

CROSS

Confidential Reporting on Structural Safety

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NEWSLETTER No 41, JANUARY 2016

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Reports sent to CROSS are de-identified, categorised, and sometimes edited for clarification, before being reviewed by the CROSS panel of experts. The panel makes comments that are intended to assist those who may be faced with similar issues. In the Newsletters the reports are shown in black text and the comments are shown below these in green italics. Reports and comments are also given on the web site [database](#).

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INTRODUCTION

A report last year was about high local winds in a city centre causing damage to temporary works. This generated interest in the SCOSS Committee so an Alert: [Wind Adjacent to Tall Buildings](#) was published in December 2015. Although the Alert was prompted by concerns regarding the design of temporary structures, it is noted that wind around tall buildings can lead to unpleasant, and sometimes dangerous, conditions for pedestrians.

Aggregating a number of reports, whether they are on matters sent confidentially to CROSS or from other material, to produce a SCOSS Alert is part of the Structural-Safety system. Ian Fleming wrote: "Mr Bond, they have a saying in Chicago: *'Once is happenstance. Twice is coincidence. The third time it's enemy action'*." At Structural-Safety the third time means that an Alert may be needed.

The first report in this edition is about a near miss involving pre-cast and in-situ concrete from which a number of lessons can be learned. After the next article on wind problems there is a case about defects during construction and the relationship between an engineer and a client. Then comes an example of the problems that can arise at the interface between steelwork and concrete encasement. Moving on to demolition a reporter voices concerns about flat slab structures when unexpected shear failure adjacent of a column can precipitate general failure. Another has concerns on the way in which a mansafe system was designed without recognition of structural principles and which was found during a third party review. Finally a building control officer found a bug in a proprietary software programme.

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](#).

529 RISKS FROM OFF-SITE MANUFACTURE AND HYBRID CONSTRUCTION

A reporter recently investigated a 'near miss' involving concrete construction in which pre-cast and in-situ concrete were used in combination. The works comprised a circular shaft 20m in diameter and 20m deep, which required an L-shaped shelf or balcony some 5m from the top. The 16m balcony has a chord shape in plan, being against the shaft wall on one side. The shaft wall is built from pre-cast shaft lining units of standard design, with the exception that certain of the units feature a corbel, onto which the balcony is placed. The main structure of the balcony itself is constructed from 3 pre-cast planks. The purpose of the structure is to provide a Combined Sewer Overflow. In normal circumstances, water is to flow across the balcony and be contained by the upstand. At periods of high flow, water is to build up on the

What should be reported?

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

Benefits

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

Supporters

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

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.

balcony (the in-flow pipe being larger in diameter than the outflow pipe) until it weirs over the upstand into the shaft, which serves as a storage tank. In-situ concrete was used to provide headwalls for the in-flow and out-flow pipes. The headwalls are in fact large blocks of concrete, each approximately 2,500mm long and 1,650mm high. They were built using the balcony upstand to contain the concrete. During concreting, the upstand of the L-shaped pre-cast beam therefore acted as a 'shutter' and, owing to the geometry, had on it

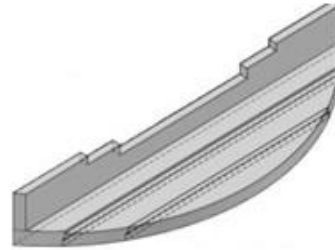


Figure 1 Isometric view of slab

the same horizontal force as would a shutter giving a force of around 220kN. It had been assumed that the weight of the L-shaped pre-cast unit, 460kN, plus the weight of the in-situ concrete itself (around 190kN) was sufficient to ensure enough friction between the beam ends and the corbel to allow the in-situ concrete to be contained without any need for the beam to be fixed in place. This proved not to be the case and the edge-most unit slid towards the corbel's edge, but did not quite fall off. As the pre-cast units are parts of the permanent works, the

temporary state was not identified as Temporary Works and so the management procedures of BS5975 were not applied. In fact, no calculations at all were made in relation to the temporary condition of the permanent works. The reporter asks the industry to be mindful on the following points. While they are drawn from this case specifically, they often apply in all cases where off-site manufacture or hybrid construction is used.

