CROSS
Confidential Reporting on Structural Safety
For an introduction to CROSS see www.structural-safety.org. Email: structures@structural-safety.org

NEWSLETTER NO 39, JULY 2015

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 web site data base.

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INTRODUCTION

In December 2013 part of the fibrous plaster ceiling of the Apollo Theatre in London fell and 88 people were injured. A 12-month investigation by Westminster City Council concluded that the collapse happened because of the age of the structure and there had been “no breach of the current laws”. A new report has been received regarding a similar type of structure in a public building in another part of the country where the fabric suspension ties were found to be completely decayed. Failure was only prevented by the shape of the plasterwork. Probably a near miss. Publicity has been given to this problem in theatres but not to the possible risk to other buildings with old and ornate heavy ceilings. The new report is published here and Structural-Safety will be giving consideration as to how the matter can become more widely known.

Other subjects include temporary works design for basements, another case of fixings failures, questions about plastic rebar spacers, rotten rafters, Building Regulations and Approved Inspectors, policing of CE markings, and construction which differs from design drawings. These are all topics which contribute to the improvement of structural safety and the reporters are to be thanked for enabling them to be shared with others. Our panel of experts is, as ever, to be thanked for providing the comments.

There are many other situations where external events have precipitated structural failure around the world in recent months such as the earthquake in Nepal and extreme heat in India and Pakistan. Engineers can help to ameliorate the effects of such catastrophes if given the resources and the more we learn the more effective we can become.

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.

518 FIBROUS PLASTER CEILINGS

This recent report of a serious concern about an old fibrous plaster ceiling has similarities to the Apollo Theatre ceiling collapse in London in December 2013. In retrieving a helium party balloon, says the reporter, a crack was discovered in a down-standing feature arch in a local authority hall built circa 1926. On closer inspection this was a non-structural plaster trough section with ornate scroll features. The crack 6mm wide was present over 2/3rds of the span and occurred on both sides. Inspection from the roof space revealed a system of small timber battens (30x18mm) tied together with hessian “wadding” type rope with “balls” of plaster around the joints – no mechanical fixings. The assembly was suspended from timber joists by similar wadding rope wrapped around the joist. Many of the wadding ropes were snapped at various places around the loop. Sometimes this was hidden below the joist, at the side or on top, particularly if there were signs of past crawl boards having been placed upon the rope

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

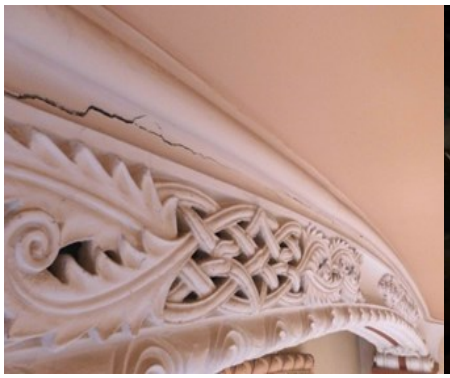
Supporters

- 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 Agency
- Institution of Civil Engineers
- Institution of Structural Engineers
- Local Authority Building Control
- Scottish Building Standards Agency
- Temporary Works Forum
- UK Bridges Board

*To find reports in the data base go to the **Quick Search** box on any page of the Structural-Safety site and enter a subject e.g. "wall" and a list of summarised reports will follow. Searches can be refined using **Search data base** facility.*

or dragged over them. Where ties were intact, they could be snapped by finger pressure. Closer examination of the wadding rope showed a high volume of plaster in the cross section and upon crushing, the fibres were found to be interwoven confirming the origin of rolled cloth impregnated with plaster rather than preformed rope dipped in plaster. The hessian strings had fully degraded and could be pulled apart with light finger pressure. It is thought that complete collapse was averted by the arched shape of the trough section and that if the ceiling was flat, prior collapse would have occurred. The estimated dead load of the trough is 1.51kN/m (154kg/m) and it is 11m to the crown. Two other halls (with flat ceilings) were inspected and found to have down-stand architectural features with similar wadding ropes. Past reports have highlighted "Theatres" and there has been recent issue of the ABTT Guidance Note 20, by the Association of British Theatre Technicians *(see below)* but there must be many similar Public buildings including Council Chambers/meeting rooms, Town/Concert/Assembly Halls, School/University Buildings, and Stately Homes that are not specifically designated as a "Theatre" that may have circa 90 year old fibrous plaster ceilings. Clearly fully inspection of these ties is extremely difficult and in this case it was considered all ties were suspect (as all examined were) and alternative means of support were installed. The reporter hopes that his photos will help to pass on the message that these may be hazardous.

