

CROSS

Confidential Reporting on Structural-Safety

For an introduction to CROSS see www.structural-safety.org. Email: structures@structural-safety.org

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REPORTS IN THIS ISSUE:

612 NUMBER OF NEAR MISSES AND THE REGULATORY REGIME.....	2
614 COLUMNS MISSING DUE TO 3-D MODELLING.....	3
581 REQUIREMENT FOR CDM SAFETY FILES TO BE TRANSFERRED.....	3
610 HIGH MAST LIGHT POLES.....	4
579 FURTHER REPORT ON FREEZING OF WATER IN ZINC PLATED HOLLOW SECTIONS.....	5
575 UNDERGROUND SCAFFOLD OVERTURNS IN WIND.....	6
599 HERITAGE BALUSTRADES AND BUILDING STANDARDS.....	6

Reports sent to CROSS are de-identified, categorised, and sometimes edited for clarification, before being reviewed by the CROSS panel of experts. The panel makes comments that are intended to assist those who may be faced with similar issues. In the Newsletters the reports are shown in black text and the comments are shown below these in green italics.

Reports and comments are also given on the website [database](#).

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INTRODUCTION

Relationships with the Temporary Works Forum have been strengthened as a result of Structural-Safety becoming an Invited member. This category is exercised at the discretion of the Directors and is awarded to an individual or organisation (not currently a Member) which, in the Directors' view, deserves special recognition in some way for its contribution to temporary works. We look forward to sharing information on improving safety in this area. New contacts have been made with CABE, the Chartered Association of Building Engineers, who have become a supporter, and many of whose members become involved with the safety of buildings during construction. On an international front a meeting has been held with AQC, Agence Qualité Construction, based in Paris on future co-operation.

Mathew Syeed of the Times recently interviewed Captain Chesley Sullenberger, the pilot who landed an Airbus A320 on the Hudson River in 2009, saving the lives of 155 crew and passengers after an engine failure. He talked about how the impressive safety record in aviation is based upon constant learning from accidents and near-miss events, a method, he said, which other industries would do well to follow. He also talked about how he had trained his brain to think calmly under stress, even as his blood pressure shot up and perception narrowed. Most striking, however, was his sense of duty. He walked the plane twice, even as it was filling with water, to ensure everyone had got out, and refused to do TV interviews, despite feverish media interest, until everyone had been accounted for. "My primary responsibility was to those under my care," he said. "That was my focus from the moment we landed to the moment I could be sure everyone was safe." Aviation safety was the model for establishing CROSS and it is heartening to be reminded of how methods of constantly learning from others can, in a very practical way, help to save lives.

CROSS is also interested in damage caused to buildings, and building related infrastructure, by weather events. These can be sudden actions such as tornadoes or lightning strikes, or longer term events such as floods. The aim is to gather information that can be used to assess the capability of our buildings to withstand the weather patterns that may be becoming more common. This study is not concerned with the reasons for climate change but only whether the consequences might lead to changes in regulations and practices. Reports can be made [here](#).

Indeed the success of the CROSS programme depends on receiving reports, and individuals and firms are encouraged to participate by sending concerns in confidence to [Structural-Safety](#).

What should be reported?

- concerns which may require industry or regulatory action
- lessons learned which will help others
- near misses and near hits
- trends in failure

Benefits

- unique source of information
- better quality of design and construction
- possible reductions in deaths and injuries
- lower costs to the industry
- improved reliability

Supporters

- Association for Consultancy and Engineering
- Bridge Owners Forum
- British Parking Association
- Chartered Association of Building Engineers
- Communities and Local Government
- Construction Industry Council
- Department of the Environment
- DRD Roads Services in Northern Ireland
- Healthy and Safety Executive
- Highways England
- Institution of Civil Engineers
- Institution of Structural Engineers
- Local Authority Building Control
- Network Rail
- Scottish Building Standards Agency
- Temporary Works Forum
- UK Bridges Board

