CROSS

Confidential Reporting on Structural Safety

NEWSLETTER NO 25, JANUARY 2012

REPORTS IN THIS ISSUE:

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 web site data base.

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INTRODUCTION

There have been recent collapses of temporary stage structures in the USA and in Europe which have resulted in fatalities and numerous injuries. The reasons why these failures have taken place have not yet been published, although initially wind has been reported as a possible contributory cause. The types of temporary structures which have been involved appear to be similar to those which may be used in the UK. SCOSS has just published an Alert; “Temporary stage structures”, about the possible risks and it is aimed at those who may commission or procure or licence temporary stages and other temporary structures, for example large outdoor TV screens, which offer potential risks to the public, These may include owners of sites and venues, promoters, contractors and their designers, local authority licensing officers and building control officers, and insurers.

The first report in this issue deals with licensing of temporary structures such as stages and demonstrates that there are concerns amongst local authorities about the current situation. There is then a report about potentially dangerous issues during the construction of a school, and two about the sudden failure of timber roofs. Finally there are four reports about issues connected with the installation of photo voltaic panels on existing roofs.

Engineers may be concerned if they identify something which they judge to be amiss but are uncertain as to the proper course of action. The Royal Academy of Engineering has recently published “Engineering ethics in practice: a guide for engineers”, which gives case studies from several disciplines and will help engineers decide how to act. Further details are given in this Newsletter.

The CROSS programme depends on receiving reports and individuals and firms are encouraged to participate by sending concerns in confidence to structural-safety.

276 LICENSING OF TEMPORARY STRUCTURES

Temporary structures, such as stages, marquees, lighting towers, video screens and the like are erected at a huge number of events in the UK each year. I have, says a reporter, inspected many such structures and have concerns that the systems in place for ensuring their stability are not working. Because of the number of people in close proximity, he continues, the failure of such a structure could have very serious consequences. The reporter works for a local authority and there are a large number of outdoor events held each year in his area which require a public entertainment licence. In granting the licence, the local authority has a duty to consider the structural stability of any temporary structure. In the reporter’s authority, the licensing department consult with Building Control and request that they deal with this aspect. There are however no controls under Building Control legislation to deal with such structures, so any enforcement must be through licensing laws. Failures of such structures can occur for a number of reasons, such as; design faults, erection faults, component failure and management failings. The Institution of Structural Engineers publication “Temporary demountable structures” is an excellent guide for all those involved with these structures. Below are problems found by the reporter.

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 Users Forum
- British Parking Association
- Communities and Local Government
- Construction Industry Council
- Department of the Environment
- DRD Roads Services in Northern Ireland
- Health & Safety Executive
- Highways Agency
- Institution of Civil Engineers
- Institution of Structural Engineers
- Local Authority Building Control
- Scottish Building Standards Agency
- Temporary Works Forum
- UK Bridges Board

Design Faults It is important that the design of such structures is undertaken by competent engineers. However, there is still the risk of errors in the design, and in recent times, continues the reporter, he has received structural calculations where moments have been calculated incorrectly and inadequate factors of safety used.

Erection Faults In the opinion of the reporter, this is the most common type of problem. Structures are often erected without any or little reference to the design calculations, and frequently the ballast provided is far less than required by the design. In addition, the fixing of the ballast to the structure is often inadequate, especially when intermediate Bulk Containers (IBC) filled with water are used. He has also witnessed columns supporting a large balcony supported only on ply decking with no support directly beneath, and even base plates to a footbridge on steeply sloping ground wedged with dead branches. It was intended that 5,000 people would use the bridge.

Component Failure Components may fail for a number of reasons and it is important to ensure that damaged components are not re-used.

Management Failings Rather than designing for maximum likely wind speeds as would be required for permanent structures, many temporary structures are wind managed. This requires an effective wind policy to be in place to monitor wind speed and take appropriate action when the wind reaches certain pre-determined speeds. Failure to abide by this wind policy could have disastrous consequences, and the reporter frequently comes across situations where there is no such policy in place.

