointed an architect who provided a planning stage drawing for the scheme. The client then appointed a specialist loft conversion contractor to take the project to completion. The reporter, a consulting structural engineer, was contacted by the owner part way through the build process when cracking started to show in the existing structure. Upon investigation, the reporter found the following concerning issues:

- Structural calculations which did not appear to allow for the full roof loading
- A structural arrangement leaving the floor undersized and the roof partially unsupported
- Loadings on existing masonry likely to cause settlement
- New steel beams supporting the new floor, causing deflection and cracking in the ceiling below
- Undersized and poorly constructed concrete padstones supporting new steelwork
- Existing triangulated roof timbers cut, leaving a partially unstable roof
- Inadequate structural support to the new stairs into the converted loft space

The reporter confirmed to the client that the design was structurally inadequate and that the building work undertaken was the cause of damage to the property. The client terminated the contractor's involvement in the project. The reporter identified the following concerns as to how the project was progressed:

- During the design period, there were no visits to site to assess the existing structure
- Structural calculations completed using proprietary design software appear as though they were not compiled by a structural engineer
- The lack of competent conceptual and detailed designs, led to a damaged building and extensive rebuilding being required
- It was not known if the appointed building control approved inspector checked the structural design or any of the works

lack of competent conceptual and detailed designs, led to a damaged building and extensive rebuilding

The reporter concluded that:

- Clients should seek chartered building professionals to put their names and reputations to projects in order that appropriate skill, judgement, and experience are applied
- More detailed design should be undertaken for small projects before appointing contractors
- Effective building control checking processes for both the design and site activities must be in place
- Be wary of cheap quotations
- Providing poorly developed services to clients should not be acceptable

C Expert Panel Comments

Conversion and changes to domestic dwellings can be complex and demanding. Structural engineers are key to ensuring that these projects are progressed competently. Identifying potential conceptual structural schemes and developing detailed schemes that are appropriately elegant, effective, buildable and economic requires significant knowledge, skills and experience. Unfortunately, however, we see far too many reports which confirm that competent engineers have not been engaged on some projects. Clients should understand that structural engineering is a complex discipline that should only be entrusted to appropriately qualified and experienced structural engineers, either typically performing as a consultant, or as part of a design and build organisation, as in this case.

> **clients should understand that structural engineering is a complex discipline**

Clients should check that the person undertaking the structural design is appropriately experienced and qualified before appointing. Using the services of a 'designer' who relies upon software to produce designs, but who is not competent to design structures, is a recipe for errors that may lead to financial loss, or worst still, lead to a structure liable to collapse.

Finally, owners considering a design and build procurement route may find it very beneficial to appoint an adviser who can use their experience to help the owner navigate the many processes and decisions required in a building project. The fees spent will generally represent good value in assuring safety and in reducing financial, time and other risks.

Submit Report

Submit Feedback

Classification of wall linings

CROSS Safety Report   Report ID: 1094

A reporter states that they have been looking into the Reaction to Fire Class for different products and noticed some discrepancies in the market literature.

Key Learning Outcomes

For manufacturers and suppliers of wallpapers and other wall coverings:

- Products should be tested for the intended end use
- Product labels should make it clear if the classification attained was only achieved on a specific substrate

For product specifiers:

- Ensure that the documentation of all products used is accessible
- If possible, attend the site when contracted to do so and check for inappropriate product substitution

R Full Report

A reporter states that they have been looking into the Reaction to Fire Class for different products; in particular, different wallpapers. One thing that they noticed is that a certain wallcovering and furnishings website shows, through the available classification reports, that some wallpapers are tested with a Calcium Silicate (CaSi) board as a substrate and others with gypsum plasterboard. However, the reporter also noted that when wallpapers are bought from a local Do-It-Yourself (DIY) store, then the classification label only lists the final Reaction to Fire Class, without any more information on how this was derived.

The reporter thinks that this is of concern because BS EN 13238:2010 – Reaction to fire tests for building products — Conditioning procedures and general rules for selection of substrates, states in clause 5.3.2.4 the following:

"The standard gypsum plasterboard substrate is representative of end-use gypsum plasterboard substrates and also any end-use substrate of classes A1 and A2-s1,d0. The standard calcium silicate board substrate is not representative of a gypsum plasterboard end-use substrate".

