CROSS

Confidential Reporting on Structural-Safety

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

NEWSLETTER NO 47, July 2017

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 website database.

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INTRODUCTION

The consequences of tragic events

In humanitarian, social and engineering terms the catalyst for profound change is often a catastrophe whose name is remembered for years to come. Grenfell Tower will become one such tragedy and the ramifications of the fire will resonate into the future. The heartfelt sympathy of everyone goes to the families and friends of the victims who died, those who were so grievously wounded, and those whose futures will have been so damaged.

Other tragic fires such as Bradford Football Stadium (1985), Kings Cross Underground (1987), and Piper Alpha (1988), resulted in changes to Stadium design and construction, underground railways, and offshore platforms respectively. Their names remind us of the event but not of the human cost.

Fifty-one years ago, a small gas explosion at high level on the Ronan Point block of apartments triggered a disproportionate and progressive collapse. Eventually this resulted in changes to Building Regulations in the UK and elsewhere, changes to the approaches to structural robustness, and new generations of safer towers. A form of failure not previously encountered led to a transformation by learning from a disaster.

The same must happen with Grenfell Tower where performance across a range of issues has clearly not been as intended, with consequences that have so horrified the public and experts alike. The full implications will not be known for some time. It is of course essential that as much as possible of the forensic evidence will be collected and preserved. Importantly the announcement of a Public Inquiry means that evidence and recommendations will be in the public domain and not, as is often the case with collapse investigations, hidden behind non-disclosure agreements.

The terms of reference must be wide, the Inquiry must proceed quickly, and its findings must be published as soon as possible and widely disseminated. Particularly those with implications for other tower blocks and perhaps other large buildings. The voices of those with knowledge and experience, as well as the public, must be listened to and recommendations implemented. Communities rightly expect their homes, hospitals, schools, and places of work to be dependably safe and secure. Not vulnerable to unconfined fire or other disastrous events.

SCOSS was set up in 1976 to monitor issues of structural safety in the built environment and it has exercised that role ever since. From 2005 CROSS has collected confidential reports on concerns about structural safety. Consequently Structural-Safety (SCOSS and CROSS combined) has a unique insight into the causes of many failure events and into how lessons can be learned and disseminated to benefit the public and the industry. This information will be available to the Inquiry.

What should be reported?

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

Benefits

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

Supporters

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

Those engaged in the development of large buildings be they clients, architects, quantity surveyors and cost consultants, structural engineers, mechanical and electrical engineers, fire engineers, regulators and local authorities, researchers, main contractors, suppliers, sub-contractors, surveyors, resident engineers and clerks of works, must always have a care for the safety and well-being of occupiers and those who may be sent in as rescuers. Government departments too. There are high ethical standards to be maintained as well as legal duties and the exercise of diligent and competent work and oversight. Structural engineers can, and should, demonstrate leadership where issues critical to life-safety are involved. There must be action from government and industry.

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.

681 POLYETHYLENE CORE CLADDING PANELS USED ON RESIDENTIAL HIGH-RISE BUILDING

A reporter writes as a precautionary measure following the Grenfell Tower Fire to say that a similar type of rainscreen panel, i.e. a polyethylene core with metal skin, was used at a residential tower block which they visited in 2011. The reporter does not know if the panels were used on all floors and all elevations and it is possible they have since been replaced. However, they believe this needs to be reviewed and assume that someone somewhere is doing a review of all buildings with similar panels so that this information can be fed into the proposed Inquiry. It is believed that this block is privately owned so would not necessarily be picked up in a review of buildings owned by local authorities and housing associations. Privately owned blocks may get overlooked in this review.

The 'Insulated render and cladding association' (inca-ltd.org.uk) might be able to assist in identifying suppliers, contractors and projects to support this review. It might however be difficult to identify all the different panels of this type that have been used due to the various trade names that have been used. The British Board of Agrément should be able to provide a list of similar products for which they have provided a BBA certificate. The French Agrément organisation and other similar European organisations might also be useful, as could the RIBA product finder and simple internet searches.

