CROSS

Confidential Reporting on Structural-Safety

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

NEWSLETTER NO 46, April 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

Two Alerts have been issued by SCOSS recently: Structural stability/integrity of steel frame buildings in their temporary and permanent condition, and Inquiry into the construction of Edinburgh Schools. Both highlight problems with the quality of construction and the lack of supervision on site. Six of the seven reports in this issue relate to quality issues and it has been a common theme in CROSS reports. The trend is disturbing and it is only by chance, good luck and timing, that there were not multiple casualties.

If there had been large scale fatalities, then public outcries and government intervention would have meant that instead of these events being near misses they would have become weapons with which to attack the construction industry. A much better attitude to safety must be cultivated by clients, designers, constructors and supervisors to protect themselves and the public.

The urgent need to restore Resident Engineers and Clerks of Works to sites must be recognised. These and other critical recommendations are given in Report of the Independent Inquiry into the Construction of Edinburgh Schools which makes for sobering, but essential, reading for all involved in the safety of buildings.

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.

602 PADSTONES OUT OF POSITION LEADS TO COLLAPSE

This report concerns the partial collapse of a terrace of four storey houses during construction. The main contractor employed a firm of consulting engineers to finalise and detail an outline scheme design by others. The roof was timber and steelwork. The superstructure precast concrete floors were supported on front and rear façade walls and internal steel beams. The internal steel beams were supported on dense concrete padstones on the compartment walls and on the inner leaf of the end walls which were of aerated concrete blockwork.

At a late stage in construction it was found that the masonry subcontractor had positioned the padstones so as to maintain the blockwork bond irrespective of the positions of the steel beams.

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

Consequently, several beams had bearing close to the ends of the padstones. Instructions were given to rebuild the work so that the beams would be properly located. Some days later one of the end walls collapsed together with the supported bay of roof and floors and fortunately there were no casualties. As the failure started the faces of the blocks peeled off allowing the steel beams to fall. Subsequent investigation found that the remedial work had not been carried out and there was evidence of covering up the ends of the padstones with a plaster skim coat. It seems that some contractors cannot be trusted to follow traditional good practice in positioning padstones and it seems now necessary to give explicit instructions on drawings.

Comments

The main feature here is that the padstone bearings were eccentric. It is surprising how quickly a small increase in eccentricity of loading can reduce the capacity of a wall panel. A combination of adverse tolerances, positional eccentricities and in some cases a lack of appropriate torsional restraint (with fixings if needed) will soon lead to a heavily reduced margin of safety. The contractor's desire to maintain bond rather than correctly locate padstones demonstrates the importance of adequate site supervision and inspection prior to covering up. To hide the ends of load-bearing padstones in order to disguise the inadequacy of their construction is extremely poor practice Shades of the Edinburgh schools' problems and the need for industry wide action. The report is also reminiscent of a number of investigations carried out by the HSE on this type of project where poor workmanship and poor supervision has resulted in collapse and ultimately in prosecution.

603 CHANGES IN TEMPORARY WORKS SCHEME

A multi-storey above-ground structure was designed so that the superstructure rested on a basement liner wall, which in turn was dowelled into the secant piled retaining wall. The temporary works designer placed raking props and whaling beams against the secant wall in the temporary case, which prevented completion of the liner wall. A sequence was specified in which all props were removed and the liner wall completed before construction of the superstructure started. Due to changes in construction programme, time pressure and lack of clarity about who was responsible for the overall temporary works strategy, the sequence of construction was changed and the superstructure proceeded without the liner wall being completed. By the time this was spotted, a significant portion of the superstructure was being supported by a partially complete liner wall, with a greatly reduced number of dowels into the secant wall. Work was immediately stopped on this structure until it was deemed safe and delays were incurred as the superstructure could not be continued until the liner wall was completed.

Comments

There have been innumerable failures consequent on change or unauthorised change with unforeseen consequences. Nothing should be changed on site without sanction from the Design Authority and this is a classic case of lack of adequate consideration of the interfaces between Temporary Works and Permanent Works. Were a Temporary Works Coordinator and a Temporary Works Supervisor appointed to help ensure this situation could not occur? The Permanent Works Designers should have provided for at least one safe method of construction, and this should not have been changed without reference back to them. Changes made to designs on site can have severe adverse consequences and again there are similarities with the Edinburgh schools. Procedures must be followed and responsibilities allocated at the start of every project for controlling change.

