

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

CROSS is keen to receive reports about damage caused by weather events and a new section of the web site has been opened for the purpose – [Weather damage](#). This is a long term project sponsored by the Department of Communities and Local Government to help determine whether the Buildings Regulations might need to be amended. In addition, of course, we continue to need reports about concerns, or possible failures, or failure events. They are sent by consulting engineers, contractors, owners and operators of large infrastructure groups, local authority building controllers, and others. After processing to remove names and identification details they are reviewed by our panel of experts who provide comments that can help others to learn from these experiences. Reports and comments are published on the web site and many are included in these Newsletters which are freely available and widely read. There is still much work to do by identifying risks during design, construction, and operation, and using these to create a safer environment for the public and for those in the industry so please contribute.

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](#).

In this issue however the high standard of reports continues with concerns about: crane base bolts, inadequate bracing in a design, more on the sudden hole in a piling mat, an embankment slip, hybrid concrete construction, wind damage to a roof with PV panels, and the safe fixing of grave stones.

585 FAILURE OF SUPPOSEDLY GRADE 10.9 BOLTS

A reporter describes an incident where there was a high potential for collapse when supposedly Grade 10.9 high strength holding bolts failed on a crane base. Sixteen bolts, which had been pre-tensioned in the standard way, all failed within four days. This was found to be a brittle failure and because the bolts were pre-stressed, they failed in a manner which released energy, resulting in the bolt heads being ejected up to 4m above the lifting frame. It is believed the failure was due to delayed hydrogen embrittlement which can be caused in the manufacturing process. This type of failure would be expected to occur within a few days of tensioning bolts as was seen in this case. The investigation is ongoing and no-one was injured. The reporter says that in future, within their organization:

- Bolts of Grade 10.9 or higher to be approved by technically competent person(s) prior to use.
- Hardness and tensile tests to be used as a minimum to verify the metallurgy of all Grade 10.9 bolts.
- Permits to include the need for technical sign off.
- All using this type of bolt to be briefed on this incident

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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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
- 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

Comments

This is another report about problems with fixings which is a frequent topic for CROSS. Presumably the bolts were delivered with the correct certification/ markings, which is why they were installed without any questions? In general, but particularly for safety critical components, inspection and test plans should be developed prior to construction:

- Obtain certification to ensure that all components are sourced only from suppliers who can guarantee compliance with specification.
- Ensure that the products are inspected by competent persons before installation.
- Ensure products are installed in accordance with manufacturer's and designer's recommendations.

There is always the possibility of counterfeit components and this was the subject of a SCOSS Alert: [Anomalous documentation for proprietary products](#) published in 2013. In the UK organisations such as Highways England use only approved suppliers to avoid installing counterfeit components. See <http://www.scheduleofsuppliers.co.uk/NHSS-Schedule-of-Suppliers.aspx>. For a company to be listed on the Schedule of Suppliers, it must be accredited by UKAS.

In the USA there are programs directed towards detecting counterfeit components including bolts and below is a list of General Indications:

- No manufacturer's or grade mark (unless certified to a specification not requiring marking)
- Evidence of machining marks
- Poor thread form, evidence of wear, or dressing
- Headmarks shown on the Suspect Fastener Headmark List (USA Department of Energy list)
- Foreign manufacturer not meeting Public Law 101-592 (USA law)
- No markings for nuts or washers packaged with labels indicating that they were manufactured to a code or specification which requires marking
- Headmarkings are marred, missing, or appear to have been altered
- Headmarkings are inconsistent
- Double stamping
- Metric and SAE stamping
- Headmarks with raised marks and depressed marks on same bolt (not normal manufacturing process)

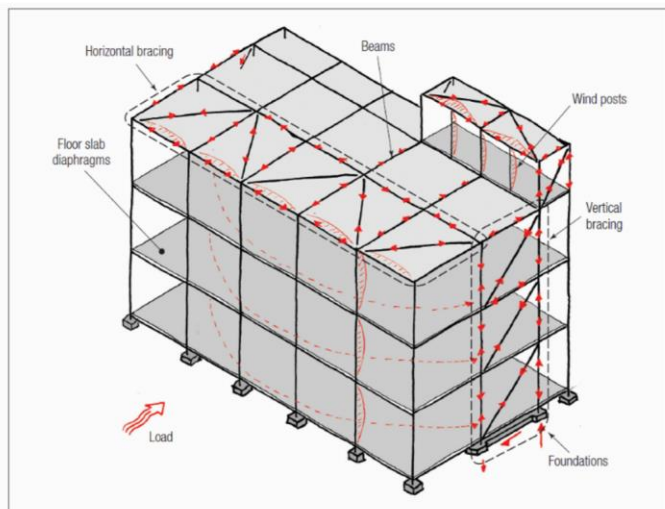


Figure 4.1 Load paths from façade to ground (shown for horizontal loads in the single axis only)

