

CROSS

Confidential Reporting on Structural Safety

NEWSLETTER No 26, APRIL 2012

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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 data base.

INTRODUCTION

The first three reports are about the condition and quality of aging multi-storey car parks which are common in city centres in the UK and elsewhere and usually located where large numbers of people may congregate. The reports suggest that there are some structures which have deteriorated and could be at risk of failure and these echo concerns that have been expressed over a long period. Indeed in the past year it is reported that several car parks have had to be demolished on safety grounds and the condition of others is unknown. Engineers must use their influence to ensure that regular inspections are carried out and the necessary maintenance is undertaken.

There follows an interesting question about the behaviour of high strength concrete columns intersected by slabs with a much lower strength. Does this have an effect? The next report is about water ingress into RHS columns and the consequences of freezing, whilst the final report concerns responsibilities of those involved in a Competent Person's Scheme.

CROSS reports are received from engineers in a wide range of circumstances as demonstrated by the diversity of subjects that are covered. Newsletters are received and read by a good number of organisations and individuals and feedback is that the contents are found be interesting and useful. The web site is visited to search the data base and the bigger this gets the better.

However there is always a need for more reports and the message which appears at this point in every Newsletter is really important. If you see value or gain anything by reading the reports then please reciprocate by sending in your own experiences.

The CROSS programme depends on receiving reports and individuals and firms are encouraged to participate by sending concerns in confidence to [structural-safety](http://www.structural-safety.org).

224 STRUCTURAL ASSESSMENTS OF MULTI-STOREY CAR PARKS

The parking industry has in recent years seen several MSCPs closed due to structural fears, says a reporter, at least two of which have since been demolished, which begs the question how close were they to structural failure before they were taken out of service? Some MSCPs hold more than 1,000 vehicles and therefore a collapse could be catastrophic. Although progress was being made with publications by ICE and IStructE (see *references in comments below*) we should be much more interested in the potential problems of structural safety in MSCPs. The reporter believes that many of the car parks in the Local Authority sector are in a very poor state of repair and they are not inspected as the money that they make is diverted elsewhere. The reporter has recently inspected some car parks - not one has been assessed structurally, they have no fire safety certificates, no electrical certification, asbestos is visible, the bolts are loose in the vehicle impact barriers, etc.and on the outside of each car park is a large sign displaying that it is a safe place to park. One of the underground car parks is reported to be flooded to the depth of a swimming pool – and it supports a large building above. Accidents continue to happen both at home and at overseas but there is, says the reporter, insufficient legislation to control the situation.

Comments – see below

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265 MULTI-STOREY CAR PARKS: STRUCTURAL CONDITIONS (1)



Soffit deterioration



Surface break up



Loose aggregate on surface

This reporter is a structural engineer who has completed a large number of remediation projects on MSCPs built mostly in the late 1960's or early 70's. The car parks were owned by various clients including major owners and operators. About half have been at Shopping Centres and half in city centres. Some years ago the condition of one very heavily used city centre car park had gone beyond being poor and the reporter's firm had written to the owner and made it clear that it was dangerous, but to no effect. Luckily a new surveyor (for the owner) turned up and had the area remediated. The reporter has no doubt that without this action there would have been a collapse. He is currently in the process of remediating two car parks in another town which, when first tendered, were thought to be amongst the largest such contracts in the UK. The original proposal, a few years ago, included a major refurbishment as well as repairs but due to economic conditions the work was delayed but has now been done. The rate of deterioration since the reporter's initial inspection and testing was, according to the reporter, an eye-opener. Over 50% of one deck had to be replaced and in total the anticipated costs rose by 50% and in consequence there is no money left for elastomeric coatings to protect the remaining areas.

There are, says the reporter, two common threads with all such car parks. The first is that there is no return on the money spent and the second is that it was OK yesterday, and OK today, it will therefore be OK tomorrow. He recently inspected another car park at a public facility. The owner was advised that the lower decks needed work doing and the top deck needed urgent repair action. The surface looked like a shingle beach with only exposed loose aggregate left in many areas, deep ponding, large pot holes, exposed rebar and a very sorry looking slab soffit. Nothing has been heard since. The reporter believes that it should be compulsory for owners to obtain a report on condition every two years and this should be in the form of a simple check list. He has no doubt that if we carry on as we are then there will be a collapse.