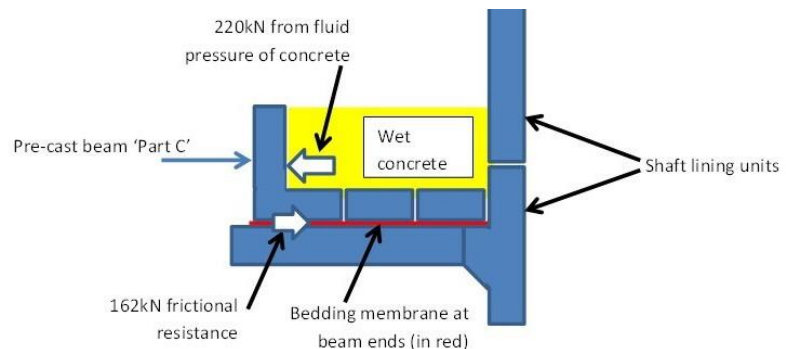


Figure 2 Diagrammatic cross section

- In developing the design, be clear about who is responsible for what aspects of the design and for what phase of the asset's lifecycle.
- Aspects of the design and pre-cast erection methodology were sub-let to the pre-cast supplier. While responsibility for the detailing of the elements was clear enough, the responsibility for ensuring that the elements were able to fulfil temporary works, temporary condition and permanent works roles needed to be clearer.
- 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. Is what we are assuming to be happening, actually happening, and is what I am told to be correct, actually correct?
- This being an industrial structure, it was not tied, as would be the case for a residential or building structure. Tying would (i) probably have given the restraint needed in the temporary condition and (ii) is good practice for the permanent works in any case. Designers are asked to give thought to robustness of all structures.

- The shaft is sited under a public carpark; in the long term a failure of the landing slab could have knocked out the columns supporting the roof slab which in turn could have brought down the roof. A gaping 20m diameter by 20m deep hole suddenly appearing in such a location certainly has the potential to be a catastrophic structural failure. Such consequences should be considered when determining the level of robustness required.

Comments

The full version of this report is given in the data base.

It is a useful reminder of the dangers stemming from divided responsibility which also shows the need to appreciate basic engineering principles. The recommendations from the reporter are most sensible and, as he says, there are several lessons to be learned. To reinforce the points:

- *Sub-letting can easily introduce risk in its own right and is often done for commercial reasons without realising the need for technical input to ensure 'interface issues' are covered.*
- *Subletting, typically by a main contractor, can fail to coordinate the legal "carve outs" that the lead designer needs in his terms of appointment for clarity of overall design responsibility.*
- *The increasing use of precast concrete hybrid superstructures adds further complexities to design and detailing responsibilities.*
- *The Temporary Works Co-ordinator has a critical role in situations such as this. The TWC is responsible on site for co-ordinating all temporary works and using the permanent works as temporary works, as in this case, comes within this remit.*
- *There should always be a 'lead designer' which co-ordinates the overall design, specifically from a robustness perspective. This individual, or the specific designer, would be expected to think through the means by which the components were to be used in the construction process.*
- *The need to have robustness and lateral restraint should be essential considerations for every structure in both the temporary and permanent conditions.*

506 WIND PROBLEMS IN CITY CENTRE

A reporter is dealing with temporary works for sub-contractors working in and around the centre of a major city. He has experienced a spate of wind related incidents where structures which have been designed in accordance with normal practice using current codes have suffered damage. It is difficult to ascertain the real cause of the problems but, having experienced local winds in the same area which have been strong enough to actually lift people off their feet, he feels that there is an issue which needs to be investigated and discussed so that Engineers dealing with structures in the vicinity of tall buildings and groups of tall buildings are fully informed. From his observations it appears that winds at low level can exceed the design wind speeds by around 100-120%. This seems to be the case when downdraughts and vortices combine with ambient winds to produce loadings from both funnelled winds and opposing acting winds on the same element of a minor structure. In a simple case, an arched tunnel seems to have experienced internal wind loads which can only have come about from winds acting on opposite ends of the tunnel which are at ninety degrees to each other, producing maximum inward pressure at one end and maximum suction at the other. In this case, the apparent increase in wind speed has been significant, resulting in suction loads on the tunnel walls with the capacity to pull out doors and windows. Clearly, tall buildings are designed using wind tunnels to ensure their stability and, the reporter assumes, to a lesser degree, the comfort of the public local to them. He doubts that the very local effects on surrounding buildings and structures are investigated in great depth but there must be some documentation that can be made available. EN1991.1.4 focuses on the primary structure but gives little guidance on how to disseminate information on the secondary effects for other structures in the vicinity. Vortex shedding is covered but once the vortices are free of the structure, they become of no real interest to the building designer. As they can exist several hundreds of metres downwind and will tend to drop gradually to the ground, they can be of enormous interest to designers of buildings and elements of buildings over a large area. Unfortunately the reporter thinks that these designers may not be aware of them until their structures fail. This, he says, needs addressing.

