

## Structural-Safety Group Review 2014

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<http://www.structural-safety.org/publications/biennial-reports/>

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## Chairman's foreword

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I am, once again, delighted to introduce a review of the important work of Structural-Safety that has a pedigree extending back to 1976 and the formation of SCOSS (the Standing Committee on Structural Safety). That enlightened step by our predecessors has led to a body of knowledge and a corpus of influence that has been hugely beneficial in field of preventative safety. Whilst it is notoriously difficult to objectively measure the direct cause and effect between safety awareness and incident prevention, there are enough examples in the Structural-Safety pantheon to convince me that we have a proud track record of beneficial and influential effort, the most recent examples of which are described in this Review.

Imitation is the sincerest form of flattery and the recent developments and interest worldwide in adopting the Structural-Safety model and principles provide a solid, objective vindication that the efforts over many years of the enthusiastic groups of experts, all volunteers, have created something of worldwide significance and value. Incidents highlighted in this review demonstrate that the world needs to raise its game, collectively, in structural safety. The work of Structural-Safety provides an important beacon of excellence.

None of this could have happened without the unstinting efforts over the years of the various Structural-Safety committees and expert advisors. I would like to pay a particular tribute in this review period to the work of Alastair Soane, who has developed the confidential reporting arm of Structural-Safety (CROSS) into a scheme that is envied by others, as well as taking on the additional duties as Secretary of SCOSS. The synergy between SCOSS and CROSS as the two pillars of Structural-Safety has been strengthened as a result.

**Gordon Masterton OBE**

## 1. Overview

This is the 2nd Review from Structural-Safety and covers the period December 2012 to December 2014 for work done by SCOSS (The Standing Committee for Structural Safety) and CROSS (Confidential Reporting on Structural Safety). It is the 19<sup>th</sup> Review since SCOSS was formed in 1976. The SCOSS Committee seeks to identify trends where industry practice may not provide adequate safeguard against failure and to suggest changes in procedures and arrangements for the future. CROSS handles issues which might not otherwise have had formal recognition, and important safety considerations have been brought to the attention of engineers, both in the UK and overseas. Confidences in the system, independence, and confidentiality have proved to be keys to success.

As shown in Chapter two the Group has issued Alerts to industry to highlight specific structural safety concerns. These include:

- Preventing the collapse of free-standing walls - September 2014
- Tension systems and post-drilled fixings - March 2014
- Anomalous documentation for proprietary products - February 2013

Two relevant failures were described in Topic Papers:

- FC Twente stadium roof collapse – learning from the fatal consequences updated July 2014
- Elliot Mall Inquiry – December 2014

It continues to be clear from the literature and elsewhere that structural failure is a world-wide phenomenon. The Institution of Civil Engineers' Fifth International Conference on Forensic Engineering held in December 2012 again illustrated numerous examples of failure. Structural failure brings economic loss and business disruption but, because of its nature, often results also in human loss. The UK has a safety record amongst the best. However, as our infrastructure is ageing and budgets for maintenance are increasingly limited, we cannot afford to be complacent.

Nevertheless the number of reported concerns or events is but a small fraction of the total, many of which are probably regarded as near hits, and not significant. The data base provides evidence of various types of failure and has been used to provide industry wide advice on several topics. In the public arena there have been some notable collapses which emphasise the need for continued vigilance. There have also been prosecutions by HSE for breaches of the law including corporate manslaughter convictions.

Key subjects discussed by the Group are summarised in Chapter three whilst a brief description is given in Chapter four of the latest from CROSS and the concerns that have been expressed. The final Chapter covers achievements in the period and considers the future.

This report is a summary and further information can be obtained from the [Structural-Safety](http://www.structural-safety.org) website.

## 2. Publications

A major part of the work of the Group is to publish information of general benefit to the construction industry and these have included three Alerts and two Topic Papers as well as quarterly CROSS Newsletters in the period. The Alerts and Topic Papers have been written in response to observed trends in the industry, and structural failure events. Alerts are to publicise the consequences of concerns or collapses that are in the public arena or that have come through confidential reports. Topic papers deal with events that have relevance but less urgency than Alerts.