The reporter is aware that the role of expanded polystyrene insulation in the spread of flame has previously been raised in fire investigations in other blocks and considers that a similar review should be carried out for high rise buildings with EPS insulation.

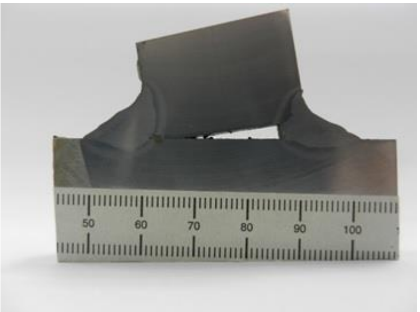
In general, the reporter believes it would be useful to hold a register of high rise buildings and what cladding system has been used. This would make it much easier to take proactive measures in the event of problems arising.

Comments

A central point for collecting data on the fire has been set up by DCLG, but this report was received before it was established so this report was passed to the relevant Local Authority. Similar reports that identify specific buildings will be passed to DCLG without the name of the reporter being given, if that is the reporter's wish. It is hoped that the data base will be updated with details of what steps have been taken in relation to cladding and associated safety matters. There will be a great deal said and written about this awful tragedy but until there are recommendations from the Inquiry, or from other authoritative sources, CROSS will only comment on factual statements.

664 STEEL CANOPY COLLAPSE DURING BUILDING COMPLETION WORKS

During the construction of a major new school facility, a 57m single span structural steel truss failed, resulting in the catastrophic collapse of a steel framed canopy supported by the truss. At the time of failure five workers were on the top of the canopy, some 15 m above ground level. All received significant injuries but survived. The immediate cause of the failure was associated with the fracture of a number of sub-size fillet welds joining paired load bearing tie bars at nodal points. The design of the 'T' shaped joint required the end of some connection plates to be cut with a bevel angle of 80.7^{o}. However, to simplify production the plates were cut at 90^{o} on the contact edge. This resulted in a gap of approximately 4.5 mm to one side of the joint (see photo of intact cross section recovered from the collapse). This gap resulted in a reduction in the effective weld leg length and throat dimension. What should have been a 10.6mm throat dimension was found to be between 6.9mm and as low as 3.7mm. Failure had occurred through the weld material at numerous nodes and assessment showed that failure of one connection at one node would have been sufficient to unzip the truss. In other words, a single inadequate connection would make collapse highly likely - meaning that the design was overly sensitive. There were additional issues with the design that made installation difficult and led to installers cutting and rewelding connections to the building. Such site alterations are often implicated in collapse incidents albeit that, in this case, the root cause lay elsewhere. Legal requirements and published guidance and standards are based on ensuring that the designer provides a structural design that is sound and straightforward to build. More complex situations need sequence and assembly instructions to be provided. This is to ensure that:



Gap at end of shaped plate on intact cross-section

- The fabricator can understand which connections are safety critical
- Components are correctly cut and prepared to achieve the specified fit
- Fit-up tolerances can be achieved both during welding and during site installation
- Difficult fabrication can be carried out under controlled shop-floor conditions and not on site
- Quality assurance checks can see what is being achieved to minimize opportunity for hidden defects

Welding standards for structural steelwork specify that 100 % visual inspection be carried out before, during and on completion of welding to ensure that production quality is being maintained. They also specify that weld size should be checked by a welding inspector and an additional visual inspection should be carried out by a qualified non-destructive testing (NDT) technician. Concern at any stage should be referred back to the designer. Since 2014 it has been a legal requirement under the Construction Products Regulations 2013 that the fabrication of building permanent works in structural steel and/or aluminium is carried out in accordance with an accredited quality scheme based on the specification given in BS EN 1090. Projects that use sensible quality assurance practices including early and regular discussion and cooperation between designers, fabricators and installers will avoid the pitfalls outlined above.