607 Settlement of driven piles

A railway platform was constructed on piled foundations and it was noticed that one pair of piles and their associated cross head settled soon afterwards. The platform was not open to traffic at the time of the failure as the route was out of use. Subsequent load testing of other pile crossheads revealed further defective piles leading to further platform settlement. The platform in the area of the failure was dismantled and the piles re-driven. The subsequent investigation found that the installation of the piles was inadequately supervised to ensure that the intent of the pile design had been met. This was that the piles should be driven until they were founded on the underlying bedrock or a specific "Set" value had been achieved. This could have been because the supervisor was inadequately briefed or failed to undertake adequate checks. Dynamic testing of the piles failed to reveal that the piles did not comply with the design intent and did not provide sufficient support for the station superstructure. It is considered possible *(although unproven)* that this was caused by a "false set" phenomenon which can occur in some ground conditions. It was found during investigation that the use of images of signatures in electronic files used for quality assurance records provided no assurance that the specified checks were carried out by the person stated, on the date stated. If such records are not trustworthy, they have no value.

Comments

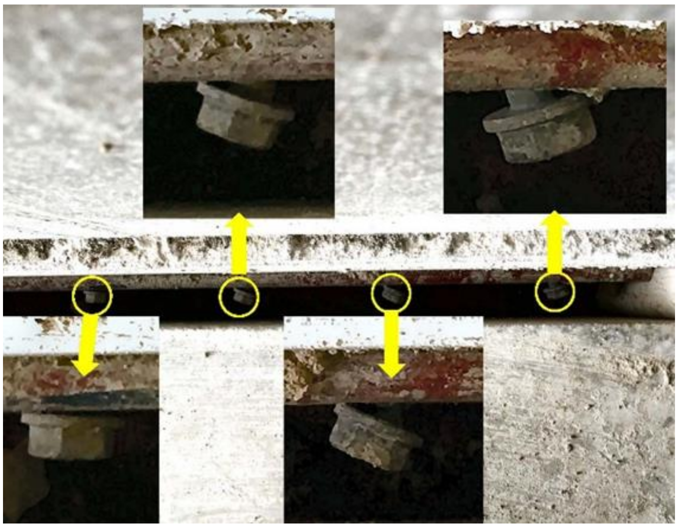
It appears that a combination of inadequate consideration of the design requirements and inadequate site supervision lead to the installation of piles which were too short and did not meet design criteria. For this to happen on a whole row of piles is unusual and may be the reason why a "false set" situation was considered as a possible reason. On the other hand, the load on the piles was presumably low so the ground in which they were installed must have been poor. It is essential that an adequate inspection and test plan is agreed with the Designer, with adequate supervision on site to ensure that design intent is assured. Dynamic pile tests may not provide a direct measure of pile settlement under loading, but the results may be better relied upon if a thorough site investigation report supports the design assumptions. 'False set' readings may occur for piles driven into cohesive soils when insufficient time has been allowed between pile driving and pile testing for the dissipation of pore water.

The issue of electronic copy signatures in the QA process is surely not what was intended and illustrates another problem with over-reliance on computer technology. A false sense of security can result from the assumption that those in a QA process are competent. In another case, untrustworthy records were detected after a small area of a structure failed (despite perfect QA record). The records for the rest of the structure were deemed to have no veracity and the entire structure had to be strengthened as if all hidden detail, which could not be verified in the as built state, was defective. Had the original records been obviously wrong or absent the problem would have cost £x to remediate; apparently, the final bill was £16x.

615 Inadequate bolted connections supporting stairs

When precast concrete stairs are installed, the landings are normally supported using either proprietary telescopic connectors (AKA 'invisible connections'), or by means of an RSA bolted to the wall. When an RSA is used, the wall is drilled to fix the bolts, whether they be expanding fixings or chemical fixings, and frequently the drilling may hit reinforcement. In such cases the hole should be moved, and re-drilled to miss the reinforcement.