There are a number of organisations that he has dealt with, says the reporter, which have excellent systems in place to ensure that design calculations have been checked, that erection is in accordance with the design and that the management policy is robust. However, from his experiences, he has real concerns that in general terms the industry is not able to self-regulate itself at present, and therefore, if we are to reduce so far as practicable the risks, it is important that there is sufficient external checking of such structures and adequate supervision on site. Having regard to the faults that he has identified, the reporter believes that the standard of checking by local authorities is extremely variable, or possibly even non-existent in some cases. Frequently erectors state “this is how we always do it” when clearly this is not in accordance with the design. The question has to be asked why structures are not being erected in accordance with the design. It is believed by the reporter that the main reason for this is that, very often, important design information is hidden in the structural calculations and is not readily interpreted by people without experience in structural design. By producing a simple summary sheet to their calculations which clearly identifies important aspects of the design, such as the ballast and bracing requirements and maximum wind speed, designers could assist both the erectors and checking authority. He believes this would significantly assist in ensuring that structures are erected in accordance with the design. This is a recommendation of the IStructE guide (TDS3) but is clearly not being followed in the majority of cases. Certainly local authorities need to consider whether they are carrying out sufficient checks and perhaps guidance should be produced for licensing authorities in this respect. It could of course be argued that there have not been too many serious incidents in recent years in this country involving such structures. However, when things go wrong, it does seem that it is often as a result of concurrent circumstances, such as erection and management failings together with adverse weather conditions, and perhaps we have just been fortunate. Based on his experience, the reporter believes that unless systems are improved a serious incident will occur, and at that time questions will be asked about the checking process.

Collapse at Indiana State Fair August 2011
(Joey Foley/Getty Images)

CROSS comments

The reporter is to be complimented on bringing to the forefront an issue which is serious and timely. The design and construction of temporary stages has been developed within the industry to include some very large and complex structures. Many of these are perfectly satisfactory but there have been catastrophic failures in recent years.

- *Millennium Point Birmingham June 2006; collapse of large video screen – see SCOSS Topic Paper: Risk issues associated with large TV/video screens at public events*
- *Bearded Theory Music Festival Derbyshire May 2009 failure of saddlespan tent– see SCOSS Alert: Temporary event structures: 'saddle span' type tents*
- *Madonna Concert Marseilles July 2009 – stage roof collapse during construction with 2 fatalities and 8 injured*
- *Big Valley Jamboree Alberta August 2009 – stage roof failure with 1 fatality and 75 injured*
- *Guns N' Roses Concert Brazil March 2010 – stage roof failure with several injured*
- *Bluesfest Concert Toronto July 2011 – main stage collapse with 3 injured*
- *Sugarland Concert Indiana August 2011 – main stage roof collapse with 6 fatalities and 44 injured*
- *Flaming Lips Concert Oklahoma August 2011 – large video screen collapse*
- *Pukkelpop Music Festival Belgium August 2011 – main stage collapse with 5 fatalities and 140 injured*
- *Jovanotti Concert Trieste December 2011 – ground support stage structure collapsed during construction with 1 fatality and 12 injured.*

These failures should provide a serious warning to Local Authorities and others involved. Guidance on temporary structures is contained in Temporary demountable structures, Guidance on procurement, design and use, Third edition, published by the Institution of Structural Engineers, 2007 (TDS3). The SCOSS Alert: Temporary Stage Structures published in January 2012 draws the attention of site owners, promoters, contractors and their designers, local authority licensing officers and building control officers and insurers to potential risks. In some cases wind forces have been cited in press reports as contributing to some of the above collapses, but as stated in TDS3 there must be monitoring of wind speed and a plan of action if there are design restrictions on safe wind loads. The issue of a licence for a temporary structure should not be any less effective than the process of gaining approval under Building Regulations. Licensing mechanisms should preclude the possibility of workers and the public being at risk from the collapse of temporary structures but are the regulations tight enough and are they being applied with sufficient rigour?

