CROSS

Confidential Reporting on Structural Safety

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NEWSLETTER NO 36, OCTOBER 2014

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

Thanks to all of those who have submitted reports, a selection of which are given below. There are others in the pipeline and the data base continues to grow. However the success of the programme depends on receiving a constant supply of material. Ten thousand subscribers receive these Newsletters and if you benefit from them then please contribute by sending concerns, in complete confidence, to *Structural-Safety*. **More reports are ALWAYS needed.**

In this edition the first report is about the failure of a tower crane leg, probably due to fatigue, and raises the issue of whether the history of an often used part should be known. There is another report on the quality of imported structural steelwork and rebar and a repeat of the frequently quoted advice "buyer beware". Two concerns on wind follow. The first relates to a two storey site cabin being blown over. The second is on the use of the Eurocode. Then come two reminders of winter with more on the splitting of RHS stanchions and a warning about snow slides from curved roofs. During site excavation a dangerous temporary spoil heap was spotted by a passing engineer who persuaded the contractor to use safer practices; an admirably responsible attitude. Another reporter describes how the load testing of a very deep beam came to a premature end. Finally it has been observed that the design of rebar in slabs with twisting moments may not always be in accordance with recommended practice.

Two of the nine cases are about design, two are about events during the normal use of a building, and the others relate to site operations. This is consistent with the usual proportions of reports. Lessons can be learned from all of them. At recent events in London; the ICE Health and Safety in Construction Conference, and the Capita Safety Lecture, it was stressed that learning from others is a key aspect of successful safety cultures.

399 TOWER CRANE – FAILURE OF A LOAD BEARING PART

A tower crane suffered a failure of one of its four main legs approximately 12m below the slew ring. The fault was discovered, says the reporter, as a result of the tower crane operator noting some unusual banging and vibrations from what he believed to be the slewing ring. The crane was immediately taken out of service and an inspection carried out. This revealed that there was no fault with the slew ring but identified a failure in the leg. The crane was dismantled, the part replaced, and a new Certificate of Thorough Examination was issued by an independent company. At the time of reporting it was not known what caused the failure and a full investigation is underway. This incident has been reported to the HSE as a dangerous occurrence and the contractor issued an instruction to all sites to immediately carry out appropriate inspections of such cranes in consultation with the tower crane provider/operating company. In an update the reporter has pointed out the recommendations from

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

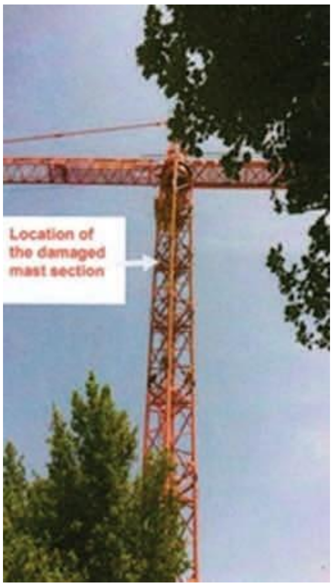
- Association for Consultancy and Engineering
- Bridge Owners Forum
- British Parking Association
- Communities and Local Government
- Construction Industry Council
- Department of the Environment
- DRD Roads Services in Northern Ireland
- Health & Safety Executive
- Highways Agency
- Institution of 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.*

the Construction Plant-hire Association (CPA)Tower Crane Interest Group *TIN042* Selection of Tower Cranes - Anticipated Utilization. These include the following 'high intensity operations' that are likely to increase fatigue in tower cranes:

- Usage in excess of 10 hours per day
- Planned lifts in excess of 6 lifts per hour
- Risk of shock loading (emptying muck skips for instance)
- Use largely within a restricted arc of operation
- Frequent use above 70% SWL
- Short mast (20m or less)
- Short jib (30m or less)
- Permanently sited tower cranes in ship repair facilities, factories and plant yards
- Use of radio controls with consequent loss of operator feedback

Crane in position



Fractured section

Comments

The investigation is not yet complete but an obvious candidate for a failure of this kind is fatigue cracking. There are two phases of fatigue damage: crack initiation and crack propagation. Both phases are linked to repeated application of stress. Fatigue cracking is a potential mode of failure on any moving structure but its initiation and rate of propagation are rather uncertain. Hence a fundamental plank of safety is the ability to inspect with the objective of detecting a crack before it progresses far enough to be dangerous. This is a really good example of a near miss from which we can all learn. Any piece of steelwork which is subjected to repeated and/or cyclic loading should be inspected for fatigue loading. The incident supports the need and obligation for regular inspections but also to consider whether the usage of a crane in some circumstances might warrant more frequent inspection? For example, lighter loads but very frequent and repetitive use (creating reversals of stress) may be more harmful than occasional heavy loads. The recommendations in CPA TIN042 are to be welcomed. There are other structures which are composed of a kit of parts each of which may have had a different history of use; for example temporary stages or even scaffolding. The history/residual fatigue life of the individual components will probably not be known. Is there a need for more rigorous systems for detecting fatigue in construction equipment components? It is taken very seriously in the aircraft industry.