Comments

Wind around buildings is a complex issue and is affected not only by existing structures but by future development. Wind tunnel tests on new buildings in city centres are common, but cannot predict

everything accurately due to scale effects and the density of receptors on the models. Where there are clusters of very tall buildings there is a need for city wide modelling which can account for proposed development and effects some way downwind. Who however should take responsibility for this? Government cuts have hit Local Authority budgets and there is no straightforward way to identify wind issues in relation to an individual building. Designers can only assess what it is reasonably practicable and this is a difficult area but one that needs more attention perhaps than has been shown in the past? There is also the interface with planners to be considered. If an event is foreseeable then designers are obliged to take it into account (it is just one of the risks that should be flagged up in any serious risk appraisal). It is part of duty of care. Where the effect can affect (injure) people, it is a statutory duty. The difficulty is that the designer will not know what developments may be proposed in the future and can only make a reasonable judgement making sure this is recorded and relayed to the client. Furthermore climate change may result not only in different overall wind patterns but in extreme local effects such as mini tornados. As the reporter says more guidance is needed.

This was one of the reports which resulted in the recent SCOSS publication on [Wind adjacent to tall buildings](#) which includes references for further information. An interesting article on the subject has been published by the BBC: [The problem with the skyscraper wind effect](#)

515 ROOF CONSTRUCTED WITHOUT STRUCTURAL INPUT

A reporter says that his firm had been instructed by a client to carry out building control calculations for a project. At the bid stage he had discussed with the builder concerns about the scheme for the roof as drawn by the architect. After appointment he arranged to visit site to inspect the existing structure but found that the work had already started. During the visit a number of concerns were noted and passed on to the contractor and the client. The following day the client decided to end the involvement of the engineers and stated they would proceed with the builder and architect alone to resolve the issues. The engineers then emailed the client summarising their concerns about the way in which the complicated roof had been built and concluding that structure was potentially unsafe and that, in their opinion, no work should continue without further investigation. The reporter wants to highlight the problem of builders working off plans provided by an architect or surveyor and assuming that section sizes shown on drawings actually work. This is the worst case the reporter has encountered but the general problem is not uncommon.

Comments

There is no requirement in Building Regulations for calculations to be submitted by a competent engineer and domestic clients are often not well enough informed as to what is the role of engineer. It illustrates the nature of the construction industry at the small, usually domestic, end of the market. The Institution of Structural engineers is currently working on guidance for domestic clients on the importance of appointing a structural engineer. CIRIA is also working on new guidance for alteration work to small projects. In any event builders on projects of all sizes have responsibilities under CDM 2015 to plan, manage and monitor all work carried out by themselves and their workers. It is possible that the architect was in breach of a duty of care, and also of CDM 2015 by not insisting on the involvement of an engineer. Until the process is tightened examples such as these will continue.

517 FLAWS WITH PARTIAL ENCASEMENTS AROUND STEEL COLUMNS

A structural assessment was carried out on a 40 year old steel framed structure in a pharmaceutical plant. Concrete encasements, with flat tops, had been formed up to mid-story height around steel UC columns. Heavy corrosion was apparent at mid-story height i.e. directly above the top of the encasements. The encasements were cracked below mid story height and upon removal of a concrete it was found that the thickness of the steel column was substantially reduced. Vapours and liquids had gathered on the flat surface and corroded the steel overtime. The absence of maintenance and the humid atmosphere (high temperature process area) aided the rate of corrosion. To avoid this problem the reporter recommends the following:

- form a chamfer around the top of concrete encasements,
- avoid stopping the encasements at mid-story height,

- galvanise steelwork in corrosive environments
- ensure the steel to concrete joint is adequate to mitigate liquid/moisture ingress.

