

# CROSS

## Confidential Reporting on Structural Safety

For an introduction to CROSS see [www.structural-safety.org](http://www.structural-safety.org). Email: [structures@structural-safety.org](mailto:structures@structural-safety.org)

### NEWSLETTER No 28, OCTOBER 2012

### INTRODUCTION

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Half of the reports to CROSS are about problems during construction and in this Newsletter are examples of issues where temporary works have been involved. The common thread in these reports is that something goes wrong on site; due to communication issues, or quality assurance in the supply of components, or simply a lack of appreciation of the importance of stability. The importance of the subject has gained increasing recognition as demonstrated by the formation of UK Temporary Works Forum. The TWf aims to encourage discussion of matters related to Temporary Works and the group is open to anyone, individual or corporate, working within the industry and sharing this intent.

There is always a need for more reports and if you see value or gain anything by reading these Newsletters then please reciprocate by sending in your own experiences. The objective is to identify the precursors of failure and learn from them.

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

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](http://data.base).

### 332 STUD FAILURE

This concerns the failure of a stud during construction works on a new bridge associated with major road improvements. The reporter says the form of the bridge is of steel girders with a reinforced concrete deck and parapets. In order to pour the deck and parapets, cantilevered formwork



Failed weld

was installed. As one of the support rods was being tightened to take the load of a table unit, a stud which attached the forged beam bracket to the steel girder failed. The table unit was still supported by the crane and no one was injured as a result of the failure.

The stud was sent for independent investigation and it was found to be made from Gr.8.8 instead of Gr.4.8 steel and that different welding procedures would have been needed to achieve a sound connection. It was also noted that the shank on the stud was 19mm and not 22mm diameter as detailed on the manufacturer's data sheet. It was recommended that on-site hardness testing should be done to confirm the steel grade of the remaining

studs. A visual survey was carried out to identify the presence of 19mm shanks on studs at other sites with similar beams and a number were found.



19mm shank stud

The studs can be distinguished not only by the shank size and length of thread but also by the beveled edge at the top of the 22mm diameter stud. The faulty 19mm stud had a



22mm shank stud

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### 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

thread which goes all the way to the top and has no chamfer. The stud failed because it was of incorrect steel grade and as it looked the same as the rest of the studs, the installer had no way of knowing this was the case. The origin of the 19mm shank studs has not been proven and as a consequence the reporter's firm has made improvements to the supply chain, installation and testing procedures as well as the communication of material parameters by including them on the design drawings, then checking again on site.

The reporter concludes:

- Don't assume what you have been sent is the correct product – always measure/check against specification.
- Ensure safety critical elements supplied by third parties on temporary works drawings are fully specified on the drawings so that there is no need to cross reference to data sheets and can be easily checked.
- Ensure test certificates are explicit to the item being tested and not one certificate for a batch of items.
- Ensure specific weld procedures are in place for third party supplied items.
- Shear studs have a manufacturer's stamp on top of the head. It may be possible for threaded stud manufacturers to do the same. Consignment notes and conformity certificates could then be easily checked against the installed product.
- Always check the installed stud against the specified stud as part of the Temporary Works inspection.

### Comments

*There have been many failures, some with fatal consequences, due to the wrong grade of bolt being inadvertently adopted and this is a similar situation. It is important that any safety-critical item is subjected to adequate checks. Design can help to prevent the chance of using the wrong component – such as using one size/grade only (all 22mm grade 8.8 studs for example). The stud diameter can be checked by attempting to fit the correct nut but checking of steel grade of every one is not practicable. The issue of marking is important as there is no way of telling one grade of steel from another just by looking at it. Stamping every stud might be possible and colour coding could work. In design and build where the contractor does not want to pay for the designer to be on site in the Engineer role, the rigour of self-certification is often an issue. There is always the need for vigilance, especially when details are small. All contracts need a proper QM procedure to assure what has been designed is what gets built.*

## 333 FALSEWORK SUPPORT TO A BRIDGE - A NEAR MISS

This report follows the near collapse of a birdcage scaffold falsework structure during an 800 cubic metre concrete pour on a motorway bridge. Site based temporary works coordinators were appointed by the contractor's joint venture to oversee specified portions of the project and there was a design JV for temporary works. A site based temporary works manager allocated both design and design checking resources. Temporary works drawings were prepared showing a birdcage scaffold structure with proprietary connectors. Adjustable diagonal braces were used throughout and in the transverse direction there was a diagonal brace shown at each lift of each birdcage. In the longitudinal direction diagonal braces were shown at each lift. The Structural Concrete Checklist was signed off by members of the Construction JV and the Design JV. A Temporary Works Permit to Load was issued, noting the specialist's drawings and referring to e-mail correspondence which included a marked up copy of one of the specialist's drawings. Shortly after the pour there was evidence of buckled standards in the falsework.