612 NUMBER OF NEAR MISSES AND THE REGULATORY REGIME

A reporter is concerned about the number of investigations on which he is working, or of which he is aware, but most cannot be reported to CROSS because of legal or insurance constraints. He sees an increasing number of actual failures, including collapses, and an increasing number of near misses. In two relatively recent cases where steel frames have collapsed when almost complete the events have taken place when people were not in the vicinity, but had the structures been in use there could have been multiple fatalities. He has also come across serious deficiencies in the design and detailing of reinforced concrete frames. He believes that some structures are so badly designed and constructed that they are doomed from the start. Another concern is about the occurrence of systemic collapses or near misses due to multiple cases of similarly defective designs not being recognised.

There are several causes, in his view, including:

- The lack of checking or reviews being carried out by local authorities or by independent inspectors
- Giving Building Regulations approval without even asking for calculations
- Shortage of building control staff
- Limited resources within HSE
- Contractors and clients picking the engineer who offers the lowest fee
- Structures that are designed by unsupervised graduates who are so reliant on their computer programmes that they have no idea what they are doing
- Steelwork drawings issued by structural engineers should check the adequacy of the fabricators' connection designs but in practice do not
- Safety-critical information is not communicated, instructions are routinely ignored and practically nothing is checked on site

He has the view that there may be a catastrophic collapse in the UK, causing fatalities, which will result in an enquiry and a public call for more accountability. There should, he believes, be a better regulatory process for the reporting of serious concerns and near misses so that action can be taken. The CROSS system works well so far as it goes, but the Newsletters are probably only read by the "good guys" and not those who are designing or constructing badly. There should a tougher regime within the regulatory system including local authorities, private inspectors, and the HSE along with better education and training.

Comments

This echoes themes that have recurred time and time again within SCOSS/CROSS circles. There are many real disasters which kill and maim and many more near misses all of which cause immense distress and cost huge amounts of money. The difference between a catastrophe and a near miss can be wafer thin and depends whether there are people in the vicinity at the time of a collapse. Many in the industry are similarly concerned about the potential outcomes of weaknesses in conceptual modelling, design, communication, fabrication, construction and checking processes. Improvements need to be made to the standards of design and construction. Unfortunately, those who most need to be aware of the risks involved are probably least likely to concern themselves with reports such as this. Perhaps there should be a more formal regulatory process in place for reporting concerns, rather than the voluntary CROSS scheme?

There should certainly be better measures to give the younger generation a full appreciation of the skills involved in conceptual design, sense checking of computer outputs and reviewing of fabrication drawings. Of course, responsibility of the adequacy of design lies with the designer, and Building Control should not be relied upon as a means of checking. That said, Building Control should satisfy themselves, having taken reasonable steps in that regard, that Part A has been satisfied. This does not necessarily involve checking calculations, but for anything but the simplest structure should involve as a minimum reviewing the overall design philosophy and the design of critical elements.

So far as HSE are concerned they are working positively with the design community on education about CDM. In addition, CIC is doing work to look at how well new graduates are equipped to discharge CDM duties, and to support universities with better or more consistent course content where there are gaps. With respect to the call for a stronger regulatory regime, HSE cannot get involved in approving or signing off in some way design of buildings/structures – that is a matter for other regulators. However, [RIDDOR](#) does require reporting of structural collapses associated with construction/demolition. The most important contribution that structural engineers can make to safety is to do all they can to make sure that the structures they design will not fall down.

The legal and insurance constraints that the reporter refers to are barriers to the industry learning lessons, through schemes such as CROSS. There is certainly the possibility of another mega failure that will serve as a wake-up call. But that will be too late for those involved.

614 COLUMNS MISSING DUE TO 3-D MODELLING

A new 8-storey residential concrete frame building is being constructed and several columns have been omitted from the ground and first floor level drawings, says a reporter. Without the columns, a 225mm thick RC slab was being asked to span up to 14m. Some of the missing columns were spotted by the concrete frame company's project manager. Others were not immediately obvious due to transfer structures and column plan positions changing up the building. Consequently, these columns were not built by the contractor, who continued to prop off the slab in the usual way during construction of the upper floors. The consulting engineers cited the use of BIM modelling software as the reason for these serious omissions. Is the use of 3-D modelling a distraction to producing clear, accurate and well thought out construction drawings?