Comments

Major corrosion on older assets in harsh industrial environments is commonplace, and potentially critical to stability and hence safe use. This is a legacy of an era when inadequate attention was given to life-long performance, often coupled with less than adequate inspections over its life. Good detailing is a prerequisite for longevity and the safety of a structure only exists at a point in time related to the as-built condition. In all refurbishment projects a key part of the work should be to fully assess the structure's state as far as is possible. Cracking should be investigated as previous repairs to the concrete that may not have addressed any underlying section loss. Such investigations should also consider the possibility that the encasement is providing an unintended load path and therefore removal may impact the element capacity.

A building being used as a workplace should be capable of supporting all foreseeable loads imposed upon it [[Workplace \(health, safety and welfare\) regulations 1992](#)]. Depending upon the nature of the workplace, a foreseeable load might include accidental impact from say a fork lift truck. Whilst this might be the precise reason for encasing the columns, given the reporter's findings, it may be appropriate to implement additional measures that remove or reduce the risk of accidental impact. The reporter's recommendations are very sensible and if adopted as a matter of course would improve the life of new constructions.

523 SHEAR FAILURE RISK DURING DEMOLITION

A number of buildings being demolished 'top down' have suffered from partial collapse during demolition, some well publicised others less so. The process of top down demolition involves using excavators and other plant sitting on the partially demolished structure and using this as a working platform for the demolition of the remaining building. The technique is described in the NFDC document "Guidance for Deconstruction of Tower Blocks floor by floor/piecemeal". This usually results in the building carrying larger loads than originally designed. The established procedure was to assess the capacity of the existing building by investigation and analysis and then either use plant that could work without overloading the structures without propping, or to provide props to distribute the loads. The assumption is that the building is generally in the condition it was constructed. However the reporter's firm have seen areas with significant degradation of condition of concrete, reinforcement and structural steel. It has become common practice to load test buildings to establish that larger plant can be used than can be justified by back analysis. However the nature of testing has generally been to establish moment capacity at mid-span rather than shear capacity and check the shear capacity by calculation. The reporter's firm are concerned that shear failures may be a significant risk during top down demolition of flat slab and ribbed slab (hollow pot) floors. A bending failure usually leaves some residual capacity in a slab whereas a shear failure often results in a complete loss of capacity and hence collapse. They are concerned that the sources of loading during demolition are inadequately controlled and can result in significant overloading. Stockpiling of demolition material and access ramps formed from crushed concrete are two sources of this overload. In addition whilst in the firm's experience concrete buildings seem to be far more robust than calculations suggest, they have been susceptible to poor detailing and construction, as well as degradation over time. These issues can mean that there are local areas of weakness that are not identified during testing or analysis. Although the analysis approach almost always gives a lower capacity than testing it will not necessarily overcome construction faults.

Comments

Structural failures are more common in buildings undergoing alteration and demolition, and part of the reason for this may be because of the uncertainties with the condition of the structure. In structures designed for overload conditions such as in seismic design a standard requirement is to aim for failure by bending before failure by shear. This is partly because a shear failure is a brittle failure whereas bending failure is ductile. Bending usually gives warning and the structure can accommodate more loading under gross deflection states (say by catenary action). This is not so in the case of shear failures which can be sudden and catastrophic. There have been concerns that some early examples of flat slabs had weaknesses associated with shear around columns and potential problems may have been exacerbated by water leakage and general aging. It should be

noted that for concrete without shear reinforcement the approach to shear has become more conservative as codes have been developed indicating that previous codes may not have the level of reserve expected. If such slabs are recognised, e.g. flat slabs and some rib slabs, then, as the reporter says care must be taken with modifications or with demolition.

A good example of shear failure is to be found in the [Pipers Row Car Park Collapse](#) investigation. If flat slab construction is recognised then, as the reporter says, caution is needed.