242 STABILITY COMPROMISED IN SCHOOL HALL

The project in question, says a reporter, is a new school hall; steel framed with infill cavity masonry walls. The building is highly and unusually glazed, and as such, is reliant upon the steel frame for overall stability and to provide restraint to the masonry panels. An initial 'oversight' by the foundation sub-contractor and the main contractor allowed a reinforced concrete pad to be cast without the reinforcement cage. The pad is one of two that provide overall stability to the building.

NEWS ITEM

Firm fined £75,000 after man died in roof collapse

A construction firms has been fined £75,000 for breaches in health and safety rules which resulted in the death of a worker from crushing injuries when a 1.5 tonne roof from a building collapsed. Fining the contractor a total of £75,000 for two breaches of the legislation and their former architect £5,000, the Judge in the case said the accident had been caused "by a complete failure to recognise the risk involved". At the time the contractor was moving a sectional building from one location to another. Most of the sections had been successfully moved, but as attempts were made to secure another, one of the walls of the building collapsed sideways.

A further issue on the same project, continues the reporter, was cause for even greater alarm. As project structural engineer, one of his roles is to carry out an inspection of the work on site and he found that masonry panel cavity head restraint ties had not been installed by the brickwork sub-contractor. Furthermore the normal cavity wall ties did not span the full cavity width one tie to each leaf had been used, loosely hooked over each other in the cavity! The bricklayers admitted that they had run out of 140mm thick inner leaf blocks and had swapped to 100mm thick blocks. This resulted in the wall ties not being long enough and the reporter could, alarmingly, wobble a 3m wide x 2m high panel of cavity wall by hand! The site operatives had every intention of 'bodging' the installation of the head restraint ties because the primary steel rafter had not been provided with vertical cleats as detailed on the drawings. They had also further risked the safety of the building occupiers (small children) by making decisions on site well outside their remit, and trying to cover it up.

CROSS comments

The steady reduction in site supervision and inspection and the changes from engineer to contractor over the years has resulted inexorably in the greater likelihood of serious shortcomings. In this case the contractor took design decisions, wittingly or unwittingly, which were outside his remit. Design codes explicitly require an adequate quality control system to be in place during the construction phase in order that the design is not invalidated. This is frequently ignored with predictable results. Designers should provide clear guidance to Clients as to the necessary site QM required and ensure it is included in the contract. In this case the difference in lateral stability provided by an infill masonry panel when substituting a 140mm blockwork leaf with a 100mm blockwork leaf is substantial. Effectively omitting wall ties to the cavity wall leaves is also compromising lateral stability of the wall and there can be no lateral transfer of wind load between the two leaves. The designed load paths for all elements are often complicated and are not always obvious particularly to a non engineer. Details that might look minor may be critical and design instructions to site should make that clear. Had these defects not been found the stability of the school hall would have been severely compromised. There is never any excuse for contractors to make unauthorised changes and this incident is a warning to those who think that omitting site audits is a way of saving money.

School roof collapse

249 SCHOOL ROOF TIMBER TRUSS COLLAPSE

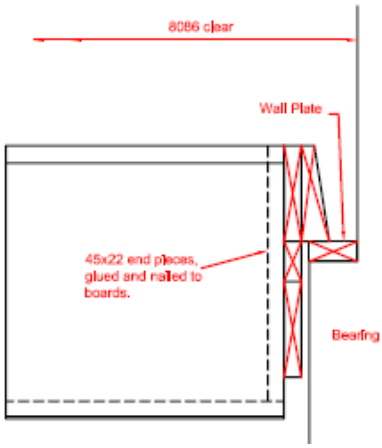
A gym/assembly hall roof to a school collapsed suddenly and without warning overnight when, fortunately the building was unoccupied. The building dates from the early 1960's and, in the view of the reporter, the collapse was due to a failure of the mid-span splice connections in the top and bottom chords of the bolted timber trusses which span the length of the hall (approximately 12m). The roof is flat over two thirds of its length but slopes upwards at 45 degrees at one end. A subsequent analysis of the trusses confirmed that the design complies with the Codes of Practice around at the time of construction, namely CP 112 (1952) and CP 3 (1952). However CP3 did not require the designer to consider the effects of snow drift loading. When snow drift loading is considered in the analysis, the mid-span splice connections to the top and bottom chord members are overstressed and this appears to be the reason for the failure. There was no snow on the roof at the time of the collapse. However during the previous winter the region where the building was located had experienced what is considered to be the heaviest and most prolonged period of snow fall for many decades. It is the reporter's opinion that this caused damage to the timber, causing it to split at the mid-span splice connections. High winds during the winter may have exacerbated the problem. There is significant damage to both top and bottom chord splice connections. The