Comments – see below

267 MULTI-STOREY CAR PARKS: STRUCTURAL CONDITIONS (2)

This reporter has two instances where his firm has prepared reports and carried out numerical assessments of city centre car parks that have led to the car parks being demolished. One had precast concrete beams which had come to the end of their life. The other was constructed in the 1970s using insitu reinforced concrete and is particularly interesting. The reporter first carried out an inspection of the structure in 2003 and noted that the underside of the reinforced concrete waffle beams were in poor condition at mid span. However, the assessment indicated reserves of strength around the columns where re-distribution of moments would allow deficiencies in sagging to be partially taken by hogging reinforcement. Based on the typical parking usage at the site it was deemed that there was sufficient capacity to allow the car park to remain open in the short term. The second inspection in 2008 revealed changes that alarmed the inspectors. Although there was little deterioration at mid span, the concrete around the columns was now in poor condition with widespread de-lamination of the upper surface. Due either to time or excessive stress or both, the top reinforcement was corroding and the spalling revealed that there had been numerous previous concrete repairs to the top of the deck during past decades. The de-lamination largely remained hidden by the surfacing but could be detected using laborious tapping of the surface. Analysis confirmed that low condition factors around the columns had a drastic effect on the capacity of the deck in both bending and shear, and particularly in bending combined with shear. The car park was shut, and the decks were propped pending demolition which was subsequently completed, but as the MSCP was above a town centre shopping area there were major complications.

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 Users Forum
- British Parking Association
- Communities and Local Government
- Construction Industry Council
- Department of the Environment
- DRD Roads Services in Northern Ireland
- Health & 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

The reporter's main concerns are:

1. these car parks were under the control of local authorities with good technical staff, who were proactive in monitoring deterioration in their car parks. This is probably relatively unusual.
2. The presence of old repairs to the upper surface of the deck slabs around the columns had remained undetected in at least two previous structural inspections. This is likely to be very common.
3. The significance of deterioration would normally be missed as it involved relatively minor, if widespread, corrosion and spalling to the upper surface of the deck around the columns. Even an experienced engineer would not generally appreciate the significance of this if viewed in isolation and as a single snap shot in time.
4. The Pipers Row collapse in 1997 (see *reference below*) showed that shear failure in car parks has been found to take place with little warning other than relatively minor cracking around the columns. The second example here had a more traditional form of RC construction, but the significance of cracking and spalling described above was believed to be very high.

Comments

Headline events such as the at [Pipers Row](#) car park collapse in the UK in 1997, a Montreal parking garage collapse in 2008 (see [Canadian News report](#)), and others show that severe, and sometimes fatal, failures occur in such structures.

MSCPs are unique structures in many ways as they are:

- *subject to relatively severe weather conditions due to exposed structure, carbonation etc*
- *Sensitive to waterproofing finish failure*
- *Sensitive to expansion joint sealant failure*
- *Subject to extremes of thermal loading akin to bridges but rarely detailed to the same standard as bridges*

The typical pattern of deterioration is such that failure is likely to be indicated by spalling but may be sudden and brittle with little or no warning. Given the history, and the likely consequences of failure, there may be a case for making it a legal requirement to have regular inspections of these structures. In the absence of such requirements those involved should ensure that their concerns are expressed in clear terms to their clients, with the consequences (to individuals and organisations) of failing to act being outlined. It may be that some owners and operators tend to ignore current legislation (not to mention their own liabilities) on the basis that a collapse of a MSCP is a rare occurrence. This is true, but they may be unaware of how close inadequately inspected and maintained car parks can come to collapse. It has been found that insurers take the same view on the basis that claims for collapses are few and the risk is acceptable given the number of car parks that they insure. From work carried out to date by the British Parking Association it would seem that the most managers would like to maintain their facilities but are prevented from doing so by lack of funds. The BPA in its [Master Plan](#) therefore recommends that: "Owners and operators set aside funds from income streams to finance periodic structural inspections and essential maintenance of car park structures". Local Authorities are non-profit making and any surplus of income from parking may sometimes go to support other services. It would, according to BPA, therefore be a major step forward to have legislation in place to provide an allocation of funds for proper inspection and maintenance in accordance with current legislation. Local Authorities practices differ and some carry out their responsibilities very thoroughly and have excellent MSCPs. In the aftermath of the Montreal collapse a coroner called for tighter inspection rules after finding that a car park that collapsed and killed a man was badly built and maintained. She says the structure, built around 1970, was in a sorry state and had surpassed its useful life.

