

# CROSS

## Confidential Reporting on Structural Safety

For an introduction to CROSS see [www.structural-safety.org](http://www.structural-safety.org). Email: [structures@structural-safety.org](mailto:structures@structural-safety.org)

### NEWSLETTER No 40, OCTOBER 2015

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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 [database](#).

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#### TENTH ANNIVERSARY

This 40<sup>th</sup> CROSS Newsletter marks ten years since the introduction Confidential Reporting on Structural Safety by SCOSS – the Standing Committee on Structural Safety. Since 1976 SCOSS had been collecting data on structural safety from publically available sources and deciding whether unacceptable risk exists. At first the Committee reported their findings every two years to the Presidents of the Institution of Structural Engineers and the Institution of Civil Engineers. Some years later the Health and Safety Executive joined as a sponsor and these three bodies continue to fund the operation in the interests of Institution members, the construction industry, and the public. Biennial reports and Alerts were produced. In the early 2000s the Committee recognised that there were many events and concerns that were not published anywhere from which lessons could be learned. A system used by the aviation industry was used as a model and in 2005 CROSS was formed.

Since then the number of subscribers has risen to 8,500, over 500 reports have been received of which many have been published in the quarterly Newsletters. Where particular risks are identified SCOSS Alerts are published. Published and other reports, together with Alerts, have been added to the on-line data base for use by practitioners and for educational purposes. CROSS and SCOSS were more recently merged into a new organisation: Structural-Safety, to streamline operations. There is interest from many parts of the world including Australia, the USA, Southern Africa and elsewhere.

Fundamental to the scheme have been the unstinting contributions from the SCOSS Committee and the CROSS Expert panel. These representatives from the highest levels of the industry give guidance and provide advice to improve structural safety and to help prevent failures. Also key to the operations have been the contributions by executives and staff at the Institution of Structural Engineers. Of course, CROSS also could not exist without the reports that are submitted so that experiences can be shared for the benefit of us all. The contribution of Rippleffect, our web site designers, is much appreciated. We look forward to the next decade and to enhancing and expanding the programme.

#### INTRODUCTION

The first two reports are significant in that they come from major bridge owners who are willing to share their experiences of in-service issues. Both illustrate the value of inspections in assessing safety and it is hoped that other infrastructure owners will be encouraged to follow suit and report incidents. Next is a concern about falling objects that may become increasingly significant as more tall domestic buildings are constructed in urban locations. In addition to new-build many buildings are altered which gives rise to numerous problems, and sometimes to collapse, so the next report which describes a near-miss is relevant. There are then

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

To find reports in the data base go to the **Quick Search** box on any page of the [Structural-Safety](#) site and enter a subject e.g. "wall" and a list of summarised reports will follow.

Searches can be refined using **Search data base facility**.

instances of components being blown off buildings and the design of fixings for PV panels. Finally there are concerns about the high costs of some design standards and about gallows brackets.

**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](#).**

## 524 SPALLED CONCRETE FALLING FROM MOTORWAY BRIDGE

It has been reported that an incident occurred at a motorway overbridge resulting in a piece of spalling concrete falling onto the carriageway and striking a vehicle. This resulted in minor injuries to the driver. It is understood that the concrete which fell was no greater than 50 - 60mm in size. It had spalled from an area of previously repaired concrete on the cantilevered deck soffit located over the carriageway and resulted in closure of the motorway for 3 hours. During closure an initial Special Inspection of the structure was undertaken and other areas of potentially loose concrete were removed. Subsequently a full review of all the structures on both carriageways of this section of the motorway was carried out and a risk mitigation plan established based on a programme of special inspections to identify areas of concrete with potential to spall. This was developed into a programme of ongoing inspections and concrete removal to manage the risk of further such incidents. Risks will be managed further when planned substantial concrete repair works are undertaken over the next two years as part of an upgrade scheme.