Comments

This is a classic example of the intimate relationship between design / workmanship and safety. The failure also illustrates a theme that has repeated in a number of recent reports which is of poor workmanship leading to disaster. It appears that this event occurred through inadequate workmanship and inadequate quality control. As with the failures in Edinburgh schools (Inquiry into the construction of Edinburgh Schools - February 2017) *one aspect is that the poor workmanship in this case could not be detected by post fabrication inspection. Rather, to assure quality, inspection 'before covering up 'should have been carried out. Over the years, CROSS has received reports of failure involving tie rods of various types. A fundamental cause has been that tie rods have no effective ductility unless special attention is paid to their end connections. In this failure, with such weak end welds, it is apparent that no reliance at all could be placed on tie rod ductility to assist in re-distributing overload.*

As is said in the report, from 2014 the requirements of the Construction Products Regulations and BS EN 1090 part 1 makes it a legal requirement for CE marking of all fabricated structural steelwork (with some exceptions) and with Execution Class specified to BS EN 1090 part 2. It is essential that client requirements and specifications accord with this.

672 UNACCEPTABLE QUALITY OF CONSTRUCTION AND LACK OF SUPERVISION ON A BLOCK OF FLATS

The reporter is a consulting structural engineer working on a project in a major UK city. The project involves new buildings for residential flats over a single storey basement. He attended site a number of times in the early stages of construction and found issues including: - poor document control, - using superseded drawings on site, - incorrect/failure to install temporary works required to prop the perimeter piled wall, - omission of designed steel reinforcement, and undermining of adjacent structures. His firm raised all these issues in site reports issued to the design team and client. In response, they were then told not to attend site by the client, and that supervision was to be provided by building control. However, another member of the firm recently attended site for a meeting and found that a number of critical structural elements - cantilever transfer beams supporting 5 storeys - had been built incorrectly. The beam was stopping short of the column it was meant to be supporting, leaving load from 5 storeys to be supported on the edge of a 250mm thick slab. The concern is that the contractor is of a very poor standard, is being pushed by the client, and there is inadequate supervision. If this error had not been picked up by chance the results could have been catastrophic.

Comments

This is part of the disturbing pattern we are getting and which has been crystallised in the Edinburgh Schools Inquiry, *and is another example of inadequate supervision with the potential for disaster. The situation is made worse by client actions that are apparently contrary to the CDM regulations. Where was the Principal Designer, where was the Temporary Works Coordinator and who was providing the Client with advice on their obligations under the CDM regulations? Where was the adequate supervision of the works on site? Short cuts can lead to death and injury. It is unlikely that a Building Control inspection will detect the type of concern raised by the Reporter so reliance cannot be placed on them for assurance of routine quality. That is not their job. CROSS has repeatedly warned that construction safety is not achieved by adequate design alone and there is plenty of evidence that Clients are cutting corners by not engaging designers to verify that what they have designed is actually constructed. Best practice is for Clients to engage design teams to carry out sufficient inspections to check that observed quality is matched to design intent.*

620 STEEL BALCONIES FIXED TO PRECAST HOLLOWCORE FLOOR PLANKS

A reporter's firm has been carrying out structural design calculations for a specialist steel fabricator on a housing project. He is concerned about the suitability of providing a retro-fitted steel balcony requiring moment connections to the sides of typical hollow core floor planks. There will clearly be a hogging moment at the junction of the balconies to the floors. If the hollowcore floor planks only have reinforcing tendons at the bottom of the planks – what will be resisting this negative moment and torsion in the slab and what will prevent uplift of the slabs? The firm questioned a floor plank specialist who replied, “that is what we always do" – which, in the opinion of the reporter, does not suffice as a justification. Similarly, there are scenarios where the steel brackets are fixed to the ends of the floor planks (i.e. they span the same direction as the cantilevered steel balconies) - but again, no thought appears to have been given to top reinforcement in the planks, and the only treatment is to infill the hollow voids in the planks with mass concrete at the locations of the fixings.