This may also entail re-drilling the RSA so there is a temptation not to move the hole, but to drill in a direction that misses the reinforcement. Doing this has two dangers: firstly, the hole will no longer be circular thus reducing the contact area for an expansion fixing, secondly the bolt head will not sit squarely against the RSA thus reducing the clamping effect onto the RSA. Most fixings require tightening to a specific torque, and this is not happening. The photograph shows clearly that virtually all the bolts in this example are incorrectly installed. It is likely that the capacity of such fixings is far below the specified value, especially as the pull-out 'cone' effect has been very disrupted by the skewed direction of the installed fixings. These operations fall into a very grey area of responsibility. The RSA is probably shown on the drawings produced by the pre-caster, but has to be designed by 'the Engineer'. The erection team will expect the RSA to be ready for them when they arrive to fix the stairs, so it may fall to the main contractor to source and fix it.



The person fixing the RSA will have no knowledge of the loads to be catered for, and may not appreciate the need to install a structurally efficient fixing. The Engineer who originally specified the fixings will rarely have the time or inclination to visit site to check the installation. When the erection team arrives to install the stairs, they will assume that the RSAs are suitable, and land heavy, precast landings and stairs on them. It is far from clear just who is responsible for providing a support that is fit for purpose. RSA fixings for stair landings should be subject to a stringent quality regime, covering design, installation, and checking, before any loads are installed.

They are very much safety critical, but seem to be treated almost as an afterthought, where nobody takes responsibility.

Comments

It would be thought that the Lead Designer must either design and detail such supports or formally delegate the task to another party. Almost all connections are safety critical and, as has been mentioned before, fixings make up the largest category of concerns reported to CROSS. There must be a responsible designer for fixings, and adequate design of these must take account of the practicalities of installation including potential clashes with rebar. The Designer must consider how loads are supported. If the retention of all rebar is necessary within a supporting RC structure, the fixing design will need to accommodate this and cast in supports should be considered. In any event, the fixing design will need to accommodate construction tolerances without imposing additional forces on the fixings. Proprietary fixings must be installed in accordance with the design and manufacturer's installation instructions. Guidance is provided in CFA (Construction Fixings Association) publications.

A further point is that for class 2B buildings, UK Building Regulations require these to be anchored to the parts of the structure containing the main robustness ties. There is no evidence in the report to suggest this was a 2B structure and if it was, the ties may have been provided in another way. But the point is that this creates a more robust solution that has an alternative load path should there be other issues and should therefore be considered good practice for all building types. The progressive collapse of stairs has occurred where the stair below is not capable of supporting the dynamic load of the stair above failing on to it, the collapse progressing to the bottom of the stair well. Stairs may only be heavily loaded in emergency evacuation situations and early signs of failure are unlikely to be witnessed. A structural failure in these circumstances would be a terrible thing.

619 Unrestrained stone cladding

A leisure complex completed in the early 2000s has a steel frame with infill panels of block covered with thin stone cladding. A person was injured when a large piece of cladding fell. Local investigation revealed that there were insufficient vertical or horizontal dowels to restrain the cladding. Further investigations revealed this situation to be widespread across the building. There appears to have been a complete lack of awareness of the importance of proper dowelled restraint and a probable ignorance on the part of the cladding sub-contractor as to whether these small but critical elements were installed. The reporter believes that there was a complete lack of responsibility on the part of the main contractor in having proper supervision by informed site staff. The contract is beyond the latent defects period so the contractor has avoided his legal and moral duties to Society.

The reporter's firm are currently working through the building, examining areas thought to be at risk and installing remedial restraints or taking down and rebuilding. This example, continues the reporter, once again underlines the appalling state of our construction industry with untrained, incompetent and unregulated labour. By not employing properly trained independent site supervision clients, he continues, also carry a responsibility. Until the construction industry and professionals face up to this ocean of indifference then CROSS Newsletter reports will flourish!

Comments

There is a general pattern in many CROSS reports that 'secondary' items do not receive the level of attention they deserve. All items of cladding are subjected to significant suction effects through life and as such must have a *properly engineered and installed support system to transmit horizontal and vertical loadings. When such supports cannot be inspected post installation, the QA system should ensure that there is supervision and witnessing of adequate installation. Cladding support systems must be robustly engineered, and properly installed. There are proprietary fixings systems on the market with instructions on how they should be installed and inspected. Again, there are echoes of the Edinburgh schools (*SCOSS Alert - Inquiry into the construction of Edinburgh Schools*) problems in this case.*

626 PARTIAL FAILURE OF PC TANK UNIT ON INSTALLATION

The use of precast concrete units to construct water retaining structures is becoming more common. Their safe installation however, says a reporter, is not as straightforward as may be suggested. During construction of such a tank, one of the precast units' integral stabilising feet failed as the unit was being installed. The tank comprised units up to 8m high which were placed on an insitu base slab. The foot failure was attributed to the use of shims and a steel wrecking bar used when attempting to plumb the unit. Prior to the incident, 8 units had been placed without damage. A unit was then lifted into place and with the load still on the crane, it was plumbed by placing shims under RC stabilising feet. A steel bar was used as a pry to help placing the shims. As the load from the crane was released, one of the feet failed, making the unit unstable.