The following have been identified as contributory to the concrete spalling incident:

- Corroding reinforcement as a likely consequence of poor design detailing and quality of construction (reinforcement with low concrete cover in close proximity to a drip detail and relating to the date of original construction in 1962).
- The poor quality of the concrete repair carried out around 2008 (likely poor detailing with feathered edges to the repair, poor adhesion combined with repair material not being anchored around adjacent reinforcement). In addition, there was a lack of as-built information relating to the repair.
- A recent Principal Bridge Inspection had not included a close examination of the elements of the structure above the relevant lane.

The following lessons learned have been identified:

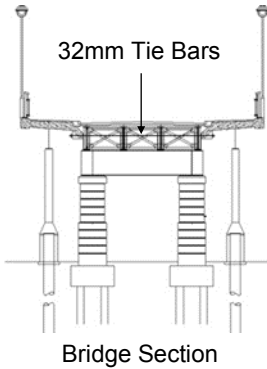
- The need for a good quality of design and construction to provide a safe and durable structure.
- The need for quality concrete repairs to be undertaken in accordance with current good practice and as-built details recorded.
- The need to undertake Principal Bridge Inspections strictly in accordance with current standards and with particular emphasis on a close examination of the elements of the structure.

**Comments**

*This is an important report from a major infrastructure owner and is most welcome as the lessons learned from a potentially serious incident are being shared. It highlights the importance of design in its widest sense and not just numerical code compliance. It is also a reminder that all structures deteriorate in use and inspections are required to look at how degradation is progressing and to be alert for the likely implications. However the remedial works were carried out only seven years ago which is not a long life span for safety critical repairs.*

## 522 ESTUARY BRIDGE - FAILURE OF STAINLESS STEEL TIE BARS

In 2002 the footways of an important estuary bridge were widened says a report from the owner. The works replaced the cantilevered footways of the structure with footways supported on steel girders which in turn were supported on steel columns. The strengthened footways and the original structure are connected through a keyed concrete joint and pairs of 32mm diameter stainless steel tie bars at 1/3 points of each span (2 pairs per span), giving a total of 90 tie bars across the whole structure. The tie bars are post-tensioned to pin the structure together and prevent a separation of the original and new structure in the event of an accidental impact of a vehicle into the bridge parapets. A Principal Inspection of the structure was completed early in 2015 and it was seen that 12 ties had failed through bar fracture, and 4 by coupler fracture. It was thought that the failure of the tie bars could have been from over-stressing of the tie bars due to unanticipated effects of the structural form of the bridge, or under-design of the tie bar durability in a harsh marine environment. Over-tensioning of the bars on installation was ruled out on the basis of records, whilst transverse thermal expansion and differential settlement were also ruled out.



The tie bars were however exposed to chlorides from sea spray and the marine atmosphere. They were sheltered from the rain and would not be naturally cleaned with fresh water so there has been a build-up of chlorides and rust staining. Examination of samples showed that there was a consistent pattern of red rust along the length of the bars and in the area of fracture there was a particularly large patch of corrosion on the 'bottom' surface with deep pitting. The small size of the final fracture region indicated that the load at the time of failure, the 225kN pre-stress, was not excessive. The coupler showed a red rust patch on the outside 'bottom' with some minor pitting evident. Several branch cracks were noted. Micro examination of the failed components showed the steel to be free from any manufacturing or processing defects and that failure had initiated at pitting of the surface of the components. Branched cracks and corrosion products indicate that stress corrosion cracking was the most likely mode of failure.



Fractured Tie Bar

### Key Learning Points

- It is essential that the correct grade of stainless steel is used for marine environments.
- Just because a steel is stainless doesn't mean that it doesn't corrode, further protection measures may be required against stress corrosion cracking and other failure modes.
- It is difficult to identify Stress Corrosion Cracking from in-situ visual inspection.
- Sudden failures can occur in tensioned elements.
- The surface finish and regular washing of stainless steel components has a major effect on their durability and can be critical to their successful application in a marine environment.