Comments

There have been reports to CROSS about balcony collapses and entering "balcony" into the Quick keyword search box on the home page of our web site *gives a number of cases (see below). These show that cantilever balconies can and do collapse, and must be designed and constructed with care. There are also many cases reported in the media of balcony collapses. The laws of physics are immutable. A cantilever will induce bending at its termination point with tension on the top face. Such tension might be resisted by the tensile capacity of concrete but that is fundamentally unreliable and the mode of failure is brittle. Moreover, a cantilever has no redundancy so the described fixing methodologies are basically unsafe. Cantilever balconies on domestic structures are safety critical and lives are at risk if they fail. There should always be a lead designer taking responsibility for a coordinated structural design. The design should result in a robust structure which should be executed and checked by competent persons. In a case such as this has the capacity of the precast units to take the loads been proven?*

CROSS reports on balconies
http://www.structural-safety.org/publications/view-report/?report=3105
http://www.structural-safety.org/publications/view-report/?report=4190
http://www.structural-safety.org/publications/view-report/?report=4365
http://www.structural-safety.org/publications/view-report/?report=8613
http://www.structural-safety.org/publications/view-report/?report=8613
http://www.structural-safety.org/publications/view-report/?report=8649

639 NEAR MISS – SPALLED CONCRETE FALLING FROM REAR FACE OF DRILLED HOLE 26 FLOORS UP

Holes were being drilled for resin-anchor fixings, where the back face of the wall being drilled was located above a 26 storey lift shaft. The holes were specified as 150mm deep, within a 250mm thick wall, to suit M20 resin-anchored fixings. During drilling, it appears that the operator over-drilled the hole (drilling deeper than the 150mm hole depth specified) and this caused spalling on the back face of the concrete, causing a lump of concrete to fall down the shaft. Size of the lump approximately 80x40x35mm. There were people working in the shaft at the time, however thankfully no-one was hurt. A number of learning points can be made:

- The manufacturer's requirements for the minimum thickness of the base material are important, as these define the required thickness of concrete left beyond the end of the hole (typically 2x the hole diameter). Exceeding this drill depth carries a risk of debris spalling off the back face.
- The hole depth should be specified as well as the embedment depth to ensure the operative is clear on how deep they must drill. This varies between manufacturers.
- Where the back face of drilled holes is exposed to a fall, attention should be brought to contractors to review provisions for closing off or protecting areas which may be exposed to falling debris during drilling.

Comments

This is a useful report with important lessons to be learned as it highlights a risk which is not commonly thought about. Falling objects on site (tools or materials) are a generic hazard but the creation of debris by excess drilling is not a problem regularly reported. It also illustrates the need to undertake adequate risk assessment when undertaking designers' duties, so that hazards can be adequately communicated to site on drawings.

651 FAILURE OF FABRICATED ACCESS STAGING BOARD

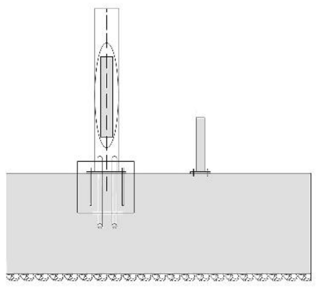
A member of a team working on a major bridge reported a close call after the supporting mesh flooring on a new access staging system gave way under his foot. This failure of the flooring mesh could have resulted in a serious incident. The access staging was being installed was part of a new system which had recently been fabricated and certified by specialist suppliers for maintenance purposes. The primary structural components of the system were globally load tested locally prior to their use and found to pass. However preliminary investigations indicate that the mesh flooring system provided differed significantly from that designed, commissioned and certified as having been supplied and this has had a direct bearing on the load bearing capabilities of the system.

Comments

As for Report 672 (and many others) a generic issue for designers is to be sure that what is built is what they thought they had designed. A proper QA scheme should assure a client that what is being provided matches the design intent.

652 DESIGNER COMPETENCE AND MISSING REBAR

A reporter says that on a major highway project it was noticed that the contractor was casting a pad foundation approximately 1.6m length x 0.9m wide x 0.9m thick to support a lighting column. However, there was no reinforcement in the base. The contractor stated that this was an innovative design which allowed for fast-track construction. However, unreinforced foundations were not permitted without agreement from the client and none had been sought. The lighting column was located at the 'third point' along the base and the section showed services running through the middle and a vehicle restraint barrier on one edge of the base.