Comments

This report has generated a lot of comment from our panel. Is this a case of user incompetence, lack of experienced engineering supervision, lack of checking, lack of ability to understand conceptual design, or all of the above. It would be hoped that any engineer would spot such gross errors in his/her checks, yet in this case it was missed. BIM is a great tool to assist with sequencing and fit, but it must be operated or overseen by experienced engineers who have a full grasp of conceptual design and can recognise fundamentals such as columns being missed. Whatever the system clear, accurate and well thought out construction drawings are an absolute necessity.

It is not stated how the issue arose with the 3D BIM model. However, it is possible that the BIM model used different software to the analysis model. It is becoming more common to import the analysis model into the BIM model and when this works the advantages are clear but in many cases the imported model needs tidying up. It is unusual to lose complete elements but it is possible that the columns were deleted by someone not appreciating their structural role. The BIM model would likely have been a multidisciplinary model and there is the possibility of another discipline inadvertently deleting the columns due to clashes with their elements. Structural Engineers need to appreciate that they are still required to check the final output regardless if this appears to simply be a copy of their analysis. As BIM becomes more common Engineers need to improve their skills and develop tools to check final BIM models against their design intent. It is they who are responsible for design not the software.

On a wider theme, the history of failures reveals a frequent pattern of gross error: that is an error so bad, you wonder how no one spotted it. This report seems to fall into that category. A lesson is for engineers to always start with looking at the big picture: are the load paths clear, is there a stability system and so on? - all before they get down to detail.

581 REQUIREMENT FOR CDM SAFETY FILES TO BE TRANSFERRED

The whole point of the Safety Files prescribed under the CDM Regulations, says a reporter, is that they shall be of assistance in the future, to owners and operators of buildings and other structures. They are not simply a chore to be signed off at the end of a complicated job. Many vital components are hidden on completion, particularly elements such as electricity cables, pre-stressing tendons, foundations, and the accurate location of services, or even culverts running beneath buildings.

Difficulties arise when properties change hands, because there is no effective system to see that these details are passed on to the new owners. Legally the owner disposing of a property possessing a Safety File is obliged to transfer it, but the HSE does not have the resources to prosecute. The Law Society has a very complicated form to be completed when a property is sold, this covers things as detailed as 'how much central heating oil is in the tank and are the light bulbs included?' Suggestions were put forward by the reporter some time ago to the ICE and the HSE that the property transfer form should be altered to include the CDM Safety Files, nothing has happened yet so far as he knows.

Comments

This contribution reflects a general theme that as time moves on, people forget what the prime purpose of an activity was in the first place. A number of CROSS contributions over the years show the danger of owners altering structures without realising the implications simply by ignorance of not knowing what is there. Passing on to each owner details about the fabric of a building makes obvious sense.

More formally, CDM files are legal documents to be prepared, maintained, and passed on to clients. Full details are given in the HSE document: [Managing health and safety in construction, Construction \(Design and Management\) Regulations 2015](#). An extract from Appendix 4 of this document says:

“The health and safety file is defined as a file appropriate to the characteristics of the project, containing relevant health and safety information to be taken into account during any subsequent project. The file is only required for projects involving more than one contractor. The file must contain information about the current project likely to be needed to ensure health and safety during any subsequent work, such as maintenance, cleaning, refurbishment or demolition.”

For the structural engineer the principal factor is that there should be sufficient accurate information to help when maintenance, modifications or de-commissioning are proposed. Structural engineers as well as other duty holders should, as a matter of good practice, draw the attention of their Clients in a specific manner to this key responsibility in respect of the handover of the Health & Safety File. As a next step, following on from this report, HSE, ICE and IStructE will consider how the matter can be progressed.

