

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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INTRODUCTION

Despite wider dissemination of structural safety information, failures still occur and as engineers we must always be on our guard. There have been three severe events in the UK recently which emphasise the continuing risks: the Didcot power station collapse during demolition in February, the Scottish schools' problems which have become manifest during normal use in January, and the Manchester Ship Canal bridge collapse during construction in May. At Didcot power station there were four deaths; the tonnes of debris from a masonry wall collapse in Edinburgh fell into school grounds which were fortunately empty; whilst the Ship Canal bridge fell at a site during working hours when there could have been casualties. The difference between a near hit or a catastrophe can be wafer thin and often depends upon the time of day (or night) or whether there are people in the vicinity. In March a bridge under construction collapsed in Kolkata reportedly killing twenty-four and injuring many more amongst those who were passing by or working beneath it. In Europe, Australia, and the USA there have been devastating storms which have ripped away infrastructure and led to multiple casualties and huge damage. Engineers are associated with every structure that is built and will feel sympathy for their colleagues who have been involved in any way with these collapses. In future, similar events may be avoided by learning lessons from what has happened, provided that the reasons are made public and can hence be used to improve structural safety.

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. Recently there have been fewer reports than usual so please add to our data base with your concerns or experiences on [structural safety or on weather related damage](http://structural_safety_or_on_weather_related_damage).

540 LATERAL STABILITY AND A COLLAPSED FRAME

This report concerns three similar buildings. The roof of Building No 1 was a concrete-composite deck supported on lattice trusses and it collapsed whilst carrying a moderate imposed load. This report relates to the findings on one of the other similar buildings designated Building No 2. The reporter's firm was appointed to review the structure of Building No 2 and the initial scope was to determine if the roof was structurally adequate to carry the same level of imposed load as Building No 1. The reporter's firm reviewed the 'for tender' documentation and the steel fabricator's 'for construction' drawings. The original tender documentation showed a steel framed building with bracing in both vertical and horizontal planes and with the shear studs along the cellular steel beams. The 'for construction' documentation, produced by another

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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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
- Network Rail
- Scottish Building Standards Agency
- Temporary Works Forum
- UK Bridges Board

NEWS

Bill Hewlett appointed Chairman of SCOSS



Bill Hewlett, MA FICE CEng FIET, has been appointed Chairman of SCOSS, the Standing Committee on Structural Safety. SCOSS and CROSS

together comprise Structural-Safety the independent body supported by The Institution of Structural Engineers, the Institution of Civil Engineers and the Health and Safety Executive to maintain a continuing review of building and civil engineering matters affecting the safety of structures.

Bill is currently Technical Director of Costain Group. From 2009 - 2013 he served as a Vice President of the Institution of Civil Engineers and in 2011 joined the

firm, shows a steel frame building with no vertical or horizontal bracing, no shear studs, and the cellular beams had been changed to fabricated lattice trusses. All the steel connections had been designed for vertical shear forces only. There were no moment connections and inadequate tie forces. The columns did not have enough capacity to act as a wind frame. In effect Building No 2 had no form of stability system. The owners of the three buildings have been informed of the situation by the reporter's firm. However, the general concern of the reporter is that other buildings, similar to these, may not have adequate stability systems.

Comments

This case involves three apparently similar buildings whose owners have been informed of the circumstances by the reporter. There seems to have been a breakdown in communication between the designer and the steelwork fabricator with significant differences between the tender scheme and the constructed building. More generally, repetitive problems are always difficult because a single defect may be repeated; something that mass producers are keen to avoid. When a generic problem is detected and other buildings of the same type are identified then steps can be taken to resolve the situation. Past examples include Ronan Point type slab and wall buildings, some early box girder bridges, and floor slabs containing high alumina cement. Those cases involved strengthening or replacement on a large scale.

A fundamental principle of structural work is that all buildings have a viable stability system, that is a viable load path to transmit horizontal loads back to ground. The party to assign this system is the main designer whose obligation is also to document and explain the stability system (and any assumptions) so that the whole team understands what holds what up at all stages of construction. Within the documentation, say on a drawing, it may be desirable to state the basic stability requirements. There is a risk that post-design modifications may be carried out by other parties, either during fabrication or during a retro-fit, who misunderstand the stability principles. The main designer should then always verify that component design matches overall design intent. A safe design will ensure adequate provision of information to allow the connection designer to design adequate connections, ensure that assumptions are verified, and ensure the contractor can enable stability at all times during construction and when complete. The reporter has advised the owners of similar buildings about what was found and this information should undoubtedly be shared with the steelwork fabricator.