474 IMPORTED STEEL

Defective steel, says a reporter, was found in a major retail store where the steel had been imported from a supplier in the Far East. This only came to light after the problem was noticed on site and subsequent testing revealed major flaws in the manufacturing process. Cable drops were being fixed to the columns by electricians who were drilling small bolt holes. They reported the steel started off as expected but soon the drill bit literally jumped through the webs. All the columns were X-ray tested and five seriously defective 203UC and 254UC sections had to be replaced with several others being repaired. The roof was on and first fix under way, fortunately no beams were involved as the records and some site sample testing indicated they were of different origin. Rebar, also imported and amounting to a few hundred tonnes, showed signs of inadequate production, some even had visible (just) laminations on their surface. The original steel had been melted and turned into billets that were then folded over and over in the production of recycled steel. Having seen recent building collapses in the Far East coupled with the all too common falsification of certification, it is little wonder, continues the reporter, why people are very cautious about using materials from some countries.

Comments

CROSS have had several reports of defective imported materials [1]. Designers should ensure they have proper certification (though we have also had reports of false certificates) and consider the imposition of random quality checks on delivered material at the start of a project. Designs are based on material specifications being met. Any designer must have an appreciation of where the material might come from and how testing can be specified for it. The issue is probably hidden within the procurement chain so perhaps it is here that more rigour is required in the review of material testing. Should clients give instructions for greater sampling of material? Normally there are rigorous certification schemes for both steel sections and steel reinforcement, assuming these products were purchased through a certified route, to ensure the provenance of materials. But this example shows that these can be bypassed. Construction contracts should be very clear on the expected procedures and the associated documentary evidence required. Buyer beware!

Where a defect is identified in a product covered by a harmonised European Standard, the trading standards department of the local authority should be notified in order that they can investigate and take any necessary action, such as product recalls and alerting other users. They can also take legal action, which will hopefully act as a deterrent to placing non-compliant goods on the market in future.

1. Alert - Anomalous documentation for proprietary products - February 2013.

NEWS

Preventing the collapse of free standing masonry

The Alert Preventing the collapse of free-standing masonry walls has been published following numerous instances of collapses; a number of which have resulted in fatalities and various examples from the Structural-Safety data base are given. Most simple walls are not structurally designed, and often have excessive height to thickness proportions. Of particular concern is the danger posed to children by unsafe walls. The Alert stresses the importance of a risk assessment when looking at a wall and there is a list of factors to consider when deciding if there is potential danger. The possibility of a wall causing death or injury depends upon its location in relation to people. If children are habitually in the vicinity this must be taken into account because of their height in relation to the size of wall. Possible courses of action when danger is anticipated are given. References are made to sources of information on the design and construction of new walls and anyone responsible for such a structure should ensure that such guidance has been followed.

The pdf version of this report given in the email to subscribers on 15 September 2014 contained reference hyperlinks that did not work. This was corrected and links in the version above are functioning.

Man killed by falling masonry

A man died when a section of building collapsed on top of him at an East Yorkshire seaside resort on 6 October 2014. Police said the fallen masonry had "struck the man and a vehicle". There were strong winds in the town, but it is not yet known whether that was the cause of the accident. The fire service said it was unclear why the masonry fell and the police said they were working to establish the cause.

450 Two tier stacked site cabin blown over

A reporter circulates the CROSS Newsletters to his staff and invites feedback on anything that they come across that may be relevant and worth sharing. One of his engineers has highlighted that there may be no guidance from the cabin suppliers who supply site cabins on double or even triple stacking cabins. This came to light following an internal investigation by a Main Contractor arising from an incident where a two tier stacked site cabin was blown over in the wind with someone inside – thankfully they were not injured.