An inspection revealed numerous deviations from the scaffold arrangement shown on the certified design drawings, primarily that transverse diagonal

## NEWS

### SEVEN SURVIVE CONCRETE COLLAPSE

The construction site for a new university building following a scaffolding collapse. Two companies have been fined a total of £100,000 over the incident which occurred when concrete was being pumped onto the third floor of the building and the supporting scaffolding holding shuttering collapsed. The workers' injuries included cement burns to their skin and eyes, and bone fractures. The Health and Safety Executive (HSE) investigation found both the principal contractor for the project and the concrete subcontractor allowed the supporting scaffolding to be erected from a preliminary design, clearly marked 'for pricing purposes only'. The drawing did not include all the information needed to erect the scaffolding correctly or safely. The companies also failed to ensure the scaffolding was checked before allowing the concrete to be poured.

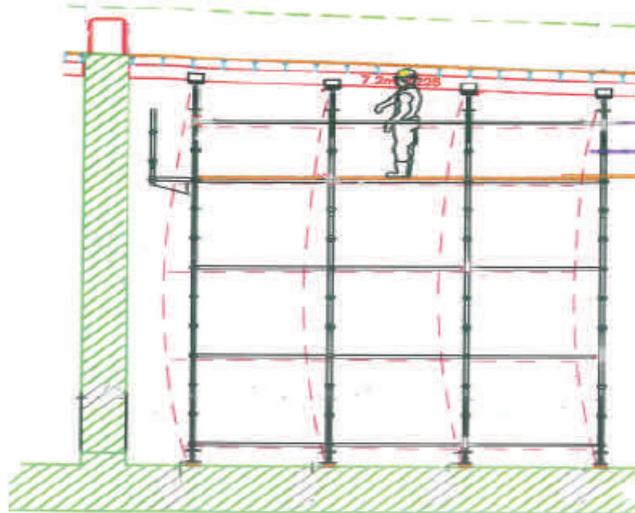


#### Comments

*The use on site of drawings stamped preliminary is wrong. The designer may not be aware that the design has progressed all the way to final construction so the act of insisting on 'For construction' drawings will focus the mind further. There are similarities to report 333 'Falsework support to a bridge – a near miss' when the shuttering did not collapse during a pour but could have done so.*

bracing was fitted to every 4th bay and not to every bay. Collapse was prevented by bowing distortion of the standards caused the proprietary ledgers to become wedged and thus provided some moment capacity at each joint between the standards and the ledgers. Furthermore the decking was locked between RC walls, thus preventing sway at the top of the falsework. It is likely that further distortion would have resulted in local collapse, as the diaphragm effect of the decking would be unlikely to extend to seven bays. Local collapse of the structure could have precipitated a more comprehensive progressive collapse.

This near miss, continues the reporter, exposed several lessons to be learnt



by those involved and by the construction industry as a whole. He says that the industry relies on competent people to undertake operations where safety is a consideration. A hazard occurs in situations where individuals or groups either consider themselves, or are considered by

others, as competent in specific areas of knowledge but are actually unaware of their lack of competence. In this case a copy of the specialist's drawing, marked up by site in an uncontrolled manner and apparently showing bracing every fourth bay rather than on every bay, was not distributed to all relevant parties. Good practice, says the reporter, would be to arrange an inspection of any falsework of significance by the designer, to confirm that it is in accordance with the design. It is noteworthy that the specialist supplier was not invited by site to inspect the structure pre-pour. The incident could, continues the reporter, have resulted in fatalities, extremely high costs and damage to the reputation of all companies of the JV. The following recommendations are made by the reporter to minimizing the risk of recurrence.