reporter believes that the bottom chord splice failed first. The damage to the top chord appears more dispersed and 'collateral' in nature. The reporter's concern is that any roofs of a similar period supported by bolted timber trusses and designed using the imposed load criteria of CP3 could be vulnerable if the shape of the roof is such that significant snow drift loading can occur.

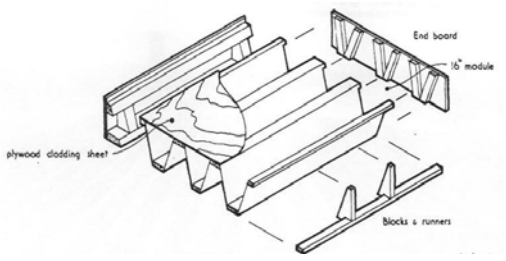
CROSS comments

It would be interesting to know if there were any indications of imminent failure. What was it on the night that precipitated the collapse? If a structure is so badly overstressed as to be on the point of failure there will usually be warning signs. Such roof structures are normally very robust and there may have been an underlying problem - perhaps with the joint detail. Were these designs based upon bolted joints or were timber connectors used in the joints (toothplates/shear plates) used? One of the CROSS expert panel some years ago came across rare cases where shear plate connectors had been used with timber members and steel splice/jointing plates. Some of the CP112 design loads for shear plates were, he believes, stated in that code slightly on the high side. If shear plates were used in joints with load along the grain direction, and the end distance from connector to timber was the minimum allowed, and the timbers had maximum permitted grade defects (knot size) over the jointing area, then failure could occur even if design was fully to the code of practice. The drift loading issue may not be the main issue here as many similar structures were designed to CP3 and there do not appear to have been many failures from the period. Another point is that in this period diagonal bracing use was not commonly used to these types of roof structure but the timber widths were thicker than modern trussed rafters and the overall construction was probably more robust.

Collapse of Timber Roof



Side View at Bearing



Roof system

273 COLLAPSE OF PROPRIETARY TIMBER ROOF

We were called, says a reporter, to investigate the collapse of a roof spanning 8m over a hall which was fortunately unoccupied and no one was hurt. The roof was constructed in 1959, and formed from a ply-web beam system, with hardboard ceiling and ply deck and asphalt covering. The asphalt had been felted, and then a further layer of insulation and felt applied. The roof had a parapet wall running around it, 100 to 150mm high, with internal rainwater outlets. There was evidence of ponding at one of the outlets and a lot of water was on the roof at the time of the collapse. Apart from creaking of the roof 15 minutes before the collapse, there was no warning. The roof was a proprietary system, which relied for support on end bearers glued and nailed to end stiffeners in the webs. The bearers sat on narrow ledges. This requires highly accurate construction of the supports; however, the failure mechanism in this case appears to be complete de-bonding of the end stiffeners and ply deck at one end, resulting in sudden shear failure. The end detail was a standard arrangement, as an alternative to sitting the beams directly on the supports. The system seems to have been used from 1953 or 1954 onwards and continued for at least 5 years (when the hall was built). The system is noted as a patented design in the 1976 version of the timber designers manual so may have been used for considerably longer. The system was used for walls, floors and roofs in a wide variety of buildings. The manufacturer however went out of business some years ago. Spans varied from 15ft to 42ft (4.57m to 12.80m). Decks at particular risk of this type of failure, believes the reporter, (until the end supports are verified) will include floor beams, decks with trimmed openings and roofs up to 9.1m span, (longer decks are less likely to have the end board detail but may still be subject to other types of failure, particularly in warm, humid environments). The only mechanical fastenings between the stiffeners and the web were small diameter nails, effectively panel pins, 3 or 4 each side, which he believes were only intended to provide gluing pressure for the joint. All such units with an end bearer detail should be regarded as dangerous and there may be hundreds in use. To identify these components a small hole and inspection with a borascope would hopefully