Comments

Another near miss, this time due to under estimation of wind loads or inadequate fixing to the ground. Site cabins are 'temporary works' in this scenario and should be dealt with in accordance with BS5975:2008+ A1:1011. A stacked cabin arrangement is clearly a significant structure that requires competent design and checking. On small sites where space is limited, cabins are often stacked up – however little thought may have been given to the suitability of the ground to withstand the imposed loads. Temporary Demountable Structures *published by the Institution of Structural Engineers, whilst not directed at temporary works situations, gives guidance on several matters of interest to temporary works designers.*

403 Application of wind load code BS EN 1991 – Wind actions

Another reporter is concerned about the application of the wind load code EN 1991 BS EN 1991-1-4: 2005 Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions. This requires the engineer to select a basic wind speed from a map, and then by means of a series of factors derive a value for wind pressure by considering various exposure factors. In most cases, he says, this gives a wind pressure greatly exceeding that which would result from the basic wind speed. However, having checked many calculations the reporter has noted that some design engineers clearly do not understand this very difficult to apply code, and just calculate a wind pressure that is the result of the basic wind speed. In his opinion there is clearly a danger of accidents occurring as a result of this. He feels that the code should be amended to have a similar format to the old superseded code CP3 Chapter V, which gave higher basic wind speeds which could then be reduced if the site was in a sheltered position. He hopes that his concern receives due consideration.

Comments

This report highlights the difficulties of dealing with new codes couched in different ways. The point about the format of code guidance is well made but is not always practical when working across disciplines or indeed internationally. Switching from wind speed definition between mean hourly and gust is one potential cause of confusion. It must also be borne in mind that pressure is proportional to wind speed squared, whatever the code, so minor changes in the speed can have a significant effect on the predicted design loads. CP3: Chapter V was superseded in 1995 by BS 6399-2 and incorporated considerable advances in wind engineering. In fact CP 3: Chapter V used factors greater than 1, which rarely caused a problem. The process used in BS6399 is not greatly dissimilar from EN1991-2 in that a mean periodic wind speed is factored up based on the size of the gust, the topography, elevation and various other factors to give a design wind speed. Furthermore a purely gust driven approach ignores the issue of continuous structures where relieving effects can make a huge difference to load effects. Another concern is that simple structures such as hoardings may not be properly designed because of the perceived complexity of the approach. The temptation is to use a nominal pressure which may or may not adequate. Also to be resisted is the temptation to mix Codes.

Designers must be aware of the impact of Eurocodes, and modify their approach accordingly. Two useful publications from the Temporary Works Forum are: The use of European Standards for Temporary Works design, and Site hoardings (April 14).

434 Freeze/thaw effects on RHSs and unexpected hydrogen generation

A correspondent is interested in reports on freezing effects on galvanised hollow sections (Newsletter 33 Report 314 More on freezing and galvanised hollow sections). Without having done calculations, he is surprised that ice would actually split an intact hollow section at the corners. He is not sure ice could generate enough stress, and would expect to see bulging of the faces first. It is significant, he thinks, that the sections were galvanised. He suspects that what has occurred is Liquid Metal Assisted Cracking - the strain hardened corners of cold formed RHS are known to be vulnerable to this - and the ice has simply broken the zinc that filled the cracks and bent the then unrestrained sides of the RHS outwards. Sealing the section to prevent water ingress may not be a good remedy. Apart from the problems discussed in the linked CROSS report, he is aware of two instances where corrosion of sealed RHS has resulted in the section being pressurised by evolved hydrogen. This has resulted in burns to people drilling or cutting the section. One incident occurred on a handrail standard; a check revealed significant hydrogen in the other standards. This was documented in an internal company memo. The other incident occurred in the USA when an agricultural plough (or plow!) was being modified; a jet of flame occurred where a hole was being drilled. To add weight to the plough, the hollow section had been filled with steel and aluminium punchings (swarf). Following the accident, simulations showed that the pressure of the hydrogen may have been as much as 12 bar. Unfortunately the reporter has been unable to find the original source of this report but it does seem that this risk is not widely known.

Comments

In plumbing pipework it is normally the thaw phase which creates bursting since a quantity of water has maximum volume at ~ 40 (not as ice). A complication is that RHS walls will be thinner at the corners but as the material is strain hardened it is also stronger and the extra strength is presumed to compensate for the loss of section. If calculations were done, they would need to be based on strain not stress since the volumetric expansion causing stress would have to be enough to stretch the steel beyond its fracture point. Hydrogen embrittlement can occur but is normally associated with higher strength steels. In addition to the RHS sections previously reported to CROSS (253 Freezing splits RHS galvanised columns) there have been cases of bridge parapet posts bursting, and because of this it is normal put a drain hole in to the post if there might be doubt as to whether complete sealing is possible. There have also been examples of RHS sign posts and gantry legs splitting through freeze/thaw action, or just filling with water. Supposedly sealed units are often found to be leaky and any defect can lead to differential pressure issues and consequent water ingress.

So far as the debate on unexpected hydrogen generation is concerned, any other experiences will be welcome. Previous CROSS reports on Liquid Metal Assisted Cracking and hydrogen generation can be found on the Structural-Safety data base.