### Alerts

#### [Anomalous documentation for proprietary products - February 2013 <sup>\(1\)</sup>](#)

CROSS became aware of a number of instances where certification accompanying proprietary products stated compliance with standards or specified requirements, but the products were found not to be in accordance with specification. On several occasions, this has led to premature structural failure of the component at loads well below the intended design capacity. The reports relate to a variety of products, including end connectors for tension rods, but evidence has been presented which shows that the problem extends to steel plate, fasteners and other cast components. There have been occurrences of unacceptable materials, workmanship, tolerances and defects, all hidden by inaccurate, missing or anomalous records. A warning is given in the alert.

#### [Tension systems and post-drilled fixings - March 2014 <sup>\(2\)</sup>](#)

There have been collapses of tension structures in buildings and tunnels in recent years. Some have resulted in fatalities and numerous injuries. Reasons for the failures vary but the message is that these are safety critical systems that have to be treated with respect. Lining failures occurred in the Boston (Big Dig) tunnel in 2006 and in Japan's Sasago tunnel (2012). Both had similarities in that large concrete sections supported by resin anchored bolts from the roof fell onto cars causing death. A recent report on an overhead liner failure at Balcome rail tunnel in the UK (2011) identifies the cause as failure of resin anchored fixings. Further details are given in the Alert together with recommendations.

#### [Preventing the collapse of free-standing walls - September 2014 <sup>\(3\)</sup>](#)

Many collapses of free-standing masonry walls have occurred and a number have resulted in fatalities and injuries. It is well known that free-standing walls are often poorly constructed and not adequately maintained. Warnings were given about them in the 9th SCOSS Report in 1992 and in the 11th SCOSS report in 1997 so the topic is not new but it is timely to address it again in the light of more recent tragedies. Examples drawn from the Structural-Safety data base include a number of cases and the Alert goes on to give recommendations for the inspection of existing walls and the design of new ones.

### Topic Papers

#### [FC Twente stadium roof collapse – learning from the fatal consequences updated July 2014 <sup>\(4\)</sup>](#)

The collapse at the FC Twente Stadium in Holland in 2011 was reported on by the Dutch Safety Board within a year and they are to be complimented on their rapid publication of the facts. There are many lessons to be learned from this event; the main aspects being that the main contractor must co-ordinate the activity of all subcontractors and that there must be co-ordination of the design process and integration of the various interfaces.

#### [Elliot Mall Inquiry <sup>\(5\)</sup>](#)

The Elliot Lake Commission of Inquiry <sup>(6)</sup> report published in October 2014 gives the reasons for a collapse at the Algo Mall in Quebec. It tells a saga of inappropriate initial construction, neglect over many years by three different owners, reports from engineers that were ignored, and some reports that inadequately addressed the issues. During almost all of its thirty two year history the roof had leaked and the ultimate cause of collapse was corrosion of a weld after long term exposure to water and chlorides. The Commission found that the collapse was due to human failure. To quote part of the summary:

*Many of those whose calling or occupation touched the Mall displayed failings –its designers and builders, its owners, some architects and engineers, as well as municipal and provincial officials charged with the duty of protecting the public. Some of these failings were minor; some were not. They ranged from apathy, neglect, and indifference through mediocrity, ineptitude, and incompetence to outright greed, obfuscation, and duplicity. Occasional voices of alarm blew by deaf and callous ears.*

Further details of the Commission's findings, and recommendations, are given in the paper.

## **CROSS Newsletters** <sup>(7)</sup>

Newsletters are issued in January, April, July and October, and in 2013 and 2014 details concerning sixty nine reports were published. This is just over half of the total received in the two years and others have been added directly to the web site data base. Some of the remainder are awaiting further information or have not yet been processed. The reports are de-identified (anonymised) and comments are provided by the CROSS Expert Panel to give general advice so that lessons can be learned by readers.