610 HIGH MAST LIGHT POLES



Holding down nuts



Base plate

Five High Mast Light Poles (HMLPs) were removed from a public site as it was considered that there was a possibility of collapse. One was a particularly obvious risk because about half of the nuts on its anchor bolts were not fully engaged. The reporter believed that the remaining four were also a high risk because of the same inherent design features and the inability to inspect critical parts. HMLPs usually consist of tapered polygonal mast fixed to a concrete foundation using multiple anchor bolts connected to a circular flange. The flange is fixed using two nuts on each anchor bolt. One nut is located below and one above the flange. The lower nut is often referred to as the levelling nut and this design is known as a stand-off base plate. The most safety critical features of an HMLP are its base-plate and anchor bolts. Failure of any one bolt will transfer load to adjacent bolts. If adjacent bolts were not able to withstand the increased load, then collapse could occur. In the reporter's opinion, the design of stand-off base plates as used on HMLPs have several severe inherent design weaknesses that could lead to collapse even when installed as-designed. Concerns expressed by the reporter about this case, but also about such structures in general include:

- Inadequate design of base-plates
- Base-plates and fixings obscured by finishes or soil/vegetation
- Nuts not fully engaged
- Corrosion of bolts
- Bolt fatigue due to stress concentration in the threads
- No pre-tensioning of bolts
- Thread type

The reporter takes the view that not enough is being done to ensure safety and says that this report has been produced in the interests of public safety. He wants Structural-Safety to consider the matter.

Comments

The reporter is quite right to be concerned about risk of corrosion to holding down bolts, especially when hidden in 'porous' materials that can hold air and water against steel. In this case the poor quality of erection demonstrated by the inadequate anchor nut installation was sufficient reason to take down the columns. There have been many fatigue failures of this family of structures (lighting columns, cantilever gantries, etc...) but failure has been in the structure, not the HD bolts. The aero-dynamic damping in these structures means fatigue damage due to wind buffeting is highly unlikely. However, Structural-Safety knows of a case where improvements in quality of fabrication led to a vortex shedding problem which caused large amplitude motion resulting in fatigue. In the past, there has always been some movement in the slip joints between stacked sections that dissipated energy and so improved structural damping. There have also been historic cases of lamp posts failing due to corrosion of the pole.

There are several practical points to be considered such as the design of the fixings and their ancillary parts to provide security against loosening, the ability to take all applied forces (which may include shear and bending as well as tension), protection against corrosion, and the possibility of inspecting the assembly in future.

579 FURTHER REPORT ON FREEZING OF WATER IN ZINC PLATED HOLLOW SECTIONS

A reporter has a further warning on the issue of freeze/thaw cracking following [report 434](#) in CROSS Newsletter No 36. His firm encountered a similar problem on a UK project and investigated the matter. The units had originally been plated but LMAC cracking was ruled out as the crack faces had no zinc on them. This was evident due to the corrosion which would have been prevented by the zinc. The metallurgical investigation provided no clear evidence of the failure mechanism. There had been however a very cold winter that was also wet. The drain holes were originally only intended to drain excess zinc not for water drainage and the hollow sections had large amounts of water in them which had not escaped. Freezing an undamaged unit was tried but a similar failure could not be reproduced. While the investigation concluded that LMAC was not the source of the problem it could not be confirmed that failure was due to freezing of water. All units had been exposed in the same way but not all cracked, so it might be a small difference in the unit that was tested that avoided the phenomenon. The hollow section was cold formed not hot formed so there would have been strain ageing on the corners. This is known to reduce toughness and, coupled with the pressure of the frozen water may have been enough to cause cracking.

Comments

Something of a forensic mystery but there have been previous reports of freeze/thaw cracking on hollow sections. The links are given below but can be found using the Quick search facility on the Structural-Safety web site and entering "RHS":

[5002 Stadia crash barriers report](#)

[253 Freezing splits galvanised RHS columns](#)

[314 More on freezing and galvanised hollow sections](#)

[434 Freeze/thaw effects on RHSs and unexpected hydrogen generation](#)

As the data base grows it is hoped that this will become a resource for checking on reports that have been made. Here the conventional wisdom is that hollow structural members should be effectively capped/sealed to prevent water ingress in the first place but problems with imperfect sealing have been known. Alternatively, there could be drain holes so that any water ingress does not build up to the degree that freezing might cause damage.