The use of shims, particularly under the body of the unit (as well as the feet) raised concerns regarding the temporary stability of the units prior to their incorporation into the parent structure. After an investigation, the following measures were taken:
1: Where shims were required under the main body of the unit temporary props were provided to stabilise units.
2: Construction supervision was increased to ensure even distribution of shims under the units and the addition of grout where necessary. Many of the issues might have been negated by the provision of a flatter base slab making excessive shimming unnecessary. That said, the provision of a suitably 'super flat' slab and the residual requirement to place shims under the unit's feet would negate many of the advantages otherwise attributable to precast concrete construction of tanks.

Comments

This shows the need to consider the practicalities of installation when developing an overall design. All construction has tolerances and all items (whether in precast concrete or other material) will require adjustment to achieve alignment so the fittings need to be 'robust'. A robust design ought also to ensure there is no gross change in state consequent on minor damage. In this case, there should have been no overturning risk if any of the items attached to aid stability had been damaged. Combinations of adverse tolerances need to be considered as part of component design.

641 SQUARE HSS EXPANSION DUE TO FREEZING

Further to report 579 in CROSS Newsletter No 45, a reporter from Canada has come across a similar problem in a few locations in British Columbia (temp range -30ºC to +40ºC). Two examples are shown in attached photos, one was a painted 2" (50mm) Square HSS on a sloped Pedestrian Railing, and the other is an Epoxy Paint coated 1" (25mm) Square HSS on a Stair Handrail also on a slope. In neither case were drain holes provided yet both hollow sections split as a result of frost action. The reporter typically specifies drain holes in all areas of HSS members where moisture can collect and checks are made to see that such holes are present before approving work, and this repeatedly finds its way into the internal space of the HSS where it collects over time (perhaps over several years). In the opinion of the reporter, although this is a dryer region of the Province, there is still a moderate amount of moisture at night (condensation).

Thereafter, moisture accumulates faster than it can escape and builds up in non-draining areas, possibly over several cold weather periods/years. The HSS member finally cracks and releases the moisture. Also, corrosion build-up is taking place inside the HSS contributing to strength loss. Corrosion filled moisture may react differently when frozen than straight water in a clean test sample, suggests the reporter. Heat (direct sun exposure up to 70ºC) may also affect the area in some way.

Comments

This phenomenon may well pose a bigger risk in climates with very cold nights and relatively warm days or where bright sunlight is enough to raise steel temperatures above zero thereby generating repeated freeze thaw cycles CROSS has had a number of reports of hollow sections cracking, usually related to water inadvertently trapped inside the tubes. In some cases tubes have had drainage holes. Sections which are detailed with drain holes will allow a path for moist air to enter and hence for corrosion to take place which can cause damage. In other cases, it is water expansion as water undergoes significant expansion during the phase change to ice and this causes splitting. Fully sealed hollow sections are likely to be more resistant both to corrosion and to freeze/thaw damage. The more cycles there are, the more likely it is that cracking or splitting will occur. Freeze/thaw damage has also been reported in temporary pockets cast into concrete structures to take handrails.

Structural-Safety Biennial Review 2015-16

The Structural-Safety Biennial Review 2015-16 of all activities undertaken by the Group is now available on the web site.

Weather damage reporting

There has been very little response to the request for reports about damage from severe weather. This may be because there have been fewer storms this winter than in recent years, but a woman was killed and at least two people seriously injured as Storm Doris in February brought winds gusting up to 94mph with snow and rain to the UK. According to media reports there was some damage to buildings. The storm was described as a "weather bomb" by the Met Office after the system underwent "explosive cyclogenesis" over a 24-hour period as it approached the UK from the Atlantic.

Lead structural safety engineer for the Institution of Structural Engineers

The Institution of Structural Engineers will soon be advertising the new position of Lead Structural Safety engineer to be based in London. As this may be of interest to readers of the Newsletters further details will be emailed to subscribers in due course.

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