576 WORKER TRAPPED IN EXCAVATION

A report says that an operative was trapped within an excavation which collapsed and he received serious injuries. The works consisted of the construction of a manhole chamber, the excavation of an 8m long, 0.9m wide, 1.85m deep trench, and the installation of ducting. Ground water was found in the excavation but not noted as a hazard. The trench was not supported and the risk of an unsupported trench collapsing was not well enough recognised either before work was undertaken, or whilst it was in progress. Collapse was due to the instability of the trench sides.

There were extensive management procedures in place from design through to construction to identify and manage risk, but it was found that some of them were not completed. Because of the position and nature of the works there could have been other serious consequences had the collapse been of greater magnitude. The reporter's organisation subsequently instituted measures to stress the importance of communication and control. Also the need to recognise the importance of appropriate temporary works when necessary was emphasised.

SCOSS Committee. He takes a close interest in the education and formation of engineers, with a particular focus on hazard awareness and engineering risk management. As part of his role he will also be involved with CROSS.

Bill said:

"I am delighted to accept the role as Chairman of SCOSS, whose work is important in alerting the construction industry to the reasons for failures and collapses, and providing advice on how these can be avoided in future - a unique and invaluable service.

"As Chair I shall be looking to build on the work done by my predecessors to improve and expand the operation so that the safety and reliability of structures and infrastructure are enhanced. A part of this will be to expand the scope so that there is greater engagement at all levels within the industry through education and encouragement; in particular I shall be seeking a greater engagement with the contracting side of the industry, and especially SMEs.

"I would encourage anyone in the construction industry to participate in the scheme by signing up for our newsletters, and most importantly by reporting their own experiences of structural safety. Reporting via CROSS is fully confidential and serves to bring about hugely beneficial change. Please visit our [website](#) to learn more."

Comments

There can be few hazards more well-known than the dangers consequent on deep trench collapse. All excavations are inherently dangerous and something as deep as 1.85m requires proper engineering consideration for assuring wall stability. The dangers are heightened by the presence of percolating water. The responsibility to avoid danger to those in excavations is absolute, qualified only by what is practicable (not what is 'reasonably practicable'). Should a fatality have occurred in this instance corporate and/or gross-negligence manslaughter charges might have followed (see [R v Cotswold Geotechnics](#)). Indeed, a construction company has recently been fined over £2m after an employee died when the 2.4m deep trench he was working in collapsed. The penalty was imposed under new sentencing guidelines for health and safety offences which came into operation for cases sentenced after February 2016.

It appears that there was a lack of corporate capability on the part of the organisations on-site, and individually, for the safety of those present. The circumstances might suggest that [BS 5975:2008 + A1:2011 Code of Practice for Temporary Works Procedures](#) was not being applied. General guidance is given in the HSE document [Managing for health and safety \(HSG 65\)](#) and reference should be made to the role of the Temporary works coordinator, (TWC) named in [BS 5975 2011](#).

Whilst management procedures, method statements and risk registers are all important tools for mitigating safety related risks, it is also desirable to create a safety-aware culture whereby everyone on construction sites or other hazardous environments is looking out for risks and looking out for each other.

Many experienced people probably passed the unsupported trench. If just one of them had spoken up, the incident would have been avoided. Documented procedures are necessary, but not sufficient, for safety-aware behaviour. They are of no value if not enforced on site by experienced supervisors who understand the inherent risks and have the authority to take responsive action. The supervisor should have not just the right experience, but also the relevant authority. Furthermore, it is essential that those in a supervisory role are not put under undue pressure to deliver to programme come what may, but they have the