NEWS ITEMS

BS 8539:2012 CODE OF PRACTICE FOR THE SELECTION AND INSTALLATION OF POST-INSTALLED ANCHORS IN CONCRETE AND MASONRY

Later this year BSI are expected to publish a new standard aimed at clarifying the roles and responsibilities of all parties involved in every aspect of the use of construction fixings for safety critical applications in concrete and masonry. The initiative for this standard followed the publication in Ireland of a Regulation with the same objectives which was itself prompted by the death of a worker on a construction site in Dublin. Accidents involving fixing failures reported through CROSS, especially those involving suspended ceilings, have also informed this work. Guidance for specifiers will cover the selection process, recommending wherever possible that anchors qualified with European Technical Approvals are used, but also including topics sometimes overlooked such as planning for hitting rebar and a procedure for how anchor specifications may be changed in order to eliminate the known cause of at least one death. The document is available as a "Draft for Public Comment" and the Construction Fixings Association, who has led the drafting panel, invites any engineering practice that wishes to comment on the draft to contact them at info@fixingscfa.co.uk and details will be forwarded. Open webpage <https://drafts.bsigroup.com> and enter "BS 8539" into the Keyword Search box to bring up the relevant page although the review end date is 30/04/2012.

COLLAPSED FARM BUILDINGS PROMPT DESIGN CHANGES

[Farmer's weekly Tuesday 13 March](#) published an article on the design of agricultural buildings and the changes that will come about in relation to Eurocodes and CE marking. Mention is made of the numerous collapses of farm buildings that occurred in the winters of 2009/10 and 2010/11. These were reported on by CROSS and an Alert: [Snow loads on agricultural and other building structures](#) was issued by SCOSS in March 2011.

The Institution of Civil Engineers has a comprehensive report on inspection and maintenance: [Recommendations for the inspection, maintenance and management of car parks](#), the Institution of Structural Engineers has published an updated version of its report: [Design recommendations for multi-storey and underground car parks \(Fourth edition\)](#), whilst the planning portal from the Department of Communities and Local Government has a report '[Enhancing the whole life structural performance of multi-storey car parks](#)'

Previous CROSS reports on similar topics have been:

Report 106: [Car park staircase collapse at construction joint](#)

Report 119: [Multi storey car park defects](#)

296 COMPATIBILITY AT RC COLUMN TO SLAB JOINT (STRONG COLUMNS/WEAKER SLABS)

A reporter worked as an independent engineer to review the structural design of a project. It is a commercial building of about 30 storeys with a central RC core, RC internal and external columns, and flat slab floors. Construction is in-situ and columns have at least 4% of reinforcement. His concern is that the strength of concrete in the columns, grades C70/85, is greater than the strength of the slabs, C30/37, so there is a layer of weaker concrete at each floor level. Under vertical loads, continues the reporter, there will be negative moments over the columns and to the tensile bending stress in the top of the slabs will be additional axial tensile stress from diaphragm loads in the slabs. As the concrete will be cracked in the tension zone he wonders if it will properly constrain the compressive loads from the columns. He believes that compatibility at the column/slab joint is not satisfied.

Comments

With the growing use of high strength concrete in columns, a common problem in design is to know how much the effective strength of the column is reduced by a weaker intersecting slab. Although this can theoretically be avoided by casting a 'pool' of high strength concrete in the slab at each column location, in practice this requires very careful site management and supervision, and a design solution accepting some limitation in the column strength is usually preferred. BS 8110 does not cover the situation. Neither is the subject dealt with directly in Eurocodes although there is mention of confinement. Some guidance is given in [Concrete Society Technical Report 49 Design guidance for high strength concrete \(cl 6.3\)](#). Relevant research has been published by various authors in Germany, Canada, and Australia.