Newsletters are circulated by email and are distributed further by some groups and internally by some organisations so the number who has access to them is greater than the 7,000 subscribers. There is the highest potential for reducing risk of structural failure through the Newsletter reports because of the number and range of issues that have been highlighted. Three hundred reports have been published in nine years.

## **External publications**

To promote the Group the Chairman has written several articles for New Civil Engineer and has made presentations at international events. The Director has published technical papers <sup>(8), (9)</sup> and a series of articles <sup>(10)</sup>.

## **3. Key topics**

A major change during the period has been that joint meetings were held between the SCOSS Committee and the CROSS Expert Panel. This was to improve efficiency and also to broaden the approach so that the widest range of expertise could be brought to bear on subjects under discussion. A list of topics is maintained and updated quarterly with matters that have been brought to the attention of the Group. By its nature some items are ongoing and indeed are similar to those considered over several years. Others are more immediate such as a major collapse. The following is a summary of some key items discussed since the 2012 review.

### **Climate change**

Climate change has been a subject of interest to the Committee and presentations were made which underlined the significance of global warming. Temperature and humidity effects on the durability of structures are well understood because of experiences gained in cities in countries with more extreme climates. The more difficult impacts to assess are drought, flood either from rivers or failed coastal defences, and subsequent public health issues. To obtain evidence on damage to buildings in the UK a trial scheme has been designed to collect and analyse information using the CROSS reporting system. The work will be funded by the Department of Communities and Local Government (CLG) and the results will help them to formulate long term strategies for Building Regulations. It is anticipated that the project will be implemented during 2015.

### **Communications strategy**

A review of communications was conducted by a working group from the Committee. The initial driver was "to recognise the different perspectives and different communication modes commonly used by younger practitioners". It acknowledged the overarching quality of content within existing communications. However, through the course of the work the scope was widened to consider the broader objectives of Structural-Safety communications.

Recommendations were put to the Committee for consideration, development and agreement. These can be summarised as follows:

- tighten-up the website text with strong key messages,
- add functionality to the Structural-Safety website to allow the audience to post feedback on specific Reports,
- ensure that items in the web site library can be found by third party search engines,
- use LinkedIn as a focus for social media and Twitter as an advertising tool,
- confirm the strategic purposes of the different publications in turn (relating to audiences and objectives) and ensure that these purposes are communicated clearly.

The Committee are grateful to the authors for their work and the recommendations are being implemented as resources permit.

## **CROSS International**

Expressions of interest in the operations of Structural-Safety have come from groups in several countries. To provide a common platform for sharing information the web site was therefore further developed to create a CROSS Hub with sectors for new groups. The intention is for each group to be autonomous in terms of its local organisation with their final reports on concerns available to all. Lessons to be learned will hence be shared.

The first sector is CROSS-SA from Southern Africa. It is run under the auspices of JSD (Joint Structural Division), SAICE (South African Institution of Civil Engineers), and the Institution of Structural Engineers. The site is operational but has got off to a slow start so far. For some time there has been contact with Engineers Australia about the formation of CROSS-Aust for structural and civil engineers and discussion is continuing. The Hub concept is at an early stage and it remains to be seen how effective it will be on the international scene.

## **Early disclosure**

Some jurisdictions permit the results of forensic investigations to be published in advance of any court cases related to the event. For example the Dutch Safety Board referred to in Chapter 2 who quickly published the reasons for the collapse of the Twente Stadium. The same Board published information about the crash of the Malaysian Airways plane in Ukraine in 2014. Such speed is not possible in the UK so the Structural-Safety sponsors requested that SCOSS investigate the issue of legal confidentiality preventing early release of information. Some progress has been made to identify a way around this using existing legislation when a previously unknown trigger event results in a new type of failure that the industry ought to be made aware of as quickly as possible. Examples might include the Ronan Point collapse, box girder bridge collapses, high alumina cement concrete – the types of high profile, high impact occurrences that triggered the formation of SCOSS.