(Note there are more photographs on the web site)



First crack to be spotted

Broken tie

Snapped tie

Another rotted connection

Comments

This is an issue of real and immediate concern and duplicates the findings following the Apollo Theatre Collapse when 88 patrons were injured as plasterwork fell during a performance. Advice issued after this by Westminster City Council is given in CROSS report 442. When hessian ties are holding up heavy ceilings in places of public assembly there is a risk of failure as described above, when the ties deteriorate.

NEWS

Balcony collapse in Berkeley California

Six young people fell 12 metres (40ft) to their deaths and seven were injured when the balcony they were on came away from the exterior wall of an apartment block on the Berkeley campus of the University of California in June. Photographs on the internet show a row of cantilever timber beams which have fractured near to the wall. Investigations into the causes of the collapse are ongoing.

Comments

This is a tragic event involving a cantilever structure. Balcony collapses are unfortunately not rare. It is a reminder that cantilevers are completely unforgiving as with no redundancy a failure results in sudden collapse. Those involved in the design, construction, and maintenance of cantilever structures, such as balconies, must be aware of need for them to have adequate capacity for loading and be properly constructed with due regard to protection against deterioration.

Submissions for Part A of the Building Regulations

ICE has published a paper setting out good practice on 'Submission of structural engineering data for approval under Part A of the Building Regulations'. This is available at https://www.ice.org.uk/disciplines-and-resources/best-practice/submission-of-structural-engineering-data

The paper stems from long-standing concerns first expressed by SCOSS and since then by others at the poor standard of some submissions. Similar guidance is being given by IStructE.

Talks

Lunchtime and evening talks are given to firms and organisations about Structural-Safety with illustrations and descriptions of failures and concerns from CROSS. Recently these have been given to contractors, clients, consulting firms, Institution branches, and universities. They can also be used as CPD material. If you are interested then contact alastair.soane@structural-safety.org.

There may also be loading changes if lights or other items have been added over the years and there may be dynamic effects which exacerbate the situation. In February 2014 Westminster City Council said: "As a result (of the Apollo Theatre incident), we recommend that in addition to what was stated in the interim guidance the wadding ties of all suspended ornate ceilings are thoroughly inspected from above as a matter of urgency by a competent historic plaster specialist and a structural engineer." In response to the Apollo incident The Association of British Theatre Technicians published Guidance Note 20 – Suspended Fibrous Plaster Ceilings in May 2015. This has been compiled by specialists in the field and provides excellent guidance. More publicity is needed about the potential risks to other buildings and local and national government agencies and others are asked to draw attention to these.

423 TEMPORARY WORKS DESIGN FOR BASEMENTS

A reporter had an inquiry from a Contractor who, after appointment, discovered that there was a serious lack of temporary works design information (surveys/loads/wall thicknesses, sequencing, in principle method statement regarding the party walls). The Contractor had phoned twelve Consulting Engineers who had all turned down the opportunity to carry out the temporary works design due to lack of information, as did the reporter. The main Consulting Engineer insisted that the above information had to be determined by the Contractor's own Engineer. The reporter considers that few Contractors would spot this before they take on the job. They then have committed to a programme of works and struggle to find another Consulting Engineer to take on the work. The reporter is also aware of instances where the main Consulting Engineers did not supply the contractor with a Pre-Tender Health and Safety Risk Assessment. When asked for one they simply stated that the drawings were the Risk Assessment, however the unknowns/ risks were not stated on the drawings. These are, says the reporter, collapses waiting to happen.

Comments

On a large project the consulting engineer would normally be engaged by a client, either individually or as part of a design team and would be contracted to design only the permanent works; his responsibilities would include ensuring that his design can be constructed safely by a competent contractor. The consulting engineer would normally indicate in outline one method of safe construction but would expect the contractor to take on the detailed temporary works design. However, the design of builders' actual temporary works will be dependent on the builders' particular method of construction and will include consideration of available skills, resources, programme of works, available space on site, and so forth. The expectation is that the main contractor is responsible for the detailed design of temporary works which may involve developing alternative methods which can often give them commercial advantage and offer best value to the client. On small projects (e.g. residential extensions and the like) the client generally engages a builder and it is the builder who engages a consulting engineer. The scope of works for the consulting engineer in this instance is therefore determined by the builder and will usually include for both permanent and temporary works design .