575 UNDERGROUND SCAFFOLD OVERTURNS IN WIND



Underground scaffold blown over

This concerns a 5m high scaffold screened with fabric that was erected to protect against debris and dust from adjacent demolition works of the arched structures below a building. When the demolition broke through into the arched structure, airflow was introduced producing horizontal load on the scaffold which overturned. It fell onto a section of a pedestrian route for the site team and fortunately there were no injuries. The root cause of the event, says the report, was misinterpretation of the scaffold standard TG20:13 in that the need for a designed scaffold was not appreciated, wind loading was not considered, and there were inadequate ties to the masonry arch. A procedure was in place that stated all classes of temporary works/scaffold should be on a register which this was not, and whilst the scaffold requirement was discussed on site at a temporary works planning meeting this did not cover the scaffold screens.

Comments

All internal structures can be subjected to horizontal loads, including wind pressures, and should be designed as such. This is almost a classic case of not considering the safety attribute of 'sensitivity'. The original assumption of no wind was wrong so even a slight pressure would have been serious. Achieving robustness always requires a presumption of some horizontal forces but there is always also danger in assuming low wind speeds for temporary works designs. The force difference in say going from 2m/sec to 4m/sec is $(4/2)^2 =$ an increase of 400%. It is essential that temporary works are designed and constructed to BS5975 and associated [TWf guidance](#), with any fixings needed for stability designed and constructed to [BS8539](#) and [CFA guidance](#).

599 HERITAGE BALUSTRADES AND BUILDING STANDARDS

A reporter is hoping that Structural-Safety might be able to help with some research for a heritage project. The project falls into the "Conversion" category which invokes the requirement to provide improvement to as near the Building Standards as reasonably practicable. As the building is A listed the Heritage authorities and Building Standards authorities view this requirement differently. The issue is how to treat an ornate cast-iron balustrade guarding a stone interlock stair, which is an important historic feature of the building. The existing arrangement does not meet the modern requirement, because a 100mm diameter sphere can pass through a gap in the balusters that is 130mm wide. Unfortunately, the ornamental nature of the balustrade does not lend itself to simple alterations so the reporter would be interested to know if there are any recorded incidents where the spacing of balusters has been found to be at fault, particularly in a heritage context. Perhaps a systemic issue was identified that led to the introduction of this regulation? He would be grateful if this were something Structural-Safety could shed some light on, because either way it would be a useful contribution to the discussion.

Comments

There are often conflicts between Building Regulations and heritage aspects of buildings, and sometimes compromise is needed. The 100mm sphere referred to is to protect against children getting stuck, rather than protection from falling. The ornate balusters, may however be more susceptible to climbing. This might not apply unless it was a building to which children may go. An answer to this may be to insert an independent guarding in front of the balustrade, which could be glass if the visual aspects were important. However, in the case of a stone staircase with cast iron balustrade it might not be practical to add glass on the inside, and indeed this could result in making the stair less safe due to the extra weight on the outside edge of the stair and the difficulty of making fixings in brittle materials. This is obviously something to be discussed with the different authorities. Sometimes however, there may be no way to ensure a safe building and satisfy the heritage aspects. If that was to be the case, then it should be accepted that the conversion is not possible and this is something that an owner should consider before embarking on a project of this nature.

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HOW TO REPORT

Please visit the website www.structural-safety.org for more information.

When reading this Newsletter online [click here](#) to go straight to the reporting page.

If you want to submit a report by post send an email to the address below asking for instructions.

Comments either on the scheme, or non-confidential reports, can be sent to structures@structural-safety.org

DATES FOR PUBLICATION OF CROSS NEWSLETTERS

Issue No 46	April 2017
Issue No 47	July 2017
Issue No 48	October 2017
Issue No 49	January 2018