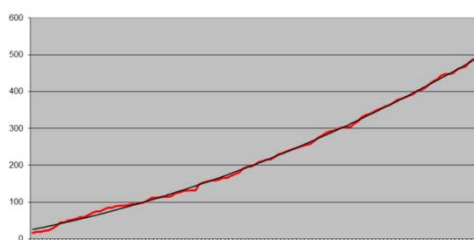
## **Requests for urgent action**

Occasionally requests for intervention or urgent action even though it is stated on the web site that questions on such matters cannot be dealt with. Following legal advice a standard statement is now included as appropriate in responses to these requests saying that we do not have any ability to take action. Reporters are instead directed toward the relevant regulators who have powers to act.

## **Structures at the end of their design life**

The Committee have been considering what is meant by the design life of a structure and a review was prepared by a member. The structure, services and finishes are likely to have been upgraded progressively without disproportionate cost and with limited regulation. For major public works a design life will have been specified in the design brief, although conventional estimates of say 60 years appear to have no factual basis. Repairs, changes in loading and use, and service upgrades will have often have been made long before the design life has been reached. For industrial structures the economic life of the system of which the structure is a part is usually governed by the M&E equipment and the commercial viability of the production system or the resource being exploited. In many commercial structures the structure itself is likely to have a longer economically viable life than the commercial application. It has been noted by the Committee that the use of third generation BIM will be valuable for future life extension of new structures.

## **4. CROSS reports**



**Figure 1**  
Reports from 2005-2014

The number of reports received increases year on year as shown in Figure 1 where the red line indicates actual numbers and black is the trend. By no means are all of the reports confidential although each one is treated as such. Some cases come from HSE and some from press reports where a relevant event has been identified. Most originate in the UK but a few have come in the last two years from Australia and Southern Africa, and the occasional report from elsewhere. They are all however relevant to structural safety. Table 1 shows the complete list.



**Table 1**

**Reports received 2012-14**

Dangerous excavations	Engineered timber floor joists – loading	Theatre ceiling collapse
Basement party wall	Site use of concrete 'twin-wall' products	Post-fixed RC anchors
Cracks in tunnel	Wind load code EN 1991-2	Unsafe spoil bank
Wall stability	Probable false certificate	Cost of design for scaffolding
Quality of some designs	Design of gusset plate connections	Misleading software
Enhancing durability- Forensic Investigation	High strength concrete incident	Masonry wall collapses
Hazardous excavation process	Temporary works and safety reporting	Stability of terraced buildings
Substitution of undersize steel sections	Rail tunnel fixings	Two tier site cabin blown over
Errors in text book	Bulging vertical hand rail posts	Concern about light gauge framing
Slope stability at private railway cutting	Quick and cheap design calculations	Pins failure on roofing project
Differences between analysis and design	Freezing splits more RHS columns	Masonry façade collapse
Polyethylene pipework handrails	Site hoarding	Alteration to historic column bases
Rebar cage temporary stability	Blockwork lateral restraint	Child killed by falling fireplace
Corrosion of plasterboard wall fixings	Structural bolts and CE marking	Metal cladding panels
Certification of seismic design software	Consequence classes and structures	Roof soffit linings failure
Mezzanine floor stability	Snow slide from curved roof	Fatal underpinning collapse
Deadly wall collapse	Contractor varies design intention	Proposed raised walkway
Composition of new blocks	Portal collapses under construction	Secondary steel items on roofs
Bolt failures on bases	Temporary works design	Items falling from buildings
Freedom of information	Theatre ceiling collapse during show	Masonry falls in tunnel
Lightweight steel roof partial collapse	Cladding and structure interaction	Cold formed framing and racking
Brick wall removed	Failure of epoxy resin anchors	Failure of load test setup
Basement retaining wall removed	Suspended scaffold fixings	Wall instability
Building defects	Spacers in slabs	Cantilever balcony collapse
Bearing issues	CDM safety files	Propping to dangerous arches
Structural engineers and building control	Pre-cast concrete retaining wall	Imported steel
Fabrication issues with imported steel	Unexpected hydrogen generation	Stability of brick walls
Proprietary software for cantilevers	Balcony strengths at blocks of flats	Cantilevered brickwork collapse
Grades of weldable quality bolts	Mobile scaffold tower falls 7 storeys	Man killed by falling masonry
Steelwork connection design	Mobile message board in strong wind	Dangerous alterations
Met mast collapse	Snow sliding off industrial building	Gallows brackets
Partial collapse of shopping centre roof	Cold formed multi-storey framing	Unbraced temporary props
Pull out tests to verify fixings and anchors	Computer analysis and slab moments	Crane overturns
Freeze and thaw of another RHS	Tower Crane – failure of a leg	Load testing piles
Building Regulations Part A modifications		Garage roof slab