The transfer of relevant information between the various parties and the identification of residual, significant risk is a fundamental part of CDM. As this report suggests, it is debatable as to how well this is sometimes achieved, particularly with domestic projects and even projects where a

CDM-C has been appointed (pre CDM2015). A key change in the revision of the CDM Regulations in 2015 has been the introduction of the Principal Designer. In the same way that a principal contractor must plan, manage and monitor the construction phase the Principal Designer has the same duty during the pre-construction phase, and this includes domestic projects. The Principal Designer should be appointed early and have the skills, knowledge and experience to understand the work being undertaken during the pre-construction phase. They should consider the adequacy of information provided by designers and challenge this if it is considered to be unsatisfactory. For example, has the main consulting engineer provided enough information for a temporary works designer to do their job properly?

430 Failure of anchor bolts holding suspended scaffold

During the removal of a suspended scaffold it was found that a number of the 12 x 100 hexagon head screw bolt anchors had failed. The scaffold spanned a 10 metre wide, 20 metre deep, pumping well which had been fully boarded as a crash deck and light use access platform. The overall failure rate was less than 8 per cent (circa 14 bolts). At the main spine beam connection, two fixing brackets were used with six holes in each bracket, four at 15mm diameter and two at 13.5mm diameter. Four bolts were installed in each bracket fixing. At one of these fixings the bolt failure rate was found to be 87 per cent with seven out of eight bolts having failed. A full investigation was launched to establish the reasons for the failure. Due to the unusual site conditions the investigation proved to be quite complex in nature and was a collaborative exercise that involved the main contractor, the bolt manufacturer, and the scaffold installation team. The investigation team could not identify a primary cause for the bolt failures but did identify significant contributory causes that could have led to the failure of the platform. These have been reflected in the key learning points and actions to be taken by all parties.

Key learning points:

- Extensive laboratory tests were carried out on the recovered sheared bolts to help establish the cause of failure but these were inconclusive.
- Quality control and inspection procedures have been revised by all parties.
- Ensure all fixings are installed as per the manufacturer's instructions
- And that the contractor/installer is fully briefed on the approved and agreed method of installation.
- Ensure contractors are aware that any change of design specification must be checked and approved by a professional engineer before works can proceed.

Action to be taken by site management:

1. Ensure all the required inspection regimes are in place and undertaken.
2. Ensure all fixings are installed in accordance with the manufacturer's requirements.
3. Ensure all installers are briefed on the approved method prior to work commencing.
4. Screw bolts can be used in less critical situations e.g. propping of wall forms where multiple fixings are present. The risk of potential failure should be assessed by a competent person.
5. If in doubt refer any questions to an in-house (or external) engineering specialist.

Comments

The report shows a commendable degree of collaborative investigation and passing on lessons that may be learned. An additional aspect is ensuring the traceability of the fixings – are they actually what they say they are? Fixings problems amount to a considerable proportion of all CROSS reports and many are related to hanging structures. In a redundant system it is not possible to predict the forces in hangers with accuracy. This means that fasteners must be capable of redistributing overload, which is not always possible. Either they pull out, as in many of the reported ceiling failures, or they can fail in tension setting off chain reactions. In general to guard against failure there should either be ample redundancy by means of multiple fixings, or the capacity for some yielding of the hangers so that loads can be re-distributed.

Self-tapping concrete screws are a well-developed fixing technique carrying significant advantages over some traditional fixing types especially for temporary works applications. Similar failures in one type of this sort of fixing have been recorded previously and it is thought that hydrogen embrittlement may have been a contributory factor. Hydrogen embrittlement is a phenomenon which afflicts very high strength steels when subjected to stresses and is a complex subject. Failure is precipitated by stresses causing the migration of hydrogen atoms within the steel to the point of highest stress which, in a bolt type fastener, may be at the root of the first thread or a fillet radius under the head - particularly if either of these has been badly formed. Contributory factors leading to the incorporation of hydrogen in the steel include poorly controlled heat treatment during the hardening process and acid pickling as part of the plating process. Self-tapping concrete screws are typically made from very high strength steels and are subject to a certain degree of stress when being installed into concrete so, if they happen to have been subject to poorly controlled manufacturing processes, failure due to hydrogen embrittlement is a possibility which may be exacerbated by over tightening. However it is not known if these circumstances applied in this case.

Self-tapping concrete screw anchors that have been awarded an ETA (European Technical Approval/Assessment) will have been subjected to a comprehensive test regime which includes a test specifically designed to identify anchors with a high susceptibility to hydrogen induced brittle fracture. To help avoid such failures choose an anchor with an ETA, ensure it is selected in accordance with the ETA, and is installed by a trained operator in accordance with the manufacturer's instructions. A practical issue is that bolts should be substantial enough to resist possible mis-use by over-tightening.