[Concrete Society Technical Report TR64](#) suggests the following options:

- *Increase the strength of the concrete in the slab*
- *Cast the slab concrete over the column perimeter and within a prescribed area outside the column perimeter with the higher grade concrete*
- *Cast the lower column through the slab.*
- *Confine the concrete by using large diameter links in the slab.*

Whilst there is still debate over the best model a suitable approach would be to consider possible effects and make design decisions accordingly.

253 FREEZING SPLITS GALVANISED RHS COLUMNS

At a construction site a number of ground floor RHS columns had split vertically. The columns were 120 x 120 x 5.0 Hot-Rolled Square Hollow Sections and part of a single-storey section of a new complex. The construction was only partially complete and included the profiled metal deck roof and in situ concrete slab only, and possibly some nominal construction live loading. The design was checked and found to be



Report 253: Split RHS due to freezing



SCOSS Biennial report 2001:
Split RHS due to freezing

satisfactory and the failure mode did not follow the expected Euler buckling shape for compressive forces. The sections are galvanised and holes had been left in the cap plates for drainage as part of the galvanising process. These had been left exposed to the elements prior to concreting. The reporter suspected that water had come in through the holes and filled the hollow sections, and that this had then frozen to exert a significant bursting pressure sufficient to split the steel along one corner, (not at the weld position). Holes were drilled through the columns near to the base and proved this theory as water jetted out under pressure (see photo). This could have gone undetected if the weather had not been sufficiently cold to freeze the water within the columns, but could have occurred at a later date following completion of the building with greater consequences.

Comments

The [SCOSS biennial report](#) for 2001 included a case where barrier posts had filled with water that had caused the damage on freezing in winter. The barrier structures were only 4-5 years old and made of RHS sections with fully welded joints and end plates. Visual inspection of the barriers showed no sign of any openings that would allow ingress of water (see photo). It appears that water can be drawn into tubular steel structures of this type by capillary action. The phenomenon has been experienced in other structures; such as roof trusses made from hollow steel sections, and welded box girders. Although the structural elements are manufactured as 'sealed units', continuous welding does not necessarily produce a complete seal and water may accumulate inside where the units are exposed to the weather. Research into the phenomenon in Canada has shown that a partial vacuum caused when a relatively warm, imperfectly sealed steel tube is rapidly cooled by rainwater, can draw in water through very small cracks and holes. Over a period of time this can result in a considerable build-up of water trapped inside. Where such a steel tube forms a structural element that is exposed to the weather, the trapped water may freeze in winter. The element may thus be damaged as it fails to restrain the expansive action of ice formation. The resulting bulging and/or splitting may reduce the load-carrying capacity of the element substantially, thereby undermining the safety of the structure. SCOSS draws attention to this reported experience because tubular or other 'sealed' steel elements in crush barriers; bridge parapets and other structures may be similarly affected. The phenomenon may exist elsewhere even though it has not yet progressed to the point where bulging and/or splitting has become visible. The presence of water cannot be detected merely by an external visual inspection until damage occurs. Inspecting engineers should be aware of this possibility and, where appropriate, consider specific investigation. For the damaged crush barriers, the reported remedy was to repair and replace damaged posts and to make drain holes just above ground level to allow water to scape. A boroscope inspection through the drain holes enabled the internal condition of the posts to be checked for corrosion. More generally for tubular steel structures exposed to the weather and in unheated buildings, the report on the Canadian research advised either complete weld seals free from porosity or, the provision of some form of drainage with periodic inspection of drain holes to ensure they do not become blocked. Provision of holes also prevents the development of partial vacuum in the units and can also enable beneficial ventilation of the internal voids. Similar problems have been found on highway structures with water ingress into 'so called' sealed steel sections used as gantry legs when there were freeze/thaw splits, and relieving holes had to be drilled and repairs carried out.