### Comments

*As with 524 this is an important report from a major infrastructure owner about a potentially serious situation and is very welcome. Apart from the recommendations about stainless steel in a marine environment it further emphasises the value of regular inspections. Advice about the use of the material can be obtained from the [British Stainless Steel Association](#). There are a number of references to Stress Corrosion Cracking available such as [Stress Corrosion Cracking – National Physical Laboratory](#).*

## 495 OPEN BALUSTRADE BALCONIES OVER A PUBLIC HIGHWAY

A reporter has watched the construction of a large residential development adjacent to a public highway where the balconies oversail the footpath. Even though some of these balconies are on the upper floors, they only have vertical infill bar balustrades with 100mm gaps between the bars. He is concerned that nobody has fully considered the risk to the public of small - but heavy – objects (e.g. coins, bunches of keys, small heavy toys, etc.) falling from these balconies between the gaps in the bars, from a considerable height, onto pedestrians below. The reporter would be interested to know whether this had been included in the risk assessment by the designers. He also cannot understand

why the planning or highway authorities haven't picked this up when issuing Section 177 projection licenses under the Highways Act 1980. Whilst the balconies may satisfy Building Regulations, they present an unnecessary hazard in the view of the reporter that could have been easily prevented with a solid parapet (e.g. glass or perforated metal sheet).

### Comments

*Building regulations do not cover items being dropped off of buildings, and nothing in the guidance requires gaps to be less than 100mm. However, there is a clear risk here which should be considered. Is this risk greater than someone dropping something over the top of the balustrade or out of a window? Risk assessment is the role of the designer and it is quite foreseeable that items could be accidentally dropped. Such assessment would take into consideration the number, frequency and proximity of pedestrians. Whilst not similar to the hazard of dropping items from the top of balconies or through their balustrades, work place requirements ([The Work at Height Regulations 2005](#)) include for toe-boards to prevent items being pushed off scaffolds and the like.*

## 479 DANGEROUS ALTERATIONS



Three Span Beam with Columns Removed



Beam Joint

An existing building was being converted to another use, says a reporter. The structure is being replaced, but the facade retained. The construction method was to create a new frame within the existing, with columns punching through the existing slab. The facade was then to be tied into the new frame and the old structure removed. The local authority building control officer went to site and witnessed on an upper floor that the columns had been removed out of sequence, before the new frame had been constructed. The existing beam over had been left simply supported, with no continuity over the columns. Upon removal of the columns, the beam tripled in length and with load reversal at the column points, the compression flange had no positive connection. It seemed that the floor over was spanning through membrane action, as there was luckily very good tying between members. The building control officer asked for the beams to be propped immediately and no damage occurred. The reporter says that this highlights poor site control, an inadequate construction plan and a lack of understanding of the structure by the site operatives. Furthermore, he says, the structural engineer did not make any visits to the site.

### Comments

*Judging by the number of failures that are reported to CROSS, the skills of assessing temporary stability during construction or alteration seemed to be lacking. In any alteration there is no substitute for breaking down the planned changes into discrete steps and for then assessing strength and stability at each stage. The CDM Regulations make clear that both phases be adequately planned, managed and monitored by the designers. It is good practice to refer the contractor to the HSE page [Temporary Works \(TW\) FAQs](#) which advises the appointment of a TWC who then needs to direct the design and sequencing of the temporary works. It also requires that those involved have the right skills, knowledge, training and experience to carry out the tasks required of them. Site monitoring is often neglected in terms of risk management, but it is a question that would arise in any formal proceedings in the event of failure. Insurers sometimes advise engineers to limit site visits unless specifically included in agreements and temporary works are generally additional services. CIRIA is currently (2015) undertaking a review of structural stability during alteration work and a series of recommendations will be published in due course.*