More reports are always needed and there are continuous efforts to encourage individuals and organisations to submit their concerns.



## 5. Achievements and looking ahead

Publicity has been given to many issues of concern and it is known from feedback but the information is well received by the industry. It is used as a teaching tool in some universities, as a learning tool for younger engineers, and as a reminder to more experienced practitioners. Publication of significant events includes:

- The quality of documentation accompanying some products. Correct and unambiguous documentation is essential for maintaining structural safety and is relied upon by designers, suppliers, contractors, and end users.
- Advice given on tension systems and post-drilled fixings and the need for inspection and maintenance.
- Lack of competency is believed to be a major reason for most of the safety-critical matters. Almost a half of all reported events, 44%, are related to construction and temporary works, with design accounting for 13%, and in service operations 34% with a few other minor categories.
- The deadly collapse in 2013 of the Rana Plaza building in Bangladesh which emphasised the need for care at every stage of the construction cycle everywhere in the world.
- There have been two major collapses of shopping mall roofs: one which was under construction near Durban, and the other in Latvia. At the same time a CROSS report on a partial roof collapse at shopping centre showed the importance of recognising pre-cursors in shopping malls.
- Another near-hit was the partial collapse of a suspended plaster ceiling at a theatre in London. Westminster City Council and HSE asked Structural-Safety to help to publicise the preliminary reasons for failure.
- The discovery of a large number of reinforced concrete cantilever balconies with the critical top reinforcement in the bottom has led to reviews of similar buildings.

All too frequently a building or engineered structure will collapse somewhere in the world. Over the past two years many hundreds of people have been killed and many more injured. Examples include multi-storey building collapses in India, in Africa, in parts of Asia and in many other places. The human toll is shocking to those of us in a country where we have few major failures. It is however most important to be able to know what has gone wrong, and in due course it is hoped that forensic details of some of these tragedies will become available so that lessons can be learned by engineers, and others, everywhere.

The need to understand failure is an essential part of the learning process to develop better safety cultures, particularly where saving lives is concerned. Many checks and balances exist in any regime where there are responsible designers and constructors working in accordance with sound regulations which are responsibly enforced. But there are always cases where something goes wrong and the difference between a near miss and a catastrophe can be wafer thin. In a learning culture such events are recorded, acknowledged, analysed, and the findings disseminated to make a difference in future. Cognisance of pre-cursors in any environment is a proven way of helping to reduce the consequences of more extreme events.

SCOSS maintains a watch on events globally but remains the only body of its type anywhere so its influence is restricted. Governments and relevant organisations in other countries are encouraged to adopt similar processes so that greater structural safety in their countries can be developed.

## References

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10. Four contributions in 2013 and three in 2014 to The Structural Engineer, London, <http://www.istructe.org/thestructuralengineer>

## Acknowledgements

Thanks are due to the Committee and Expert panel members listed in Appendix A, to individual advisors for their contributions, to the staff of the Institution of Structural Engineers, to the construction industry for its support, and of course to the reporters.