Additionally, the reporter found that a well-known fire test organisation carried out a study on wallpapers and found that wallpapers with CaSi as substrate in the Single Burning Item test (SBI, according to BS EN 13823) obtain a better classification than wallpapers with gypsum plasterboard as an SBI test substrate. This was mainly attributed to the top layer on the plasterboard being paper, which is combustible. According to the study, this finding "clearly highlights the importance of manufacturers defining the field of application of test results and regulators such as building control professionals understanding the field of application".

The reporter raised the following main points:

- In their opinion, any SBI test for wallpapers should not be done on a CaSI substrate as, at least as far as they are aware, the end-use condition will not be on a CaSi board.
- From the test certificates available in the market literature that they reviewed, it appears to them that one particular fire testing organisation does not seem to test on CaSi boards and any reports using a CaSi substrate are performed by other testing agencies.
- One of the websites they used to access product test reports only lists the final Reaction to Fire Class at the frontpages but not the substrate used. Given that the substrate has a big impact on the outcome of the SBI test they consider this a misleading practice.
- The reporter visited a DIY store and bought wallpapers. Following that, they tried to contact the manufacturer to ascertain the substrate used in the SBI test. The manufacturer referred the reporter to another company, and then this company referred them to a further company. The substrate used is still unknown. This is either because nobody knows, or they don't want to share the information.

The suspected motivation for this practice according to the reporter is that manufacturers want to get a better classification by choosing a testing facility that uses a substrate beneficial to the product classification, without thinking about the possible consequences this may have once out in the market. The reporter finds it essential that more information should be shared in the market literature on how the SBI test was conducted; a suggestion would be that the CE-marking could show the substrate and type of fixing used.

Finally, the reporter is of the mind that since wallpapers can be bought by laypeople, the CE marking for wallpapers tested on CaSi should clearly have a disclaimer that the Reaction to Fire Class is not applicable for other uses, such as plasterboard.

C Expert Panel Comments

The panel is of the mind that the reporter's concerns appear to be justified and supported by previous comments that CROSS has made around the clarity and openness of product testing, certification, and dissemination of information.

If a manufacturer of a particular product is making claims about their fire performance, they ought to be clear about the type of substrate that the test result was obtained on. If they are not, and the tests were carried out using a substrate that performs better than what typical materials used in construction do, that could be a cause for concern. CaSi boards can be used as sheathing in construction, but when it comes to internal use then plasterboard will almost always be the chosen solution. Since wallpaper is an internal lining, it is highly probable that its end-use will be application to plasterboard, and thus the Reaction to Fire Class considered should be the one that used plasterboard as a substrate.

It could be argued that what the reporter has identified can at best be ambiguous and, at worst, intentionally misleading.

if tests were carried out using a substrate that performs better than typical materials used in construction, that could be a cause for concern

Submit Report

Submit Feedback

Tower crane base designs

CROSS Safety Report   Report ID: 1093

A reporter's firm has been involved in the design and checking of numerous tower crane bases and have come across many examples where the supplier of the tower crane has supplied incorrect loadings. These incorrect loadings could have led to crane failures had the errors not been spotted.

Key Learning Outcomes

For crane and lifting equipment suppliers:

- Base loadings should be validated before being provided to others

For civil and structural design engineers:

- It is good practice to carry out an independent check to verify loads received from a third party
- Check detailing of crane bases carefully, particularly tension resistance

For contractors:

- Appoint a competent Temporary Works Coordinator (TWC) who can coordinate the design and sequencing of temporary works
- Good planning can ensure independent design checks are carried out in time and approved prior to the works commencing on site
- Be mindful of the required tension capacity of crane bases

R Full Report

A reporter's firm has been involved in the design and checking of numerous tower crane bases and have come across many examples where the supplier of the tower crane has supplied incorrect loadings. It is only through their experience that the firm is picking up these errors and can challenge the suppliers. The reporter provides three examples found in a 12 month period to illustrate the problems.