NEWS ITEM

Ethics report from the Royal Academy of Engineering

The Royal Academy of Engineering has recently published a guide; Engineering ethics in practice: a guide for engineers, that aims to support engineers in addressing the ethical issues they face in their daily professional lives; helping them to identify, analyse, and respond effectively to the challenges raised. It follows on from the Royal Academy of Engineering and Engineering Council's Statement of Ethical Principles which was developed to identify the common ethical standards to which all engineers are committed. The present report contains principles together with case studies to help readers explore the application of ethical principles and is part of the ongoing process of providing support to professional engineers in the development of their ethical skills, such as their ability to recognise the ethical aspects of engineering decisions, and to fulfill the ethical expectations of the general public.
The primary elements in these skills are the abilities:

- to identify the different, and sometimes competing ethical concerns they face
- to analyse the issues that might underlie those concerns and to respond effectively to those concerns.

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be enough as the members are quite distinctive, with their inclined webs, but these of course may be hidden by ceilings. Figures show the aftermath of the collapse, an exploded view of the form of construction, and a side view drawing of the bearing.

CROSS comments

This report raises a number of issues: water ponding as a result of blocked outlets which cannot be seen from ground level, deterioration of timber (and glued components) arising from wetting conditions through water ingress, and possibly details associated with the bearing such as the bearing length. At the time of construction such plywood box beams were either structurally glued or structurally nailed. If structurally glued then tacking nails were used to hold the assembly together while the glue cured. After curing the nails were redundant and not considered in the design. In structurally nailed assemblies there was a designed dense nailing pattern along flanges and down stiffeners and 11 gauge galvanised nails were commonly used. The glues that were typically used are water resistant if applied correctly and plywood web beams were good structural elements provided that manufacture and construction practice was controlled. It may be that the design and construction were satisfactory but that a lack of maintenance allowed rainwater ingress to occur. This could have affected the timber at the glueline, or the failure may have been related to support conditions, or it could have been a combination of the two. Whatever the cause this is a potentially serious issue and possibly there ought to be a requirement in building management to periodically check long span roofs. As suggested by the reporter the use of a boroscope could be helpful when assessing conditions at bearings. In the section on robustness in Approved Document A there is a clear indication of higher risk when the consequences of failure are multiple injuries. In this case, and that of report 242 (above in Newsletter No 25) there were long span roofs over school halls where the risk of injury could be very high. There have been previous examples of roof failures in schools which prompted large scale investigations. In 1973 at Camden School the beams made from concrete containing high alumina collapsed and many similar structures were checked and some strengthened: see Question on high alumina cement. In 1976 the timber roof over the gymnasium at Rock Ferry School collapsed again resulting in widespread checks of such structures. For example see The Structural Engineer volume 78, Issue 1, A Century of Innovation: Structural Engineering 1900 - 2000.

266 PV SOLAR PANELS

This reporter queries whether enough attention is being paid to the loads applied by PV (Photo Voltaic) solar panels added to roofs. Such panels, he says, weigh at least 12kg/m^2 and Building Control ask for justification of additional load on existing roofs. Some old roofs could be tipped over the safe limit and collapse. Modern trusses may be shown to be adequate, but not all, says the reporter who considers that it up to truss suppliers to make sure their products are adequate and advise the industry to this.