## Appendix A - People

### SCOSS Chair

**Gordon Masterton** OBE DEng DTech (Hon) BA MSc DIC FEng FRSE FICE FStructE FIES MCIWEM, Vice President, Jacobs. [From October 2008]

### Structural-Safety Director

**Alastair Soane** BSc PhD CEng FICE FStructE, [from 2005]

### SCOSS Members

**Prof Colin Bailey** BEng PhD CEng FICE MStructE MFireE, Faculty of Engineering and Physical Sciences, the University of Manchester [from January 2010]

**Brian Bell** MA MSc DIC CEng FICE FStructE, Director, Bell Johnson Ltd [from October 2008]

**Angus Cormie** BSc CEng FICE FStructE FIES, Chief Engineer, J D Pierce [to April 2014]

**David Cormie** MEng(Hons) CEng CEnv FStructE FICE M.ASCE, Associate Director, Arup [from July 2012]

**Andy Gardner** CEng MStructE MA (Cantab), The Institution of Structural Engineers, [from July 2013 to July 2014]

**Bill Hewlett**, MA CEng FICE, Director, Costain [from January 2011]

**Steve Parncutt**, BEng (Hons) CEng MICE, HM Principal Specialist Inspector (Construction), Health and Safety Executive [from July 2014]

**James Pratt** LLB (Hons), Arup [from June 2012]

**Chris O'Regan** BEng CEng MStructE, the Institution of Structural Engineers [to April 2014]

**John Rees** BEng ACGI MSc DIC CEng MICE, Flint & Neill [from January 2011]

**Alastair Soane** BSc PhD CEng FICE FStructE, Director, Structural-Safety [from 2005]

**Richard Snell** BSc (Hons) FICE FRAE FStructE, Consultant, formerly BP Exploration [From October 2008]

**Phil Wright** BEng MSc CEng MICE MCIOSH DipH&S, HM Principal Specialist Inspector (Construction Engineering), Health and Safety Executive [to July 2014]

#### Co-opted members

**Roger Faires** MEng IEng AMStructE, Structa [from November 2010 ]

**Helene Gosden** MEng ACGI CEng MICE [From Nov 2010 – July 2014]

### CROSS Expert Panel Members

**John Carpenter** Consultant [to December 2014]

**Neil Loudon** CEng MICE MCIHT, Group Manager, Head of Structures Policy [from 2009]

**Allan Mann** BSc PhD CEng FEng FStructE MICE, Senior Consultant, Jacobs [from 2005]

**David MacKenzie** BE MS FStructE MASCE MHKIE, Chief Executive Officer at Flint & Neill Limited [from 2005]

**Ganga Prakhya** BTech PhD(Cantab) MTech CEng FStructE, Engineer, Sir Alfred McAlpine [from 2006]

**Steve Parncutt** BEng (Hons) CEng MICE, HM Principal Specialist Inspector (Construction), Health and Safety Executive [from July 2014]

**Nick Price** MSc CEng MICE FCIWEM DMS, Senior Engineer, Building Regulations and Standards Division, Communities and Local Government [from 2013]

**Mark Pundsack** CEng MStructE MRICS, Principal Building Control Officer, City of London [from 2012]

**John Rushton** BEng MSc CEng MICE FStructE, Partner, Peter Brett Associates [to October 2007]

#### Secretary

**Laura Kirk** MEng, the Institution of Structural Engineers [to July 2013]

**Ala Hammad** BEng (Hons), the Institution of Structural Engineers [from August 2014]

## Appendix B - Terms of reference

The terms of reference of the Structural-Safety Group are to:

- Consider both current practice and likely development from the standpoint of structural safety.
- Be aware of trends and innovations in design, construction and maintenance from the standpoint of safety.
- Consider whether unacceptable risk exists or might arise in the future and, if believed so, to give warning to relevant bodies.
- Consider whether further research and development appears desirable from the standpoint of structural safety.
- Collect confidential reports on the concerns of structural and civil engineers and others and provide comments in relation to these concerns.
- Maintain a data base of reports and publications.
- Disseminate the findings of the Committee by a biennial review and by other appropriate means.
- Avoid duplicating the work of the Health & Safety Executive, of the Institution of Civil Engineers and of the Institution of Structural Engineers.
- Report to the Presidents of the Institutions of Civil and Structural Engineers annually and from time to time on specific issues.
- Influence changes to improve structural safety.