Horizontal load path from IStructE guidance

597 INADEQUATE STRUCTURAL DESIGN OF SCHOOL

A reporter was appointed by a Contractor to undertake specific temporary works design for an extension to an existing primary school. The extension included a teaching block and an enlarged hall. As part of this process he received the original Engineer's design drawings and calculations. On review the reporter noted several major issues including an almost total lack of vertical bracing throughout the extension, and a total lack of roof bracing in the hall. The design was carried out internally by the local authority who was responsible for the school yet it appeared to the reporter to have been carried out by inexperienced engineers with lack of adequate or competent checking.

These concerns were raised to the contractor who then relayed them to the local authority and modifications were made. This is at a time, he says, when there have been closures of a number of schools in Scotland due to construction issues.

Comments

This is about the importance of a structural design being carried out, and thoroughly checked, by competent Engineers. It was fortunate that due to the diligence and experience of the temporary works designer the issue of unsafe design was picked up and corrected. Indeed, when a professional engineer notices defective design or workmanship there is a moral obligation to advise the building owner/operator. The apparent lack of basic understanding of overall building stability in reports such as this is alarming and raises once again potential deficiencies in training of engineers and competent checking processes within design/drawing offices. The IStructE guidance on structural stability of buildings <http://shop.istructe.org/stability-of-buildings-package.html> contains valuable information, such as this diagram on how horizontal load is carried from façade to ground by way of bracing.

596 SUDDEN HOLE IN PILING MAT— MORE INFORMATION

This is further information about Report [566 Sudden Hole in Piling Mat](#) which was published in the April 2016 Newsletter. The report at that stage was not conclusive about the cause of the hole and does not reflect the conclusions of later investigation. The report has therefore been updated as follows. Diaphragm walling, with a toe level 60m below ground level was being constructed within a dewatered cut-off box of sheet piled and slurry walls. The cut-off box was toed into the underlying clay and was 120m by 40m on plan. Trench stability calculations had shown that the groundwater level should be a minimum of 2m below the level of the bentonite support fluid, and dewatering of the granular soils above the clay was initially carried out from a number of dewatering points. During excavation of two panels, in incidents about one week apart, holes hydraulically linked to the panels opened up in the adjacent piling mat. The panels were backfilled with granular material, so as to make safe and allow for further investigation. Initially the possibility of bentonite wash causing a vacuum was suspected. However, it is now considered that the hole was formed by a failure to maintain the required head difference between bentonite level and groundwater level. This was likely caused by some combination of the following factors: - The bentonite level not being maintained during the excavation process. - De-watering and groundwater level monitoring arrangements implemented not being sufficient to draw down levels throughout the cut-off box. - Lack of clarity with regards to the targeted design dewatered groundwater level in a number of temporary works design documents - Another possible contributing factor was the panel being left open over a weekend in a period of very wet weather. Additional deeper dewatering points were installed following an investigation and the two panels were subsequently re-dug, as were the remainder of the diaphragm wall panels, without any further holes have occurring in the piling mat. A regular monitoring regime was implemented for checking the bentonite level and groundwater level and function of the pumps throughout this period. In conclusion the reporter's firm believes that temporary works schemes reliant upon dewatering need their design intent clearly communicated and a robust approach adopted to implementation and monitoring on site.

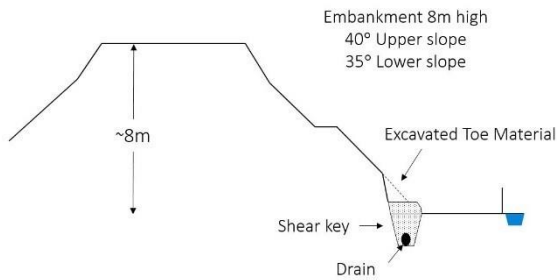
Comments

Lack of communication of the design intent through adequate drawings and other design documentation is a recurring theme. The CDM Regulations 2015 should strengthen this area with the introduction of the role of Principal Designer, whose obligations include the following;

- *Work with any other designers on the project to **eliminate** foreseeable health and safety risks to anyone affected by the work and, where that is not possible, take steps to **reduce or control** those risks.*
- *Ensure that everyone involved in the pre-construction phase communicates and cooperates, coordinating their work wherever required.*
- *Liaise with the Principal Contractor, keeping them informed of any risks that need to be controlled during the construction phase.*

In this case coordination of designs, clear communication of dewatering requirements, and communication of monitoring requirements should have provided the robust approach needed.