438 Snow sliding off industrial building roofs

Collapse of a lean-to roof, at a lower level than the main roof of a large industrial building, and damage to ground level equipment, was caused by snow. It had accumulated on the main roof, thawed and slid off imposing large imposed loads due to impact. The reporter says that sliding snow forces are addressed in UK codes but only in the context of loads on the back of parapets. Modern single storey buildings can have shallow curved roof profiles and no parapets so there is little restraint to snow falls from height. Sliding snow falling from eaves is acknowledged abroad, typically on relatively steep roofs by the use of snow guards at eave positions. Some projects in the UK incorporate snow guarding but the risk of snow falling through height is generally not considered. Building designers should assess the risk to users and adjacent structures of snow load impact resulting from large roofs with no parapets.

Comments

This eventuality requires more publicity and the report is an example of how design should be risk based rather than code-driven. Indeed designers should address this risk especially in areas prone to heavier falls and if the roofs coverings are of glass or other slippery material where snow can accumulate and then slide as an entire mass. In cold parts of Europe (and elsewhere) pedestrians have been killed by large icicles. In any risk assessment the generic hazard of 'falling objects' should be one of the key words. CROSS has previously had reports on collapses due to snow loads which can be found on the Structural-Safety data base by entering the key word "snow".

444 Unsafe spoil bank

An unsafe site excavation with very steep and high spoil banks and machinery in precarious positions was seen by a reporter. He contacted the contractor who stopped work until a safe method of working could be implemented. A success (as he says himself) for the interventionist.

Comments

There have been innumerable incidents of diggers and cranes toppling on unsafe ground. It is a recurring problem. Equally, the temporary stability of slopes is a serious issue and designers need to consider this coupled with possible slope degradation in heavy rain. This illustrates how a commonplace construction activity can have the potential for fatality or serious injury unless it is carefully thought-out.

469 Failure of load test setup

A composite steel girder was designed to support the platform for a Metro Rail station and it was decided to do a working load test on it at the fabrication yard before erection. Unfortunately the load test setup failed due to over-estimation of the capacity of the ISMB (Indian standard steel beam) provided for supporting the girder.

An investigation into the failure found three contributory causes.

1) A detailed 3D analysis simulated the design bearing load over the ISMB-300 member and it was found that the stresses in the member were more than 3 times greater than yield strength.

2) The design size of the Elastomeric bearing pad was greater than the flange width of the ISMB300 so the bearing area was insufficient.

3) The main cause of the failure of the load test was the lack of proper stiffening plates.

Test load setup

Remains of the supporting beam

Comments

Assuming that it was an overestimation of the strength of the supporting member then the lesson is that test rigs should be designed to the same level of detail as the piece being tested. SWL need to be defined for the test rig, as often the tested piece may be significantly stronger/stiffer than expected and loading to deflection/failure criteria of the test piece can fail the rig. As is so often the case attention to detailing is required. All elements on the load path need to be looked at - there is always a weakest point.

441 Computer analysis and slab design twisting moments

A reporter has noticed on many occasions, when checking reinforced concrete and post-tensioned slab designs, that engineers often neglect to consider twisting moments when arriving at slab design moments, derived from computer software analysis. For equilibrium, twisting moments Mxy must be distributed (i.e. summed) to the bending moments in the principal directions: Mx and My. One way to achieve this is to adopt the Wood-Armer method which is included in the post processing of most common structural software packages. However, the user must first be aware of twisting moments and secondly switch on this option in the software package to arrive at the correct design moments. Twisting moments often occur when the geometry of a structure is irregular. The magnitude of twisting moments can be significant. They occur in suspended slabs, ground bearing rafts and walls. The following references are given for further reading: "Advanced Structural Mechanics" 2nd Edition by David Johnson, Thomas Telford, and "The Assessment of Reinforced Concrete Slabs" by Denton and Burgoyne, The Structural Engineer, Vol 74, No.9

Comments

Wood and Armer[(1)] proposed one of the most popular design methods that explicitly incorporate twisting moments in slab design. The method was developed by considering the normal moment yield criterion (Johansen's yield criterion) aiming to prevent yielding in all directions. The method is incorporated in proprietary slab design packages and can be particularly relevant when skew slabs are being considered. As the reporter says this option may have to be switched on depending upon the software. Simply adding the Mxy to the Mxx and Myy is a slightly conservative but simpler approach. Even simpler is to set the torsion stiffness very low such that torsion stresses in the chosen "equilibrium" are very small. Ignoring torsion is however a safety issue. If the torsional moments are required for equilibrium they should be designed for! Often ignoring them makes less than 10% difference but as suggested in the report there can be cases where it is more significant. Ensuring the user understands the software and is able to validate the output remains one of our profession's greatest challenges.

1. Wood, R.H., "The Reinforcement of Slabs in Accordance

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.

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

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