Example 1 - A tower crane supplier stated that the in-service moment was 500kNm, while the out of service was approaching 20,000kNm. These two numbers are a world apart and were challenged. The in-service moment was corrected to 5,000kNm (a zero had been missed out). Admittedly, the in-service does not generally drive the design, however, suppose the mistake had been in the out of service moment, and we had designed for 5,000kNm in service and 2,000kNm (i.e., the same error of a missing zero) out of service. The base would have had less than a third of the capacity required.

Example 2 - The loads to one of the legs of a self-erector tower crane were given as 0 under all three loads cases. This could clearly not be the case. We challenged the supplier and a revised loading detail was provided showing the actual load.

Example 3 - A tower crane was originally proposed to be used with minimal ballast, effectively just the self-weight of the kentledge base. The crane was quite short and not particularly large. The initial loadings supplied indicated a very minimal tension load of less than 100kN. The reporter's firm was undertaking the cat 3 checks on the base, and it became apparent that the designer had used an incorrect factor in the design. As the piles had already been installed and did not have sufficient tensile capacity the crane supplier was asked for loadings allowing for an additional 60 tonnes of kentledge on the base. The revised loadings supplied indicated a tensile load of over 200kN, over two times greater than the previous loadings supplied. Logically the load should have reduced not increased. After discussion, the crane supplier admitted that the original set of loadings was completely wrong. A design based on this incorrect information could well have led to the tower crane falling over.

Data for tower crane loadings

The reporter believes the data for tower crane loadings are generally obtained from a large document that shows all variations. The crane supplier possibly then copies the loads into another document. It appears that these transcribed numbers are in some cases not checked before they are supplied to the base designer.

The reporter would like this information shared to ensure that designers 'sense check', as far as they can, the loads they are supplied with. They would also like crane suppliers to use more care when providing loads, perhaps implementing a checking regime for all loads provided.

This firm carries out a significant number of tower crane base designs in an average year. If they are finding this many errors, they believe there must be others. They believe the problem of incorrect loads being supplied, may be happening quite regularly across the industry.

C Expert Panel Comments

This is clearly a worrying account, and the reporter does well to raise it. Good practice in crane foundation design will involve sense-checking input data. This can be relatively easily done by (a) reference to crane manufacturers' data, and (b) by basic mechanics to within an order of magnitude. Experience also plays its part; experienced and competent designers, know what order of magnitude and scale of members they should be seeing, as appears to be displayed by this reporter. This applies as much to crane bases as to any other structural element.

Crane bases and their foundations are 'temporary works', which in accordance with good practice (and industry consensus) should be designed to *BS 5975 – Code of practice for temporary works procedures and the permissible stress design of falsework*. One of the key features of BS 5975 is that it requires checks to be made on temporary works designs. The value of such checks has been demonstrated by this report. **CIRIA Report C761 'Guide to tower crane foundation and tie design>** further states that the design of all tower crane bases should be subject to an independent design check to at least Category 2 as per BS 5975. Clearly for this to be effective, it must surely be the case that the design loadings passed by the tower crane supplier to the foundation designer must also be checked to this standard. The Temporary Works Coordinator (TWC), as appointed under BS 5975, may consider it appropriate to assure themselves that appropriate checking processes are in place for all parts of the temporary works design, including for any tower crane and its foundations. The proper coordination and control of temporary works, as would be undertaken by an experienced TWC, is fundamental in avoiding confusion and with it, reducing the risk of something going wrong.

The Construction Plant-hire Association confirms in their Tower Crane Technical Information Note 031> that '*for a tower crane installation to be safe, it must be properly managed at all stages of its procurement and use, from initial planning during the pre-construction phase to removal from site*'. Clearly, this requires the correct design loadings to be provided to the foundation designer and tower crane providers may benefit from checking as to how they ensure the correct loadings are communicated to foundation designers.

tower crane providers may benefit from checking as to how they ensure the correct loadings are communicated to foundation designers

The design and detailing of crane bases is an area where designers should be vigilant. Poorly detailed bases may see conflicts between holding down assemblies, base reinforcement and/or piles that require amendment on site. In such cases, it has been known for the site amendments to remove tension resistance. Tension loads and tension resistance are a fundamental part of the whole crane installation. In many cases, it will be good practice to integrate the crane base into the permanent foundations. Contractors should be mindful of the required tension capacity of crane bases.

contractors should be mindful of the required tension capacity of crane bases

A previous CROSS report **Tower crane foundation design error>** described a case where incorrect foundation pile loadings were provided, albeit the error was made by the structural engineer and not the tower crane provider; nevertheless, this error again illustrates the need for all involved to validate tower crane foundation loads.