Base with no rebar

The client expressed concern that inclusion of services and vehicle restraint would not distribute the loads through the whole foundation without reinforcement, and that cable ducts so close to the HD bolts would induce local failure. As part of the justification for the design, the designer had provided a report that included calculations to several different standards and technical papers, including temporary works standards. The design was not accepted by the client and the upshot was that almost 100 bases had to be removed and replaced with conventionally reinforced units. It was later discovered that the contractor had submitted a design check certificate stating that the design complied with client standards. This design check certificate was signed by two chartered engineers but all information submitted indicated that the contractor did not design to the standards that they certified.

Comments

In principle, it might be acceptable to use mass concrete bases for certain applications. However, the issue here appears to be one of management control and the recurring theme of all parties being clear about the Design Intent. In some cases, the desire for innovation to allow reduced construction time manifests itself as poor or inadequately thought through design, which leads to huge additional costs and delays. When there is the opportunity to add value though innovation there must be adequate time available to ensure that the innovation is technically sound. In this case the design was not robust and the assurance failed. As ever it is essential that competent designers are engaged.

663 Inability of roller shutter doors to meet the pressure specification for dominant openings

A reporter is working on buildings located in a mountainous region of Scotland. Two buildings had sets of roller shutter doors specified for 3.5kN/m² up to 10m span, which failed within weeks of installation at winds far below the pressures that would be normal for buildings set in England and Wales. Two other companies offered to replace the doors with new roller-shutter type doors, yet their products again fell far short of the specified design requirements. A third company has solutions involving stacked steel beams joined with material that can be designed for almost any required pressures. It would appear to the reporter that doors have been, and are still being, supplied and installed without anyone noticing that they cannot meet the standards for the rest of the building. It may be several years before winds reach levels and directions to test their capacity. Obviously, with mean average temperatures shooting up past 1.5°C above temperatures used for statistical analysis for the wind codes, the chance of very high winds will increase significantly. When doors over dominant openings fail, the increase in pressures will place the cladding and the structure at risk. The reporter would be grateful for some feedback on whether SCOSS has received previous reports on this subject.

Comments

*CROSS have a scheme to receive reports of extreme weather conditions (*http://www.structural-safety.org*) and so far, little data has been received so this report is welcome. An interesting feature is the wind pressure of 3.5 kN/m² which is extremely high. The ability for a roller shutter door to sustain such pressures over a 10m span would be extremely exacting if the intent was to sustain no damage. A potential design route for safety might be to accept that the door panels were damaged (deformed) under extreme conditions but retained in place to assure prevention of a dominant opening effect. Indeed, doors of sufficiently robust construction to withstand such a load would have to be so heavy as to be difficult to operate. To answer the reporter's question neither CROSS nor SCOSS have received any similar reports so any feedback would be appreciated.*

News items

Prison sentence and fines follow steel cage collapse tragedy
Two companies have been fined a total of £700,000 and a director has received a suspended prison sentence following the fatal crushing of four workers at a site in 2011. The workmen were constructing a large reinforcing cage in an excavation some 23m long, 3m wide and 2m deep. The cage would have weighed about 32 tonnes when completed. See here for further details.

The rebar cage prior to collapse

After collapse

Comments

The Temporary Works Forum (TWf) has published a safety bulletin aimed at those specifying, managing, designing, detailing and installing reinforcement cages concerning key issues to ensure stability and safety. This TWf guidance, Stability of reinforcement cages prior to concreting is being updated presently. Research work is also on-going at City, University of London and Swansea University into the strength and stability of steel reinforcement cages in their temporary state.

Scan the QR code on the right for access to Structural-Safety

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 48	**October 2017**
Issue No 49	**January 2018**
Issue No 50	**April 2018**
Issue No 51	**July 2018**