

CROSS

Confidential Reporting on Structural Safety

Newsletter No 23, July 2011

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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.

Please [click here](#) for link to CROSS website

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INTRODUCTION

This Newsletter starts with a report about the use of water filled containers when used as ballast for temporary structures such as those erected for music festivals. In Scotland in the winters of 2009/2010 and 2010/2011 there were many collapses of, mainly agricultural, buildings during periods of high snow loads and reports on these have been consolidated to provide an overall picture of the events which took place. The CROSS panel have provided comments and the information, in co-operation with the Scottish Government, has been forwarded to the British Standards Institution for consideration. A further report is about dangerous and almost simultaneous snow slides from 100 domestic roofs, and there is a salutary lesson in a news report about a column constructed with no foundation. Finally the British Parking Association is requesting information about the condition of multi-storey car parks.

CROSS needs [reports](#) all the time so that lessons can be learned and if you can contribute please do so.

5 WATER FILLED CONTAINERS AS BALLAST FOR TEMPORARY STRUCTURES (Report 255)



Typical water filled containers used as ballast

The reporter is a local authority Environmental Health Officer who is responsible for licensing the safety aspects at a local festival. As part of the structure of the main stage, water filled plastic containers are used as anchors/ballast. He says that he has concerns over the suitability of these as he believes they could become crushed quickly and not provide the weight that is intended. The rigging, straps, lines and other components, which have all been tested for their suitability and strength, are secured to a riveted fixed aluminium frame around the container. Neither the frames nor the containers, so far as the reporter is aware, have been tested for their capacity as fixing points. When the reporter has questioned the suitability of the system he has been told it is industry practice. The reporter would if possible like guidance for the sector with which he works closely.

CROSS comments: *There are systems that use water in purpose made steel tanks. Some vehicle based fairground rides contain water (typically 12,000 to 15,000 litres) in 'belly' tanks in the chassis to aid stability. Also some very large tower base systems have in built steel tanks to provide stability and in both of these cases there are proper valves and methods to make sure the water stays in place. However in the example given by the reporter the water ballast appears to be in plastic 1,000 litre ISO containers. These are quite expensive to buy new but are widely available on the second-hand market. A significant premium is charged to provide certification that they are not contaminated so many that are in use may not have been cleaned and this may present a number of hazards. The valve mechanisms are prone to damage, to failure due to contamination of the seals, and to simple vandalism.*

NEWS ITEM

Missing column foundation leads to fines (Report 221)

Part of the first and second floors of a new build commercial development were supported on a blockwork column. However, the column had been constructed directly on top of the ground floor beam and block floor construction, rather than continuing down to the foundation. With the gradual increase in load from the construction of the upper floors, the column eventually punched through the ground floor construction causing partial collapse of the building. One worker was injured. It was not clear on the design drawings that the column was to be constructed on a foundation and this fact was never queried by the contractor. There were many other issues that came to light as part of the investigation, but the failings boiled down to these two simple omissions. The designer may argue that he shouldn't have to provide a competent contractor with such obvious information. However the contractor might argue that as he is not a structural engineer, how would he know that the floor is not capable of withstanding the imposed loads?. Worryingly, the collapse could have occurred at a time when the building was complete and occupied. The designer and the contractor were prosecuted under the Health and Safety at Work Act 1974. Both pleaded guilty resulting in fines of £7,000 and costs of £24,000. More information on construction site safety is available at www.hse.gov.uk/construction

CROSS Comments: *This case illustrates the ever present need for co-operation between designers and contractors and for vigilance about the loads applied to structures and the ability of structures to transmit these to suitable foundations.*

The tanks, if in vulnerable positions, could be damaged by vehicle impact. Also the walls of the tanks are very easily pierced with a screwdriver or similar tool. In one city with an annual event requiring a large number of such tanks the problem of vandalism was so severe that the plastic containers had to be encased in protective steel jackets. A secondary problem with tanks in winter is that the water may freeze and be impossible to remove. A practical solution at one site was to add plenty of salt to the water. How to fill the tanks, and how and where to discharge water after an event, are issues that have to be considered. These are examples of just some of the problems that might arise.



Concrete ballast blocks within a structural frame

It may be difficult to attach the tanks externally to a structure in an effective way. Examples have been seen where there is no proper load path from the ballast to the structure, or where the load is transferred through inadequate arrangement of ropes. The commercially available tanks often have surrounding lightweight alloy cages which are intended to stop them bulging outwards when full but are completely inadequate as fixing points. Any tensile system for transferring the ballast load it should be through a properly designed and robust structure. An alternative way of doing this (depending on the circumstances) is to place the ballast within the structure, so that all the weight is properly transferred to the structure. The above illustration is of concrete blocks used in this way. Advantages of concrete are that it is 2.2 times denser than water and hence less bulky, it cannot leak away, be vandalised, or potentially contaminate the ground. This solution of course depends on the particular nature of the circumstances involved. In short if water is being used as ballast for significant structures the support and rigging systems must be properly designed and constructed. General advice on temporary structures is to be found in the Institution of Structural Engineers publication, [Temporary demountable structures: Guidance on procurement, design and use, 3rd Ed, 2007.](#)