572 EMBANKMENT SLIP



Cross section through embankment

Vertical movement was observed on the safety critical surface at the top of an 8m high embankment. This occurred over a distance of some 25m directly above a length of rockfill shear key being installed at the embankment toe. Had there been a failure of the embankment the consequences could have been severe. The design intention had been to perform the construction in short bays. However, a continuous 130m length of toe of the embankment had been excavated during the previous week and cut back with a face of 1-2m high at an angle of approximately 70 degrees. After investigation it was concluded that the surface deformation above this section was as a result of movement within the embankment caused by the method of excavation. The excavation was later stabilised and strengthened by the installation of a rock fill berm with a shear key and the slope was re-profiled

Recommendations from the reporting organisation:

- The Principal Contractor should clearly document the scope of enabling works and clarify the authorisation process to allow these to commence on site.
- Include a requirement for the contractor to document, prior to completion of the design, the findings of buildability reviews for similar works that have been categorised as higher risk.
- Ensure that the requirements of CDM for site specific hazards (such as earthwork instability during excavation works) have been clearly communicated to the Principal Contractor during the project planning stage.
- Review arrangements for the storage and retrieval of findings of meetings or investigation reports that contains risk information and lessons that can be learned.

Comments

The root cause of many failures is lack of clarity on design constraints to those who build, aggravated by poor communication. Well intentioned decisions taken on site can compromise design intent and the safety of the works. Designers should be better at identifying critical constraints, especially in higher risk situations, and contractors should further mitigate the risk of misunderstanding by actively seeking confirmation that their chosen method of construction does not compromise the design. Parties to a project have to be sure how that finished state will be arrived at safely and consider the implications of any proposed construction methodology on safety at all intermediate stages.

Whatever procedures were in place it might have been obvious to those on site that an excavation face 1-2m high at a slope of 70° was inherently unstable. Also a design team has to consider how its design will be implemented on site having regard to potential risks; in this case a clear risk of instability both by length and height of excavation. Put more formally it is a statutory requirement for pre-construction information, which should contain details of significant residual risks, to be passed via the Principal Designer, to the Contractor. Even though the parties may be from the same organisation, this should be done through nominated individuals who have authority for design and construction issues. If temporary works are to be involved then a Temporary Works Co-ordinator (TWC) should be engaged in the process to give advice as to the practicality of the design proposals, and secondly, when on site to ensure control as envisaged by [BS5975:2008+A1:2011 Code of Practice for Temporary Works Procedures](#).

There should be a Method Statement for the works which has been agreed with the designer and communicated to those actually carrying out the work. The Method Statement is not there for paper trail protection; it is there to be implemented. In safety-critical situations, such as this, it is important that the risk management process is controlled by someone who is capable and experienced.

This process should include 'lessons from past experiences'. There may be occasions, in high-risk situations, where an independent reviewer should be engaged to provide oversight (as recommended by SCOSS for structures: see [Independent peer review through peer assist - form of agreement Jan 09](#)). Projects require an intimate relationship between design and construction, it is prudent for the design team to visit the site during the works when possible and liaise with the site staff to assure safety is being achieved. This might include the need for a competent Geotechnical Engineering presence to ensure embankment conditions of a variable nature meet with the designer's intent.

574 RESPONSIBILITIES FOR HYBRID CONCRETE CONSTRUCTION

There has been a report about a problem during the construction of a hybrid concrete over-bridge. A substantial pre-cast element, weighing over 10t, had been placed in position and used as part of the shuttering for an insitu pour. During the pour the element was pushed out of alignment by the pressure of wet concrete and there was a substantial spillage onto an operating area below. This caused considerable disruption, delay, and additional cost. It was subsequently established that the designer and construction team did not adequately review the proposed design to agree upon the construction sequence, including any limitations of the proposed permanent works design to resist temporary loads. The Contractor assumed the temporary load case would have been considered by the permanent works designer. In turn there was an assumption by the permanent works designer that the temporary loading would be checked as a matter of course by the Contractor. At no point was the absence of dowels or other form of fixing queried by the site team. The site team assumed the unit had been designed to resist construction loading from wet concrete. A lesson learned is that the force which the riser units could have resisted should have been stated on the drawing rather than relying on management of the construction sequence.