- Vetting of sub-contractors
- Adequacy of Management Procedures
- Training on Management Procedures
- Training and recognition of Temporary Works Co-ordinator role

#### Comments

*Lack of appreciation of basic stability is a vital issue and the competency of the individuals making the decisions on site is part of the problem. It can and does lead to fatalities. Routing the inspection back to the designer of the temporary works is important as it emphasises that these are designed systems; the cost of an inspection is trivial. The general management issues recommended above could be extended to training of the people installing the equipment – tool box talks on the consequences of omitting parts of the design. The person signing the installation checks should be carrying out regular checks whilst an important structure like this is installed. It is very difficult to check on completion and much more time consuming and expensive to correct. A 'scaff tag' type system should be used to ensure the installer is certifying their work for use. Record photos and even video clips can be used to help check the installation against the drawings. Whilst experienced old hands on site may know as much or more than the designer this cannot be relied upon. In all circumstances BS5975 should be*

## NEWS

## CONTRACTOR JAILED AFTER WALL COLLAPSE

The director of a building firm has been jailed for two years after a substandard wall collapsed killing a three-year-old girl. He was found guilty of gross negligence manslaughter. An investigation by police and the Health and Safety Executive found that the wall had been acting as a retaining wall but had not been



*Aerial view of the scene of the wall collapse*

designed or constructed for this purpose and fell under the weight of the earth stacked up against it as the child walked past.

An HSE Inspector said: "On the day of the incident the director (and the firm) backfilled the wall despite knowing that retaining walls should be designed by a specialist structural engineer. This case is an important reminder to those working in construction to make sure that design work is done by competent people and building is done to the appropriate standard."

**Comments**

*Wall collapses are too common as is one of the main reasons for them; inadequate appreciation of the forces involved particularly when there is back filling.*

*followed. (BS 5975:2008+A1:2011 Code of practice for temporary works procedures and the permissible stress design of falsework)*

**342 GRP PANELS AS PERMANENT SHUTTERING**

Glassfibre Reinforced Plastic (GRP) panels were used, on a highway construction project, for the permanent formwork during the construction of numerous bridge decks. A reporter says that problems were found which included:

- a) The panels were porous. This led to the leaking of fines during a concrete pour and potentially spillage onto the live traffic beneath.
- b) The geometry and makeup of the panels was inconsistent.
- c) The assumptions used in the calculations for structural strength did not match the product that was supplied.
- d) The panels contained metal sections which had not adhered to the GRP material although this was a requirement of the design.

It was found that the supplier used secondary suppliers over which there was poor quality control. The manufacturing process needed to be challenged by the contractor and client on numerous occasions, and as a consequence the production method was radically altered until the final result was of sufficient quality. GRP panels are widely used to support bridge decks during concrete pours and remain in place thereafter. The performance of the panels must correspond with the design assumptions and quality control in the delivery yard and constant vigilance on site during pours is required.

**Comments**

*Permanent shutters are important structural elements particularly when a slab is cast over an inaccessible area and the consequences of failure would be severe. Shutters should certainly not be porous and tolerance can be an issue. When panels have a small bearing area a shorter panel may dislodge and fall out during reinforcement fixing and concrete placing. Risk might be reduced by fixing the panels to the supporting beams. The design of the beams as well as the panels themselves needs to include adequate allowance for the variation in fabrication of panels. GRP panels (and panels made from other materials) can deflect during a pour leading to increased concrete depths and loads resulting in larger than anticipated permanent deflections. There are generic issues here about ensuring adequate control of the requirements for procurement, approvals and inspection.*

**258 COLLAPSE OF A HOLLOW CORE UNIT**

This refers to the collapse of one modest span PC hollow core concrete unit and the excessive deflection of others on a building which was under construction. The collapse occurred when the only load was self-weight and fortunately the falling debris missed workers below and there were no injuries. The units, which contained embedded polystyrene, were composed of bottom pre-stressed panels with a top layer of concrete placed in the works a few hours later. The usual method of manufacture, says the reporter, would be to use normal concrete, with the two pours being separated by a suitable interval and vibrated with a poker to give interlock between the bottom slab and the connecting ribs from the top sections. In this case self-compacting concrete was used with no vibration between the bottom and top pours. The result was an almost smooth surface at the horizontal joints and it was here that delamination occurred on site as a 50mm thick pre-stressed slab tried to support over 200mm of dead weight from the top part of the sandwich. Other panels were removed from site because of defects unrelated to the delamination such as cracking and excessive camber or no camber. Some were removed which showed signs of shear failure cracking.