SNOW LOADING IN SCOTLAND (A summary of Reports 183, 184, 191, 193, 195, 199, 236 and 248)

There were heavy snowfalls over the entire United Kingdom in the winters of 2009/2010 and 2010/2011. CROSS received a number of reports, mostly from Scotland where a significant number of buildings suffered roof collapses. The reports have been summarised to give an overview from the reporters but individual reports can be found on the web site data base. A common thread is that the snow in Scotland fell vertically, in low temperatures, and in still air conditions which resulted in significant depths. These were reported as being from 600 mm up to 1,200 mm with ice underlying snow in some cases. This led to reporters questioning whether loads calculated from BS codes are adequate in such circumstances and how indeed would buildings fare if designed to Eurocodes.

NEWS ITEM

Conditions of multi-storey car parks

The British Parking Association are supporters of CROSS and they have concerns about the current state of some multi-storey car parks and the lack of money to finance essential structural maintenance and repairs. The following statement has been included in the master plan for their members:

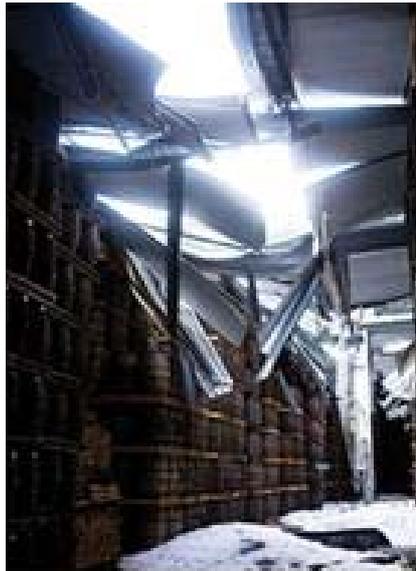
“We (BPA) want to see a greater emphasis on the need to ensure that parking structures are properly inspected and maintained. Owners and operators should be encouraged to have a financial mechanism in place through income streams for their car parks to budget and fund routine structural assessments, life-care planning and essential maintenance”.

Examples of deterioration within car parks may be reported to [BPA](#) or to CROSS in which case they would be de-identified and processed in our usual manner before being passed to BPA who would use them to help with a study of the situation.



Steel framed agricultural building in northern Scotland

One reporter encountered collapses of two modern well built structures - one was a 1,000 m² portal frame shed and another was a very large domestic building with a flat roof carried on glu-lam beams. In both cases the reporter observed a build-up of ice on the roofs ranging in depth from 75 to 150 mm overlain by around 400 mm of snow. Arguably, and very likely he said, the loadings were even higher when the failure occurred. Another report was about a lightweight pressed metal framed building that completely collapsed with a snow depth of approximately 500 mm on the roof.



A collapsed warehouse roof (courtesy of World of Whiskies)

Most were steel framed portals with spans around 20 - 30 m and generally the purlins failed first. The reporter recommends that in such buildings purlins should be at no more than 1.2 - 1.3 m centres and that frame centres should be at 6 m. Most of these buildings were clad with cementitious sheeting which is favoured by farmers because there are no drips, particularly onto cattle, from condensation. In one case a farmer had lost two sheds and had a newly completed shed which was at risk of collapsing so he took in a number of straw bales and set fire to them to melt the snow.

One reporter noted evidence of lateral torsional buckling instability of rafters between rafter restraints due to over load. Instability of the rafter in the apex haunch area suggests to him that it would be good detailing practice to fit rafter stays at each purlin position on either side of the rafter and at the two penultimate purlin positions either side of the apex, as these are in the vicinity of plastic hinge positions which are very likely to form should the roof be overloaded.

A significant report was about forty whisky storage warehouse buildings that suffered from partial or full roof collapses. These were generally steel frames with steel lattice roof trusses from 20-40 years old and 2,000 - 2,500 m² in area.

Another reporter says that nine agricultural buildings collapsed in a region where there was between 1,100 and 1,200 mm of snow with an icy layer at the base of each snow storm and more powdery snow above each basal ice layer.

There was a further report of twenty five cases of agricultural buildings which collapsed when the depth of snow was 1,200

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
- Health & Safety Executive
- Highways Agency
- Institution of Civil Engineers
- Institution of Structural Engineers
- Local Authority Building Control
- Scottish Building Standards Agency
- UK Bridges Board



Typical purlin failures

What is not known is how the return period of the recent snow event relates to the assumption in Codes of Practice. What is apparent, says another reporter, is that farmers want their buildings designed for real loads.