Useful references include:

1. *Guidance Note: "Self-tapping concrete screws" - Construction Fixings Association.* http://www.the-cfa.co.uk/publications-and-downloads/guidance-notes/
2. *"Fundamentals of hydrogen embrittlement in steel fasteners." - Salim Brahimi Eng.* http://www.boltcouncil.org/files/HydrogenEmbrittlementInSteelFasteners-Brahimi.pdf
3. *General guidance on the use of construction fixings in safety critical applications: BS 8539:2012 - Code of practice for the selection and installation of post-installed anchors in concrete and masonry. BSI*

Clarification on Report 430 Failure of anchor bolts holding suspended scaffold

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

431 Plastic spacers in slabs

A reporter has spotted plastic 'rails' about 1.5 m long being used to support the bottom rebar mat of a slab. They are 'U' shaped with the open side being placed against the soffit. They are quickly put down before the rebar is placed and avoid the need to fix on the traditional type of spacer. There are

openings along the sides to allow concrete to fill the void. Having looked after the soffit was stripped, the reporter couldn't see where they were, which was encouraging. However, he is uncomfortable with how they may affect the slab strength near supports, where the slab is hogging and the concrete around the rail is in compression. He has heard that some such spacers have holes which are too small to allow aggregate to enter the void, just 'grout'. He has also heard that they may move around as the concrete is placed as they are not wired on, and presumably some may end up being loose. Are CROSS aware of these spacers being used and do others have any concerns?

Comments

Such spacers have been in use for many years. BS7973 gives requirements for plastic spacers and requires an open area to allow for aggregate to pass through. To prevent movement they can be wired to the rebar. As with every product, they need to be used in accordance with manufacturers' recommendations. Care does need to be taken where very heavy rebar cages are supported, as plastic spacers may not have the same capacity as concrete spacers.

503 Rotting of rafters likely due to spray foam insulation

Rafters as shown here had rotted in areas to 40-50% of their original depth due, says a reporter, to spray foam insulation having been installed some years previously. This may have been due to water ingress from the tiles, lack of ventilation or both. What was supposed to be re-tiling of a roof, turned into replacement of all the rafters.

Comments

The public are constantly being pressed to add more insulation in lofts but if this is done without adequate ventilation the risks of condensation rise hugely. Occupiers sometimes complain of leaking roofs when actually it is condensation in the loft space exacerbated as windows have become more draught proof. The safety risk is that the rot is in structural members that may never be accessed for inspection. Whenever insulation is added to a tiled rafter roof, the ventilation requirements must be considered. In a traditional construction, ventilation is provided to the roof space to prevent condensation occurring and it may be that the sprayed insulation blocked this. Even in a 'warm roof' construction, ventilation is normally needed above the vapour barrier.

Rotten rafters

507 Building Regulations and Approved Inspectors

Owners, who provided this report, contracted a house extension company (Company A) who claimed to handle all aspects of the house extension. (However they were actually only responsible for plan/ design and "contract management" between the client and the independent building contractor they nominated). Company A's contractual obligations included obtaining building control approval for plan/design and bringing the project to completion. A series of defects started surfacing after the completion of the project. It was then discovered by the owners that the building control inspector was not from the local council but a private company, an Approved Inspector, Company B. Company A explained that the altered design and the consequent works were checked and approved by the Inspector, and the Inspector insisted that no contraventions were found during their periodic inspections. The owners requested that the Inspector provide a basic record of the inspections: when and what was inspected. However this request was rejected because the Inspector was contracted by Company A, and had no contractual obligations to the homeowner. It was also discovered the Approved Inspector signed and submitted the initial notice to the council on behalf of the owners with an accompanying letter stating they had authorisation. This had not been asked for or granted. Is it standard practice whereby an architect/designer or the builder can pick and choose the Approved Inspector and enter into a contract themselves without any involvement of the property owner? The owners in this case believe public awareness should be raised regarding the possibility that building control can be performed under a business to business commercial contract for the interest of

someone other than property owners, rather than for the safety of the people in and around the building.