263 CONCERN ABOUT FAULTY SELF-CERTIFICATION OF NEW INSTALLATION

A reporter's client had work done in a domestic property by a specialist contractor who was registered under a self-certification Competent Person's Scheme (CPS) but the work was faulty. The scheme was intended to ensure that installations complied with Building Regulations. The regulatory body for

THE UK ROADS LIAISON GROUP PUBLISHED THE FOLLOWING IN ITS APRIL 2012 ISSUE

The Standing Committee on Structural Safety (SCOSS) provides advice to the civil and structural engineering professions. The safety of bridges has always been of great importance to the committee's work. In 2005 a scheme for Confidential Reporting on Structural Safety (CROSS) was formed to collect confidential data on concerns that might not otherwise be published and provide expert non-judgemental commentary. The sponsors IStructE, ICE and HSE plan strategy, oversee development and provide the funding. There is a new website www.structural-safety.org which includes all archive publications from Scoss, the Cross Newsletters and a data base of material that has been developed. The site gives information on how to report concerns about structural safety on bridges and buildings and these are always confidential. Confidential reporting is not "whistle blowing" but a way of transferring valuable information between fellow engineers. The process has been embedded in the Highways Agency procedures (IAN 136/10) and by DRD Northern Ireland. New reports are the life blood of the programme and are needed continuously so by sending these in, through the web site, the bridges community will further improve structural safety and enhance good practice.

Whilst CROSS 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, CROSS does not accept any liability to any person relating to the use of any such information.

HOW TO REPORT

Please visit the web site:
www.structural-safety.org

When reading this Newsletter online [click here](#) to go straight to the reporting page.

Post reports to:
PO Box 174
Wirral
CH29 9AJ
UK

Comments either on the scheme, or non-confidential reports, can be sent to:
structures@structural-safety.org

the scheme was unwilling to arrange remedial works and it took more than a year (and two re-installations) before an adequate job was done. The underlying reason was that the self-certification body stated that it had no power to have another firm replace defective work - it could only use its influence to ask for re-installation of work which had been done and, in this case, that was wrongly self-certified. After a lengthy period, and on the third attempt, the work was put right. Most householders would not persist so long, says the reporter, nor be capable of paying the substantial professional expenses to achieve any action. No specification was provided of the work was finally completed, nor were there any records of inspections. There was no full and updated certification or documentation about insurance or a guarantee. Although the CPS organisation did employ an independent supervisor, out-of-pocket and professional expenses had to be funded by the householder. From this example the reporter is worried about the structural capability of some specialist contractors and the possible consequences of disturbance to the existing fabric of buildings. When the house is sold, a conveyancer for the buyer may not accept the adequacy of multiple re-installation and remedial works.

Comments

A number of Competent Person's Schemes (CPS) are run under the auspices of the Department of Communities and Local Government. Membership of a CPS enables companies that install equipment to self-certify compliance under the Building Regulations. Such CPSs have no direct, or financial, responsibility under their terms of reference to carry out remedial work. The responsibility is with the installer. A local authority could possibly prosecute for non-complying work carried out outside of the scheme, and building owners can take action in the civil courts, although in either case legal advice would have to be sought. Before CPS schemes were introduced there was a high proportion of non-compliant work for these types of business. One main purpose of the CPS scheme(s) was to reduce non-compliance by having installer registration. It was also to reduce burdens of compliance for minor and repetitive works and to reduce "out of control" work and bring some order to the situation. This has been generally successful and the number of problems of non-compliance in this area has gone down very significantly with CLG apparently hearing of very few problems now. The reporter is concerned about structural stability and whether this may have been compromised during the works. CROSS has had reports of damage and failures resulting from incompetent and inappropriate alterations to buildings, and the reason is frequently that there has been no engineering input. To comply with the Building Regulations, for example Part A, it is not necessary to use a qualified or chartered professional. There is also concern that a lack of documentation in cases such as this might frustrate future owners.

Falsification of records

CROSS has had some reports about false documentation in relation to materials or components and would be interested to hear more about experiences about this practice. The SCOSS committee is currently studying the matter and would like to have further information. Reports should be sent confidentially to CROSS.

DATES FOR PUBLICATION OF CROSS NEWSLETTER

Issue No 27	July 2012
Issue No 28	October 2012
Issue No 29	January 2013
Issue No 30	April 2013