CROSS comments: *The fact that there are so many records of increased snow loading is a reminder that all loadings are statistical projections and there is always a chance that they will be exceeded. Designers should be generally alert that safety is not prejudiced by any single assumption (in strength or loading). They should avoid situations where, should the assumption be in error, the result will be a significant safety hazard. This might be the case if structures are very light weight and the only dominant loading is snow. Where there are significant amounts of dead and live loading, it is unlikely that both will be in error at the same time. 'Safety' should not be 'sensitive' to any one assumption. The example of the farmer burning straw to melt snow reflects the practice at some sporting events where there are marquees of having space heaters available to prevent snow from lying on the roofs.*

Agricultural type buildings may be designed with lower safety levels for economy and because safety to humans is not likely to be prejudiced. But designers (and their clients) should also consider carefully the commercial consequences of failure. It might be worth accepting a higher risk of failure if the structure is just protecting stored fodder, but if the protected contents are valuable livestock, it might be thought prudent to look for a more robust structure. The marginal cost increase of a safer more robust design may well be a sensible investment. It is not known however what design loads were used in any of the reported cases.

The industry should also beware of changing practice and inadvertently rendering inherent assumptions invalid. Thus the demand in many structures for increased roof insulation renders it less likely that snow will quickly melt or slide. A number of portal frames in these reports failed under direct overload which might be tolerable in terms of safety if the form of failure were a standard plastic collapse mechanism (i.e. excessive displacement short of unstable failure), but from the pictures this appears not to be so. An investigation of forms of failure might show less risk of catastrophic damage simply by boosting connection capacity or paying greater attention to avoiding failure by instability: benefits that might be achieved at minimum cost. These examples and other evidence has been collated by the Scottish Government and used to issue guidance to the agricultural community and designers, and a report has been sent to BSI so that the data, along with other information, can be considered with reference to Eurocodes and their UK National Annexes. Alerts were also issued by SCOSS in 2010 and 2011. The situation emphasises that design is a risk management process; it needs thought, and some argument perhaps, to decide if the relaxations currently permitted for agricultural buildings are as acceptable as once thought, when weighed against the cost of failure – albeit mostly economic in these cases.

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FEEDBACK

With the 'Feedback' facility you can send comments on any aspect of CROSS or of the site or on anything to do with structural safety, and also read the input from others. More feedback is wanted.

REPORTING

Use either the 'How to report' button on the top of the website www.cross-structural-safety.org or the similarly labelled button on the right hand side to send on-line or off-line reports. It is simple, confidential, and could be important. [Click here](#) to go directly to the reporting page

HOW TO REPORT

Please visit the web site www.cross-structural-safety.org for more information, or email Alastair Soane, CROSS Director, at dir.cross@btinternet.com

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

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For other buildings, it may also be that designing for increased snow loads, and making additional effort to avoid build-up/drifted opportunity may be a worthwhile investment when set against business disruption should they present a high risk of failure. However many of the collapses were probably of buildings which were designed to superceded Codes and it is possible that some buildings may not have been built as designed and that there were cases of construction defects and of maintenance issues. Designers and constructors of new buildings, particularly agricultural buildings, in areas potentially subject to heavy snow falls, should refer to the SCOSS Alert [Snow loads on agricultural and other building structures](#), the Scottish government publication [Effect of severe weather on farming community](#) and the publication by Structural Engineers Registration [Guidance Note 9](#).

The winters of 2009/2010 and 2010/2011 were very severe in other countries and in the USA, for example, there were numerous reports of failure due to snow loads and it will be interesting to find out whether these are being regarded as abnormal. Of course snow falls may be related to climate change, but the science, and work to support it, is not sufficiently advanced to provide an answer.

DANGEROUS SNOW SLIDES FROM 100 HOUSES (Report 246)

A reporter is a structural engineer and has been involved in the investigation of gutters collapsing under snow load in the winter of 2011. A noticeable feature was the influence of the roof construction on snow build up. All the houses that were investigated had cold roofs i.e. the insulation at ceiling level prevented any heat reaching the roof surface. The effect of this, says the reporter, was that the snow built up rapidly on the roofs (35 degree slope) and stuck to the roof tiles. The build up continued until the weight of the snow caused a shear plane failure within the snow mass with all the snow, estimated between 2 and 4 tonnes, falling from the roof. This happened on over 100 houses at around the same time. There was clearly a significant danger of loss of life – fortunately in these cases the falls took place in the early morning. If however the falls had taken place during the day, there could have been severe consequences with injuries or deaths as many children played adjacent to the houses. Such falls could be mitigated by the use of snow guards or trace heating in the roof. The number of cold roofs is increasing rapidly – action, says the reporter, needs to be taken.

CROSS comments: *Snow can be deadly as demonstrated by the number of fatalities from avalanches in mountainous areas. In countries with severe winters the risks from sudden roof snow slides are well known but it is not a frequent occurrence in the UK. If a roof is steep enough then high build up of snow is unlikely and UK practice has been to assume that above 60° pitch snow does not lie. The practice of installing snow guards might be thought a prudent precaution if the falling snow presents a hazard, whereas in other cases it may be better to actively promote snow sliding off roofs. The reporter is concerned that the level of thermal insulation could have been a contributory factor in preventing roof temperatures from being affected by rising warmth from within the houses. Within the UK this may be an aspect that needs further review as it could be an unintended consequence of the practice of enhancing the levels of domestic thermal insulation.*

DATES FOR THE PUBLICATION OF CROSS NEWSLETTERS

Issue No 24	October 2011
Issue No 25	January 2012

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