280 LOADING FROM SOLAR PANELS

Another reporter visited a dwelling which already had a two solar panels installed on the roof and where the owner then wished to have more. The reporter inspected the roof framework and advised the panel supplier that the structure was already overloaded with the self weight of the roof covering without the addition of solar panels. The property was built in 1971 and has a very slim roof structure which, in the opinion of the reporter, would be in danger of collapse if a snow load of any significance were to be added to the loading of the weight of any solar panels on an already overstressed structure.

NEWS ITEM

British Parking Association

The BPA has published an updated version of Parking Practice Note covering:

- Legislation/legal obligations
- Duty of the owner/operator/employer
- Duty of the car park manager
- Discharging the legal obligations
- Insurance
- Park Mark
- BPA Master Plan Objective

An ongoing concern is the structural condition of some older multi storey car parks.

Falsification of records

CROSS has had some reports about false documentation in relation to materials or components and would be interested to hear more about experiences about this practice. The SCOSS committee is currently studying the matter and would like to have more information. Reports should be sent confidentially to CROSS.

287 CONCERN ABOUT PV INSTALLATIONS

A reporter who has been pricing PV installations for portal frames would like to draw the attention of CROSS to concerns regarding issues that are emerging within the industry. There seems to be, he says, evidence of PV companies buying design software and having a go themselves without any training or supervision by a Structural Engineer. Given the number of collapses of buildings in Scotland in the winters of 2009/10 and 2010/11 due to the snow loads, the lack of regulation and training for those allowed to purchase and to use this software presents risks. In the opinion of the reporter there is the potential for failure. In addition the reporter's company has received enquiries from PV companies seeking 'remote surveys' for their installations and asking for a 25 year guarantee that the structures will carry the newly applied loads! The reporter understands that it is not a requirement to submit structural calculations under Building Regulations for a PV installation *(not so - see comments below)*, but this does not offer any protection to the public against injury should wind suction cause a panel to come off the roof, or indeed if panel loads push a portal design to the limit! He feels that there is a justifiable case for Building Regulations being applied to such installations in the interests of public safety.

269 SOLAR PANELS AND EFFECT ON SNOW SLIDES FROM ROOFS

A reporter writes in connection with Newsletter No 23 and report 246 Dangerous snow slides from buildings and asks if any of the roofs had had Solar Panels? Would this make any difference to the ' the slide off factor ' and would the extra dead load of the panels make any difference in this respect to the failure of the roofs?

CROSS comments

The installation of solar PV panels is a material alteration under the Building Regulations and needs assessment. In England this is to be done either under a Competent Persons scheme (such as the MCS scheme) or the local authority requires notification. Some competent person's schemes only operate for electrical requirements of the Regulations and then need the local authority to check other relevant aspects such as Parts A and C of the Building Regulations. Issues of loading on existing roofs whether wind or snow or dead therefore come under control. Clearly there is a need to assess whether an existing roof structure can carry the extra load and that applies globally and locally (at fixing points). But there are additional concerns. In the past CROSS (refer to SCOTCROSS report) has reported on many cases of danger following parts becoming detached from roofs so it is essential that panels are properly fixed down against the very high suction loads that might occur. In areas of higher snow load sudden thaws can cause snow slides with significant impact and danger if the slides fall on people or adjacent lower lying roofs. The potential for large slides might exist given the nature of panel surface material. The concerns are likely to increase as pressure to reduce energy consumption grows. Insufficient attention being paid to structural integrity is not new on small works. The examples quoted above all relate to competence and so far the solar panel industry is unregulated. Notwithstanding this the installation of solar panels is covered by the CDM Regulations and hence all those involved have statutory duties to safeguard others. It may be that a code of practice could be a good starting point. The Scottish Government has published a report: Risk assessment of structural impacts on buildings of solar hot water collectors and photovoltaic tiles and panels – final report

DATES FOR PUBLICATION OF CROSS NEWSLETTER

Issue No 26	**April 2012**
Issue No 27	**July 2012**
Issue No 28	**October 2012**
Issue No 29	**January 2013**

HOW TO REPORT

Please visit the web site:
www.structural-safety.org

When reading this Newsletter online **click here** to go straight to the reporting page.

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