### Comments

*This is similar to report 342 'GRP panels as permanent shuttering' in that supplied components did not meet expectations. Proper quality control is vital at all stages and here there seems to have been a lack of appreciation of the need to provide a shear key between the two concrete elements. QA is not just a form-filling exercise and to be successful depends upon having adequately trained and vigilant supervisors throughout the process. HSE files contain many cases where collapses of shuttering under load have led to deaths and serious injuries.*

## 277 EFFECT OF STAFF CHANGE ON A DESIGN

This report is from a reporter in Australasia who said that the ground floor of a warehouse was supported on concrete beams and columns. The perimeter beams also supported large site-cast two storey concrete panels. The panels, in turn, supported a concrete 1st floor and roof steelwork. The panels' widths were the same as the column centres below. The reporter goes on to say that a contractor was awarded the contract 6 to 9 months after design was completed. It became apparent to the contractor that it was not practical to cast such large panels. He rang the consulting engineers and asked if he could split the panels in two with a vertical joint at the beam mid-span. The engineer who received the query was not the original designer (who had left the firm). Apparently the engineer confirmed that the panels could be split but when they were erected large cracks appeared in the beams. Investigation revealed that the original designer had envisaged the full span panels would act as a deep beam and hence only load the beams near the columns. The beams had therefore been designed for a low bending moment at mid span. When answering the contractor's question the second engineer had assumed the beams to have been designed for a uniformly distributed load from the panels so did not realise the inclusion of the mid span joint between panels would have this effect. Clearly, says the reporter, the second engineer should have checked the design before answering the query. However, it was an easy mistake to make and illustrates how risk is generated from staff turnover. Perhaps the initial mistake was that the original designer did not investigate 'buildability.'

### Comments

*It is good practice for designers to start their calculations with a written statement of the principles that have been adopted and the assumptions that have been made. UK practice is to use an 'Approval in Principle' to describe how the structure is to be designed and it must include statements on key assumptions e.g. deep beam action, and this information needs to be passed to the contractor on construction drawings. The example here illustrates two basic issues: firstly the need for buildable designs and commensurate review procedures, and secondly the need for a formal change control procedure and record keeping. Staff turnover must not prejudice safety. More generally this is also a classic case of interaction between final design and construction methodology. It also belongs to the generic group of failures whereby a practical problem had to be overcome leading to consequences not foreseen. A tragic example was the collapse the Hyatt Regency walkway in Kansas in 1981. The fabricator changed the hanger design from a one-rod to a two-rod system to simplify the assembly task, doubling the load on the connector, which ultimately resulted in the walkway's collapse. One hundred and fourteen people were killed.*

## 286 NEAR COLLAPSE OF MASONRY HIGHWAY BRIDGE

A contractor working for a water utility company when laying a water-main along an unclassified road, had installed a new 315mm diameter water main across a masonry arch bridge without prior consent from the local road



authority. The new pipe sat directly on the barrel due to the lack of sufficient cover to the road surface. About 15 months later a second contractor, again working for the water utility company, laid a 750mm large diameter water main approximately 6m from the bridge structure in land adjacent to the bridge structure. This required the ground to be de-watered and it is believed that the process caused the foundations of the bridge to subside which resulted in large cracks appearing in the arch barrel, right through to the road surface following the line of the first water main. The bridge was damaged beyond repair. It is clear that the water utility company should have contacted the local roads authority prior to installing both the first and the second water mains, and most likely approval would have been refused due to lack of cover to the arch barrel. The water utility contractor/s had wrongly assumed that placing their work on an electronic notification system was sufficient warning.

### Comments

*Before starting any process in the ground; excavation, underpinning, trench digging, piling or as in this case de-watering, consideration must be given to the stability of adjoining structures. There have been numerous cases where excavation has led to the collapse of adjacent structure. Arch bridges rely on thrust support from the abutments to keep the arch in place and the barrel in compression. De-watering will cause significant ground movement and consequent abutment movement. It is surprising that a public utility did not recognise the consequences of such actions or the need to contact the owners of the bridge. As with other reports in this Newsletter there has been, at some stage in the process, a lack of basic engineering input.*

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### HOW TO REPORT

Please visit the web site  
[www.structural-safety.org](http://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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### DATES FOR PUBLICATION OF CROSS NEWSLETTERS

Issue No 29	January 2013
Issue No 30	April 2013
Issue No 31	July 2013
Issue No 32	October 2013