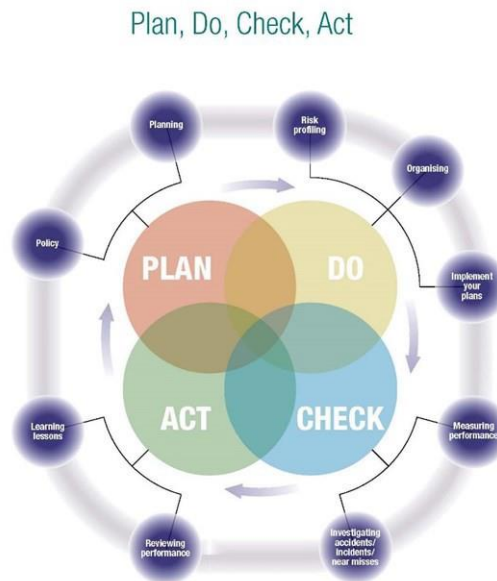


Diagram from HSE web site

authority to deliver safely, and stop proceedings when there is undue risk. This demands a culture shift within parts of the industry to prevent such wholly avoidable circumstances from occurring. The case demonstrates yet again that unless people are prepared to actually observe all the relevant safe working procedures, serious incidents will keep on happening.

549 FALLS OF MATERIAL FROM BRIDGES

Reports about materials falling from bridges have been sent by a bridge owner and some are given below.

549 A member of the public reported that he was hit by falling concrete from an underbridge. Responsibility for the bridge was in a "grey" area between two owners and the organisation concerned recommended that clear and transparent demarcation is required for all assets where maintenance liability is shared. Where defects are identified on grey assets then liaison between liable parties should be carried out to ensure risks are managed appropriately.



549 Spalling concrete



553 Spalling masonry

553 A member of the public contacted authorities to report masonry falling from a bridge. It was found that weathering in the form of repeated freeze/thaw cycles was responsible. This is a high bridge in an urban area with a pavement underneath so persons could have been hit by debris.

558 Inspectors found loose concrete spalling from the arch of a reinforced concrete bridge soffit

560 A 4.5m length of concrete encasement was detached from a bridge soffit and fell onto a public area. Fortunately, no one was injured, but clearly the incident could have caused a fatality. The root cause was corrosion of the reinforcement after cracking of the concrete, but differential temperature between the metal beam and concrete had a part to play in the final failure – around that time a temperature of 34°C was recorded.



560 Fallen concrete encasement



561 Missing bolts

561 A report was received from a Local Authority about a fracture in a footway attached to the side of a main bridge structure. The footway was supported on cantilevered members and it was found that of the 8 bolts holding these in place 4 bolts had fallen out.

Comments

SCOSS/ CROSS has reported many times on the dangers of falling material. It has led to injury and death. See for example [Confidential Reporting on Structural Safety for Scottish Buildings](#). It is a reality that the nation has a vast portfolio of ageing property and infrastructure which will deteriorate for a variety of reasons. Standard hazards are both weakening and material falling with obvious danger, the risk being most acute when people might be hit. All owners have a responsibility to manage the risk and that starts with an awareness of the hazard followed by condition inspection to assess the likelihood.

Joint ownership (Report 549) has caused many problems – often one party assumes that the other party is maintaining the asset and/or is responsible for parts of it. There have been cases where one shared-owner modified a structure, not realising the changes were unsafe. In another case an owner carried out no inspections or maintenance, so it was fortunate that the operator of the infrastructure underneath, who did not know it was not their structure, inspected and maintained it. In a similar case no inspections were carried out due to misunderstanding about ownership. This was a newer

structure such that significant deterioration would be obvious but, nonetheless it was of concern. It should be stressed that the owners of structures over and under roads and railways have an obligation to inspect and maintain these structures in accordance with the procedures set out by the operator of that infrastructure. Engineers advising on these structures should ensure that their clients are aware of this obligation. With new structures this is hopefully covered by the O&M documentation. There is need for a robust asset ownership matrix, both within separate divisions of one entity, but also where asset ownership may be shared between separate entities. Such a matrix, shared between asset owners and agreed by all. It is also important that there is adequate quality control of structurally significant change such as alterations and renewals, and of inspections.