Comments

A home owner has the choice of where to get Building Regulation approval for building work; either through Local Authority building control or by an Approved Inspector. When a builder is appointed they may arrange for Building Regulation approval on behalf of the owner although the owner may not realise this. If an Approved Inspector is chosen by the builder an Initial Notice is submitted to advise the Local Authority of the position. It can be argued that there may be a flaw in the system in that homeowners are not always aware that the builder has decided to use an Approved Inspector, or indeed the Local Authority, even though the responsibility is ultimately theirs. In the case of a complaint against an Approved Inspector CICAIR Limited, the body responsible for deciding all applications for approved inspector status in England and Wales, should be approached. http:// cic.org.uk/services/register.php. In respect of complaints against Local Authorities the Local Government Ombudsman can be contacted after exhausting internal complaints procedures.

It is worth noting that building control bodies do not have to inspect everything, but to satisfy themselves as far as reasonably practicable that the works comply. The scope of services applicable to the work a client can expect from an approved inspector/LA Building Control is set out in legislation, either the Building Regulations/Building Act or the Building (Approved Inspector) Regulations. There is also a 'Building Control Performance Standards' book which sets out what is generally expected of Building Control Bodies (BCBs). A question often asked is whether BCBs can be held responsible for breaches of duty. If there is a breach of Building Regulations, then that is primarily the responsibility of the client and not of building control. Any action to be taken for a breach would be against the client, who may in turn have rights against his designer or contractor. Action can be taken against a BCB for not administering the regulations correctly (i.e. the duties placed upon them by the regulations). In the case of a Local Authority, this would be taken up by the ombudsman. However, clients' direct rights against BCBs are limited .

510 POLICING OF CE MARKING ON STEELWORK

A reporter has a question regarding structural steel safety, particularly on steel gantry systems supporting lifting equipment. He has seen some recently erected gantries that use steel I beams connected together using (in his view) untested, cheaply made plate style clamps. He knows from EN1090-1 and 2, that structural steel work should be CE marked, and from July 1st 2014 these new regulations were enforceable under criminal law. He wants to know who "polices" these new regulations, and are they really enforceable if the inspectors are unaware of new regulations and "legitimate" fasteners? Because as it currently stands these gantries are held together with, in the opinion of the reporter, an unsatisfactory system. The wider issue is: who should be advised if it is suspected that material or components are being used which do not comply with the CE marking regulations?

Comments

There is wider concern about the lack of enforcement of CE Marking by the authorities in general, and also by their seemingly lack of understanding of both the law (i.e. the Construction Product Regulation) and the requirements needed for a certified Factory production Control system. Not all steel contractors are thought to be CE Marking compliant which creates conflict when those that have taken the trouble to do so are in competition with those who have not. The government approach is risk based and said to be focused on the need to help businesses comply with such regulations rather than immediately pursuing enforcement action. The understanding of CE marking is very poor with a lot of misunderstanding and this is unsatisfactory.

513 FABRICATION DIFFERENT FROM DESIGN DRAWINGS

An Australian reporter created a design for propping required to carry out partial demolition and re-construction of a small tower on a mine. On a site visit for another project some time later the reporter noticed that the propping design had been fabricated and installed but a number of connection details did not match the design drawings. The structure as fabricated had effectively no stability in one plane

and there were other non-conformities. Investigation revealed that the mine had submitted the design drawings to a fabrication company, which had then sub-contracted the fabrication out to a second fabricator who had then sub-contracted out the creation of shop detail drawings to yet another drafting company. Somewhere in this chain of responsibility the decision was made to standardise the end details of each member without getting approval from the design engineer. This had the effect of simplifying the fabricator's task but completely voided the design intent. More importantly however may be the lack of engineering oversight of the fabrication and construction stages of the build. In the reporter's experience in the local mining industry, small projects such as this one are often done in three stages - design, fabrication and installation. Typically all of these are done by different companies. They rarely interact except through the project manager from the mine site who is usually not a qualified structural engineer and often has no engineering background at all. This means that there is a lack of engineering oversight that could identify potentially dangerous modifications or construction defects.

Comments

It is always important to have engineering oversight to all areas of design and construction. The disconnect between each stage is becoming increasingly common and is leading to serious risks. This example illustrates a lack of oversight and control, with the potential for lethal consequences. It should not happen in the UK if the CDM regulations are applied correctly and is a reminder of the Hyatt Regency catastrophe in 1981 (Investigation of the Kansas City Hyatt Regency Walkways Collapse) when 113 people were killed and 186 injured because of a difference between design and detailing. To quote from the NTIS report "…a change in hanger rod arrangement during construction that essentially doubled the load on the box beam-hanger rod connections at the fourth floor walkway'. A general safety principle is for designers always to assure themselves that what they meant to be built was actually built.

HOW TO REPORT

Please visit the web site **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

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