## 498 CLADDING PANEL BLOWN OFF

This reporter has become aware of an incident where a decorative cladding panel fell from height when it became detached from an upper level of a multi-storey building in England in high winds. The panel was of a resin concrete type which can be manufactured in sizes from approximately 500mm to around 1000mm with varying thickness and weights typically in the range 5 –15kg. It was fixed to the building via horizontal aluminium cladding rails top and bottom of each panel, located in thin relatively shallow slots about 12mm deep. Subsequent investigations found that defective workmanship in the cladding rail installation was largely to blame for the panel becoming detached with missing fixings being the principal cause. The review also found that installation process required very fine tolerances (e.g. to 0.5mm), which can be difficult to achieve under site conditions. The panel manufacture/installation process is covered by a recognised third party accreditation body, but the accreditation does not mention the specific installation tolerances. The reporter recommends that anyone contemplating similar installations ensures that those undertaking the work have specific training in the particular installation, are aware of the very fine tolerances and that there are adequate and comprehensive checks on each element of the installation throughout the erection process.

### Comments

*It is unrealistic for site tolerances to be as demanding as those given here which would seem to be more appropriate to factory conditions. For safety, a fundamental question that can always be asked is; "are you sure that what you thought was being built was actually built?" CROSS has had numerous cases where the answer was 'no' and this is one of them. A precaution is always to make some site inspections. As a generality nothing on sites should depend on achieving fine tolerances. Although this, and report **519 PV panels blown off roof** (see below), are wind related, the bigger issue is sensitivity to quality of installation. That said, it is important to recognise that high local wind pressures (suctions) can arise at the edges of roofs, and these need to be taken into account in the structural design of fixings for items such as cladding and PV panels. Some guidance is given in [EN1991-1-4](#) (wind actions) and its predecessor (BS6399-2) but it should be recognised that these provisions relate to relatively simple building shapes. Some experts advocate higher partial load factors to account for uncertainty due to building shape. Some designers specify tethers for non-structural items on roofs to ensure they do not present a hazard to the public should they become detached from their fixings.*

## 519 PV PANELS BLOWN OFF ROOF

This report is from a structural engineer who has been investigating PV Panels being blown off of a flat roof; luckily nobody got hurt. The fixing method is simple, however it relies on it being perfectly installed 100% of the time. This does not take into account human error meaning that if one component fails, then entire module is not working at optimum design and becomes potentially dangerous. The reporter is curious to know if this kind of incident has been identified to CROSS before? His firm is looking into adding a secondary safety system which will allow the panel to come from the mount but prevent it from being able to fall from the roof. Any information CROSS may have would be gratefully received.

### Comments

*Fixings make up a significant proportion of reports to CROSS and those for PV panels have been queried before. As with all structural fixing systems there have to be factors of safety, robustness, and redundancy, to cope with real conditions. Nothing can be designed to be 100% perfect. In the comments above for report **498 Cladding panel blown off** the importance of assessing local wind loads, and particularly of not under estimating the loads, is vital. Also in many cases it is not possible to define forces with any accuracy on small objects subject to wind. Items can vibrate with their fixings coming loose and then fall. In leisure rides, for example, where items might fall onto the track and where there is potential mechanical vibration to cause object to fall, it is standard practice to add secondary restraint cables. The [Guide to the Installation of Photovoltaic Systems 2012](#) from the Microgeneration Certification Scheme deals mainly with the electrical side of installing PV panels. Structural calculations should be carried out.*

## 528 PV PANELS ON DOMESTIC ROOF

This reporter is the client for construction of a residential home. The building is traditional, domestic in scale and execution. The duo-pitched roof is concrete tiles on battens on membrane on factory trusses. The roof supports a large area of PV panels whose attachments are supported on every third truss. The reporter asked the D&B roof contractor if this was sufficient to support wind and snow loads. The contractor responded that using every fifth truss for support was usual and this construction was very safe. Eventually calculations were produced purporting to prove the safety of the scheme but these did not cater for all load cases. Eventually a more complete (but still inadequate) calculation report was received showing the inadequacy of the executed work. The number of support fixings has now been substantially increased. The reporter suspects PV panels are being erected on domestic (and commercial) roofs across the UK (the world?) without adequate engineering analysis and design.