571 FALLING SCAFFOLD TUBE



571 Tube fell through this gap

It was reported that work was taking place to refurbish the roof of a large publically accessible area. Two scaffolds had been erected to enable this to happen: a high level working platform that gave access to the roof, and a lower level scaffold to support a protective deck. Whilst operatives were in the process of installing roof sheeting above part of the area a 2.4m long standard tube that had been stored on the walkway on the high level scaffold moved. It fell through a gap in the scaffold planks then struck and penetrated the protective decking below. Two children on the concourse received slight injuries.

The upper scaffolding was a proprietary system and the user manual recommended that the covering sheets be connected together to prevent gaps from forming but this was not done at the area in question. The lower scaffolding was to give protection from weather and against small items that might fall such as pieces of glass or hand tools. The designer's risk assessment, says the reporter, did not reference falling scaffold tubes. Although there was a general requirement that the lower decking should provide protection from falling objects, there was insufficient recognition of the need to withstand the impact from potential missiles falling from height.

Comments

Anything falling from height has the potential to cause serious damage, even small tools. Experience shows that items are commonly dropped or roll off platforms, or on tall buildings may simply be blown off under temporary exposed conditions. Consequently, the hazard should be a standard one for consideration particularly when working over areas used by the public. As this report shows there is also no substitute for walking the surface area with an informed 'eye' looking for potential consequences. Temporary works may or may not be designed to store materials. Where they are it is essential that the requirements and limitations are defined on drawings. Installations must be adequately inspected and the materials are stored in a secure manner which will not let them move under the influence of external forces such as wind. It is also vital that design requirements are picked up in scaffold inspections.

Falling Objects is specifically covered within the HSE [Work at Height Regulations 2005](#) and specifically Regulation 10 (1) "Every employer shall, where necessary to prevent injury to any person, take suitable and sufficient steps to prevent, so far as is reasonably practicable, the fall of any material or object."

580 ALTERATION OF CALCULATIONS ON A LOFT CONVERSION THAT WAS ALREADY BUILT

A reporter says he was pressurised to change retrospectively calculations and drawings following completion of works at a domestic property. This was to reflect alterations made by the builders contrary to the architect's original drawings and the structural engineer's stipulations. The original position of a beam was changed on site which resulted in it not passing deflection checks, so he was forced to "adjust the calculations" to pass building control. This, he says, is a breach of regulations,

structural engineer's code of practice and may also constitute a case of fraud against the client. And this was not the only case as, according to him, it took place in other cases.

Comments

This illustrates a wider theme that emerges from many reports which is to observe that what is built is not necessarily what is shown on the original drawings. It is not unusual for changes to be made to suit site conditions. For that reason many contracts include an obligation to produce 'as built records'. However, all such changes should be sanctioned in advance and those sanctioning them must verify the change will not violate design intent. Calculations are a means of predicting safety; manipulating calculations to avoid scrutiny is unscrupulous and may be dangerous. The reporter says that he was 'forced' to change the calculations but does not say by whom, and apparently felt unable to challenge the situation. It is not uncommon for there to be robust discussion within design organisations about calculations or details but all those involved in the production and checking must follow design requirements without being put under pressure to cut corners. If a designer has concerns about the way they have been asked to proceed they should raise these concerns with a senior person in the organisation. Should concerns remain then, if building regulations are involved, the relevant Local Authority may be informed although there may be a risk of not maintaining confidentiality. HSE could also be informed if the risk of failure is particularly severe. For cases of conduct which may breach Institution rules, confidential reports may be made to Institution Disciplinary panels. A report can also be made to CROSS and advice may be given but we have no powers to act and CROSS is not a whistle-blowing site. There is however a government web site on [Whistleblowing for employees](#) which gives the legal position for those who wish to disclose wrongdoing in the public interest.

584 BALUSTRADE TESTING

Designs are made by a reporter's firm for balustrade systems for a number of fabricators. In the course of this work the firm are sometimes asked to comment on proposed proprietary systems. These are often justified by testing and appear to give clients reassurance about the suitability of the product. However, the information provided often leaves a lot to be desired, for the following reasons:

- The testing may only be up to serviceability loads, and not to ultimate.
- In some cases the test panel consists of 2 baluster posts, with a handrail in between, and the barrier loading is applied to the handrail. However, this only tests the baluster posts to half of the true design load, as generally a baluster post will be part of a longer run, and so is loaded from both sides.
- The test is often with balusters on large concrete bases, away from edges, when in practice expansion or resin anchors will be in close proximity to the edge.