Comments

If the intention was always to use the pre-cast element as shuttering in the temporary condition, the design engineer should have recognised that the force from wet concrete would affect stability. There should have been anchorage for the pre-cast units, or clear instructions on drawings about limiting pour sizes. CDM requirements mean that designers are obliged to consider the steps within the construction process to ensure that their structure in its incremental state of construction will be inherently safe. So, if a designer chooses a particular method of construction, such as the integration of precast concrete with wet concrete, then the designer must understand the interim steps of the construction so as to ensure that it knows what the final stress state will be in the structure (and thereby knowing what capacity is available for environmental and live loading). The designer should be aware of any safety issues that it should be flagging to the contractor in advance. It is only when the construction sequence can have no effect on the final state of the structure and that it remains stable throughout the process that the designer can afford to sit back. Most designs will require the designer to consider interim steps that the design will go through on its route to completion of the construction process.

Once again, this report suggests that engineers aren't being taught to properly consider the implications of the various stages of construction. There was a report about a similar incident - [529 Risks from off-site manufacture and hybrid construction](#) published in January 2016 and the main points from this are repeated here;

- *In developing the design, be clear about who is responsible for what aspects of the design and for what phase of the assets lifecycle.*
- *While responsibility for the detailing of the elements may be clear enough, the responsibility for ensuring that the elements are able to fulfil temporary works, temporary condition and permanent works roles also needs to be clear. Sub-let contractors design portions need coordination, and both the Principal Contractor and the Lead Designer (under CDM2015, the Principal Designer) have responsibilities.*
- *Principal Contractors should refresh their memories that they are expected to co-ordinate all temporary works and construction methodology to ensure the safety and welfare of all on and adjacent the site. The role of the Temporary Works Coordinator is clear: it is to coordinate the work of all who have an influence on the temporary works irrespective of commercial boundaries. The involvement of sub-contractors does not detract from this duty; if anything the involvement of sub-contractors enhances it.*
- *Notwithstanding explicit design responsibilities, design management processes need to involve cross-checking (is what we are assuming to be happening, actually happening?) and double-checking (is what I am told to be correct, actually correct?)*

590 WIND DAMAGES TO ROOF WITH PV PANELS



Outline shows area of damage

A reporter has a house which was built in 2011 and had solar panels installed on the roof flush with the tiling. Later the same year she had external PV panels fitted. During the heavy storm a big area of roof tiles blew down. A neighbour who has an identical house, but did not have the solar panels installed, had no damage to their roof during the storm. The reporter therefore suspects that it is the solar panels that have caused local wind turbulence and caused loads in excess of the roof design load. She does not think this was taken into consideration when the solar panels were installed but has no knowledge of either the design or construction. An insurance company report says that the wind speed on the night in question was around 52m/s.

Comments

Structural-Safety has concerns about some structural aspects of roof mounted PV and solar thermal panels. CROSS reports have been received about problems with installations including:

- *Lack of guidance on structural aspects*
- *Excessive load on existing structure*
- *Number and quality of fixings*
- *Quality of workmanship*
- *Damage to roof trusses and timbers*
- *Damage to waterproofing*
- *Wind damage to completed installations*

This report reinforces those concerns and an Alert on the subject will be published later this year.

601 FIXING SYSTEMS FOR GRAVESTONES

This report is about the safety of pins used to hold headstones in place and representations have been made to ICE and IStructE to publicise the matter through CROSS. There is a standard pin which is widely used in the monumental masonry industry but which, when tested independently, failed when gravestones were pushed from behind or from the front. Discussions have been held with BSI who have, according to the reporter, concluded that a certain type of pin does not comply with BS 8415/2012. As the health and safety aspects of this matter are urgent BSI will reportedly publish an amendment to their standards.

Comments

Yet another example of the general problem with fixings, from suspended ceilings, fireplaces, balconies, and now gravestones. Engineers involved with such monumental masonry should apply basic engineering principles to ensure stability under normal use and also consider the possibility of vandalism.

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 45	January 2017
Issue No 46	April 2017
Issue No 47	July 2017
Issue No 48	October 2017