Submit Report

Submit Feedback

Potentially unsafe buckling resistance checks using software

CROSS Safety Report   Report ID: 1075

A reporter detected a number of anomalies in outputs from a proprietary structural steelwork design program.

Key Learning Outcomes

For civil and structural design engineers:

- Designers should understand the principles of the problem at hand (and design code) before using software
- Simple cross checking with published examples (validation), is highly encouraged before using software that the engineer is not familiar with
- Ensure any software models the structural elements as anticipated
- If you are concerned with any outputs, consider raising this with the software technical support team and seeking clarification
- It is good practice to carry out sense checks and validate all analysis and design outputs

R Full Report

A reporter designing structural steelwork by way of a commonly used software package identified a number of anomalies. These concerned buckling checks on steel members subjected to applied axial forces and bending moments. The anomalies were:

- That the design code required the overall buckling check to be based upon the maximum moment, whereas the software called for the applied moment to be used in this check. The change in terminology is unhelpful and may lead to incorrect values being assigned.
- That within an overall buckling check, the forces and bending moments at a particular cross section were identified as the critical case, whereas the overall buckling check should have been based on the maximum forces and moments in the length under consideration.
- The incorrect calculation of an 'equivalent uniform moment factor' and therefore incorrect overall buckling check, for a frame with intermediate restraint in one axis of buckling only.

Recognising that the software did not provide expected outputs, the reporter drew a number of conclusions:

1. Designers must understand the design code before using software.
2. Designers should understand the design parameters and definitions in the design code as well as the same in the design software. Designers can then correlate the two, provide the correct inputs and recognise anomalies in outputs.
3. The parameters set within the design program may not be the same as those expected by the designer.
4. Simple cross checking with examples (validation), is highly encouraged before using software that the engineer is not familiar with.
5. Design software should be used by competent engineers.

C Expert Panel Comments

The reporter is to be congratulated for bringing their findings to light and for their conclusions, which are very sound, and likely arrived at through significant experience.

Software deficiencies are relatively rare but do happen. It is a pre-requisite for using software that the user must be able to recognise incorrect or unexpected situations and outputs. Simply put, software should only be relied upon by those who know what the answers should be, otherwise, they will not recognise errors in the software or more likely, errors in the use of the software. Where errors in commercially available software are found, suppliers should be challenged to demonstrate their validation and calibration of the software.

A starting point in any design should be that designers understand the structural principles and then make appropriate models for a computer to do the arithmetic. In steelwork design, unless the designer understands member end restraints (via connections of their choice) the answer will come out wrong.

Digital tools can be very good at manipulating data, but design and analysis are always an idealisation of a structure and not 'digital perfection'! It is important to recognise that digital models are good at showing what exists in a design, but they may not be representative of a real structure. They probably will not contain the uncertainties of tolerances of construction and may not model connection stiffness well - models can be a further step away from reality.

> **digital models are good at showing what exists in a design, but they may not be representative of a real structure**

It is crucial that younger engineers develop a feel for what is right and wrong such that they too can enjoy passing their wisdom on. Less experienced engineers will benefit from deriving and repeating some computer calculations (for example capacity checks) by hand so they know exactly what the basis of the check is and to make sure the inputs and outputs match the hand check.

Computer aided design, irrespective of which design code is applied, is an essential part of structural design, but it must be remembered that the software is only an aid to the designer. The design organisation must fully understand and validate all outputs. This requires engineers who are sufficiently competent to understand the software presumptions and outputs. The importance of validation in software use is noted in the Institution of Civil Engineers publication - **The importance of understanding computer analyses in civil engineering>**.

Previous CROSS reports of interest include **Computer aided design>** concerning column design and **Unconservative design of flat slab due to software modelling issues>** which also references the thought-provoking SCOSS Topic Paper **Reflective Thinking>**.

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