The suppliers of the products are often vague on what anchors would be suitable. A recent test report has come to the attention of the firm which, on the face of it, appears to be reasonable as it was to establish serviceability, ultimate, and failure loads. However, the results were wildly different from theory. The post in question showed a serviceability deflection of ~10mm, whilst the theoretical deflection is ~67mm. As the baluster post is a simple cantilever, the reporter would expect the tested deflection to be relatively close to the theoretical. Likewise, the theoretical strength is an order of magnitude lower than that shown by the test. A product may be expected to achieve slightly better strength when testing, as the material strength requirements are lower limits, and the ultimate strength can be twice the design strength. The reporter says that testing should be done with an idea of the sort of result that could be expected (from say experience or calculations). If the result is significantly better (or worse) than expected it is a reason to investigate further. But in this case, he continues, the testing shows the baluster posts as several times stronger than the theory! It appears to the reporter that there may have been anomalies in the carrying out or recording of the test. This balustrade is being advertised for sale and it is concerning to the reporter that such systems may be specified without proper consideration.

Comments

Balustrades perform an important safety function. Their stiffness is essential to give a feeling of security and their strength is vital for obvious reasons. In principle, load testing is a good predictor of performance because a calculation is only as valid as the assumptions made. Similarly, a test result

is only valid if carried out in conditions that match the installation conditions. It is certainly possible that the stiffness of 'non-structural' items may contribute significantly to performance, say to explain a reduction in deflection. However, it is unsafe to rely on such a benefit unless the basis is understood and replicated in a real life installation. Designers should review balustrade design to ensure compliance with specified requirements such as connection design, loading requirements and serviceability limitations for deflections and finishes. It has also been observed that load tests on balustrading is sometimes undertaken on test arrangements bolted down to a robust industrial ground floor slab, whereas in practice the handrail posts may be fixed to a wide variety of construction forms. The reporter is quite right in that conditions under which test results are conducted must be known before the results are used in actual design situations. Major differences between theory and test should be investigated. As well as structural requirements, all balustrades should prevent people (especially small children) and objects from falling through. See also CROSS Reports [495 Open balustrade balconies over a public highway](#) and [336 Modifications to balustrade in a shopping centre](#).

548 LOCAL WIND EFFECTS

Further to the SCOSS Alert [Wind Adjacent to Tall Buildings](#) published in December 2015 a reporter says that he had been involved in work on the outside face of a city centre building, but at a high level rather than at street level. From this, he knows that the wind experienced on the lee side is out of proportion to that experienced on the windward side. In 5m/sec steady winds, gusting of up to 15m/sec can be felt on the leeward side. When he was working on the building he needed to have data and help to assess the likely wind speeds to be encountered, but was surprised at the lack of knowledge about what would actually happen. It seemed to him that the structural engineers involved in the building's design had very little real idea about what local effects were likely to be. It illustrates to the reporter that more information is needed on the understanding of wind effects around tall buildings.

Comments

On larger buildings it is usually for the engineer to define the peak velocity wind pressure, and a cladding consultant advises on the conversion of this to the pressure coefficients. For complex/tall buildings either computational fluid dynamics analysis or wind tunnel tests are used. However as pointed out by the reporter there still seems to be a tendency for designers to concentrate on pressure when many problems are related to suction which can be enhanced at corners, in gaps and on leeward faces which can affect finishes, glazing and cladding. There is also a significant difference between everyday experience at ground level and that at moderate height. The latter effect is not related to the well-known increase of wind speed with height but simply because in most cities, there is a common 'roof height' and above that level full exposure to wind exists. As pointed out in the Alert the design should account for the surroundings presented to the building at all stages, including reasonable scenarios for future buildings.

Whilst CROSS and Structural-Safety has taken every care in compiling this Newsletter, it does not constitute commercial or professional advice. Readers should seek appropriate professional advice before acting (or not acting) in reliance on any information contained in or accessed through this Newsletter. So far as permissible by law, neither CROSS nor Structural-Safety will accept any liability to any person relating to the use of any such information.

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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 44 October 2016

Issue No 45 January 2017

Issue No 46 April 2017

Issue No 47 July 2017