### Comments

*PV panel installation is normally subject to Building Regulations approval, which should pick up structural design deficiencies of the sort the reporter raises. Some guidance is available, as noted above for report 519 PV panels blown off roof, in the [Guide to the Installation of Photovoltaic Systems 2012](#) from the Microgeneration Certification Scheme. The Scottish Government published [Low carbon equipment and building regulations: A guide to safe and sustainable construction – Photovoltaics](#) in 2012 which also contains advice on installation. It may be that recommendations are not being followed and Building Regulation requirements are not being enforced. Some engineers recommend that for most roofs PV rails have to be fixed to every rafter. Another concern is the durability of the fixings being used. With the increase in the use of these panels, often retro-fitted to existing roofs, it may be that an authoritative guidance note is required.*

## 445 COST OF DESIGN STANDARD FOR SCAFFOLDING

The design standard for access scaffolding, TG20 is produced by the National Access and Scaffolding Association (NASc). A reporter queried NASc: "The full suite for TG20:13 appears to cost £1206(!). Is there an affordable version of the design standard?" Their answer "I am afraid the initial requirement is to buy the full suite of TG20:13 publications." The reporter is concerned that designers will not use the latest information at this price.

### Comments

*NASc confirmed that TG20:13 can only be purchased as a full suite in the first instance. Thereafter constituent parts (there are four) including the e-Guide and pocket guide may be purchased separately. A similar issue applies to the purchase of Eurocodes. Competent designers need to purchase documents required for their business and there should be no temptation to 'cut corners'. Nevertheless when safety related information is cheaply or freely available the more likely it is to be applied.*

## 481 GALLOWS BRACKETS FOR SUPPORTING CHIMNEY BREASTS

A reporter has seen suggestions that gallows brackets are suitable for support after the removal of internal chimney breasts. This is concerning, he says, because many Building Control Authorities no longer accept them as a suitable way of supporting a retained chimney stack. They may give the enthusiastic DIYer or an inexperienced builder a false sense of security.

### Comments

*These issues should be picked up by Building Control, however where trade documentation indicates to the unwary person that it is suitable, they may be tempted to believe that do not need to involve building control at all. Potential problems include fixing to existing brickwork of unknown quality, local forces on the brickwork, and possible loss of stability from removal of a chimney breast. The situation is quite similar to the use of 'dummy' masonry chimney stacks on new-build residential properties which are often incorporated as a feature to meet planning*

*requirements. Gallows brackets may be acceptable in these circumstances, but only where the bracket and supporting wall have been designed by a suitably qualified engineer to cater for the load and eccentricity. The preferred option is an arrangement of horizontal beams in the roof space to provide support to the chimney breast and cheeks. There are a number of items sold to the public which can lead to safety concerns due to inadequate instruction or technical knowledge.*

#### **Clarification on Report 430 Failure of anchor bolts holding suspended scaffold published in CROSS Newsletter 39**

*“In our report we showed images of a typical screw bolt and fractured bolts. The report indicated that it was thought that hydrogen embrittlement may have been a contributing factor to the failure of similar types of bolt. The report was accompanied by a picture of an Excalibur screwbolt. We have been asked by Excalibur to make clear that the incident concerning their bolt took place in 2012 and was subject to a full investigation and that there was no finding of any manufacturing fault or inherent defect in the product and, specifically, that there was no issue of hydrogen embrittlement”.*

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#### **HOW TO REPORT**

Please visit the website [www.structural-safety.org](http://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](mailto:structures@structural-safety.org)

#### **DATES FOR PUBLICATION OF CROSS NEWSLETTERS**

**Issue No 41      January 2016**

**Issue No 42      April 2016**

**Issue No 43      July 2016**

**Issue No 44      October 2016**