527 WRONGLY DESIGNED SAFETY SYSTEM

A reporter is a checking engineer for the client on a tall building. If tenants of the building wish to make structural alterations, they are obliged to send the reporter the details of the proposed changes and he reviews the effect on the main structure. One tenant introduced a stair between two floors. This meant that there was a double-height section of facade to keep clean adjacent to the stair, and so a "man safe" system was proposed. This consists of a pair of small cantilever posts welded to base plates; the plates are bolted to the underside of the primary structure edge beam above the stair. A cable is strung between the posts and the window cleaners attach a lanyard to the cable and to a harness that they wear. There were several critical concerns with the way in which the structure had been modelled using an inappropriate software package exacerbated by the fact that no hand check had been made. The cantilever posts were specified as circular hollow sections but they were modelled as solid bars that were monolithic with the baseplate. The base plate was modelled as fully fixed over its entire area, and so no bending in the plate was considered. If the connection had been constructed according to the original submission, and if the window cleaner had fallen, the connection would have failed, risking injury or worse to the cleaner. In the opinion of the reporter the number of errors in the submission indicated that the person who modelled the connection was not a qualified engineer. His concerns are that a supplier of "man safe" systems should produce an unsafe design and that safety-critical equipment should be "designed" by someone who appeared to have so little grasp of engineering. Furthermore there were no hand calculations to check the computer output. The errors were pointed out to the contractor and the installation re-designed.

Comments

Components such as these are often not viewed in the same way as primary structure, and often do not get the level of attention they deserve. Proprietary mansafe systems fixed to primary structure normally lead to a structural engineers check based on loads provided by the supplier. Similar issues apply to bolts and fixings as witnessed by the number of reports sent to CROSS. This case highlights issues around inadequate modelling of structure in design but also shows the value of an independent third party check. It is clear that the posts were a bespoke item and not part of a tried and tested system, and as such they should have been dealt with in a robust way. Many engineers have noted this growing tendency to design even simple structures by software and not to realise the output is critically dependent on the validity of the modeling. Whenever a computer process is carried out, common prudence requires some form of verification. Software packages in the hands of unqualified and inexperienced individuals are of increasing concern within the industry but what steps are being taken to reduce the risks?

Mansafe (fall restraint) systems need to be differentiated from abseiling/maintenance access systems and the appropriate loads and impact factors. Relevant standards, some with different minimum anchorage values are:

- [BS 8437:2 005](#) – Code of practice for selection, use and maintenance of personal fall protection systems and equipment for use in the workplace.
- [BS EN 795](#) – Protection against falls from a height — Anchor devices — Requirements and testing
- [BS 7883:2005](#) – Code of Practice for the design and selection, installation, use and maintenance of anchor devices
- [BS 7985:2013](#) – Code of Practice for the use of rope access methods for industrial purposes

538 FAILURE TO CHECK DESIGNS PRODUCED BY SOFTWARE

A reporter works as a Building Control Officer and recently checked some blockwork wall calculations for a new office building that had been undertaken using proprietary design software. He noticed a regular error appearing that returned a value of zero for the effective plan area when performing the check for the minimum area required. He queried the designer about this who in turn asked the software developer and it turns out there was an error in the software that no-one had picked up before. While this error did not affect the ultimate design for the building he found the issue rather concerning as it indicated that there had been a very limited check of the output of the design software all along the line. As the error was fairly obvious it should really have been picked up before being submitted to Building Control.

Comments

It should not be down to Building Control to discover fundamental errors. In this case it is likely that the software had been used many times before without anyone noticing yet the error should have been picked up by the software house and by users. It also brings into question what kind of quality management systems or level of internal checking being employed by designers. There is well-documented concern over inappropriate use of software and the reliance on software to give the right answer. Software should be validated and verified as noted in the Institution of Civil Engineers Civil Engineering Journal August 2013 '[The importance of understanding computer analysis in civil engineering](#)'. See also the comments on the above report 527 Wrongly designed safety system.

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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 42	April 2016
Issue No 43	July 2016
Issue No 44	October 2016
Issue No 45	January 2017