

CROSS-AUS

Confidential Reporting on Structural Safety - Australasia

Newsletter 4 | August 2020

Editorial

In this issue we present seven new reports and panel commentary specific to Australia and New Zealand practices. It is very heartening to see the increasing engagement of the profession. Clearly there is a strong appetite to learn from each other so that together we can enhance both public safety and the safety of those involved in construction and maintenance work. The CROSS-AUS team continues to promote and share our mission with an expanding pool of stakeholders, and we are grateful to many of you for helping us to share this message.

This issue's reports cover construction, design, and inspections. In construction, AUS-14, AUS-15, and AUS-20 highlight that temporary structures such as metal decking, crane bases and reinforcing cages are safety-critical and require proper attention to quality control design checks. AUS-18, AUS-19, and AUS-22 identify potential safety issues with designs for glass balustrades, light gauge steel ductility, and GFRP reinforcement. Finally, AUS-21 raises an intriguing question about the 'inspectability' of the voids incorporated into Super-T bridge construction.

Given that there are so many of these structural forms in the bridge network, it is an important question to pose to both designers and owners.

One of our main goals of CROSS-AUS is to stimulate conversations around structural safety. For this reason, Report AUS-22 which is in response to AUS-4 is particularly encouraging to the team. However, the challenges that we are all facing at present, as COVID-19 changes how we work, pose deep questions about the potential structural safety impacts: are the new forms of working leading to equivalently robust



A/Prof Colin Caprani
CROSS-AUS

design office checks? Quality control checks? Site inspections? In this time of rapid change, we must take a moment to step back and double-check that our safety assurance processes are being maintained and even made more resilient where possible.

On a different note, readers may be interested to read the paper **Once Upon a Time in Italy: The Tale of the Morandi Bridge** which has recently won the 2020 Outstanding Paper Award in the journal Structural Engineering International, published by the International Association for Bridge and Structural Engineering (IABSE). The paper reviews the design and construction of the bridge, culminating in a remarkable use of the Applied Element Method to match the actual debris patterns with those from hypothesized causes of failure. A fascinating read.

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HOW TO REPORT

For more information, please visit the [How to Report](#) page. 

If you have experienced a safety issue that you can share with CROSS-AUS, please [Submit a CROSS-AUS Report](#).

If you want to submit a report by post, please send an email to administrator@cross-aus.org.au asking for instructions.

KEY

-  CROSS-AUS Report
-  CROSS-AUS Panel Comments
-  News
-  Information
- › Denotes a hyperlink

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AUS-21: Inspection and maintenance of Super-T bridge girders

REPORT

Precast Super-T girders have been used in bridge construction in Australia for around 20 years and the reporter has some concern about their long-term durability and maintenance due to lack of access to inspect the sealed internal cavities. This type of girder incorporates large internal cavities, typically 5m long x about 800mm wide and up to 1.4m deep. The external webs of the girder are 100mm to 120mm thick reinforced with one central layer of reinforcement.

With the open flange Super-T that is most commonly used, sacrificial formwork is used to bridge the open box section and about 200mm reinforced concrete is placed over the girders to form the deck slab. On completion there is no access available to the internal cavities to inspect the internal surfaces of the girders.

Precast Super-T girders have been used in bridge construction in Australia for around 20 years and the reporter has some concern about their long-term durability and maintenance due to lack of access to inspect the sealed internal cavities.

The reporter's concern is that to their knowledge, none of these girders has been inspected internally since their introduction some 20 years ago to check for any possible spalling, cracks, or other defects on the internal surfaces of the girders due to the effect of fatigue, freeze-thaw, or other factors. It appears to be accepted that moisture can be trapped within the cavities as drainage holes are required at the bottom of each void in the girders to discharge the water. Thus, the possibility of the creation of ice on the internal surfaces of the girders is a real possibility in subzero temperature conditions.

There have been several bridge failures reported around the world, some with deadly consequences, with poor maintenance often being cited as the reason. Accordingly, the reporter is proposing that at least one of these bridges using Super-T girders, 20 years or older, should be inspected to see the condition of the internal cavities and to check whether the anticipated 100 years life duration can be relied upon.

COMMENTS

There have been many failures of bridges and other structures because of challenges associated with inspecting and problems with access to hidden regions. CROSS has recommended for years that all safety critical structures must be capable of being examined both during construction and during their operational life. Designers should take this into account whatever type of structure is under consideration and make appropriate provision for access to hidden voids.

As bridges are generally designed for a nominal design life of 100 years, durability is a primary concern and regular inspections are carried out to check their condition and to identify any maintenance requirements. However, the reporter has raised concerns about Super-T bridge girders that have large internal cavities with no access and whether these cavities should be inspected.

CROSS has recommended for years that all safety critical structures must be capable of being examined both during construction and during their operational life.

When Super-T beams were introduced around 20 years ago, there were two types, closed-flange and open-flange, both used in conjunction with an in-situ concrete deck slab - for typical details refer to **National Precast Concrete Association Australia (NPCCA)**>. To form the void in the closed-flange type, sacrificial formwork (typically

INFORMATION

What should be reported to CROSS-AUS?

Structural failures and collapses, or safety concerns about the design, construction or use of structures.

Near misses, or observations relating to failures or collapses (which have not been uncovered through formal investigation) are also welcomed.

Reports do not have to be about current activities so long as they are relevant.

Small scale events are important - they can be the precursors to more major failures.

No concern is too small to be reported and conversely nothing is too large.

Your report might relate to a specific experience or it could be based on a series of experiences indicating a trend which may require industry or regulatory action.

Benefits of CROSS-AUS

- Share lessons learned to prevent future failures
- Spurs the development of safety improvements
- Unique source of information
- Improved quality of design and construction
- Possible reduction in injuries and fatalities
- Lower costs to the industry

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polystyrene) was used that was difficult to hold in place during pre-casting, resulting in poor control over member dimensions and cover to reinforcement; and this type is no longer allowed by bridge authorities.

The open-flange type can be cast with reusable rigid (usually steel) internal forms fixed securely in place and there is much better control over member dimensions and cover to reinforcement. The **NSW Department of Transport standard drawings for Super-Ts**> specifies web dimensions, reinforcement arrangement, concrete grade, cover, and the provision of drainage holes. The QLD Department of Transport **Drafting and Design Presentation Standards Manual (DDPSM)**> Chapter 14 has similar requirements. The current version of AS5100 Bridge Design also give guidance including recommendations for different climatic zones.

The question posed by the reporter is whether the anticipated 100-year design life for these Super-T girders can be relied upon without inspection of the internal cavities and an assessment of their condition?

For bridges in a non-coastal environment (exposure class B1), that have used the open-flange type of Super-T, cast in rigid steel moulds, the risk would appear to be very small. Where bridges are in a coastal environment (exposure class B2), the risk is likely to be greater. Also, if there are bridges in use that have used the earlier closed-flange type of Super-T these are potentially a greater risk due to the casting problems identified earlier.

Therefore, if not already being done by the relevant bridge authorities, the following would appear to be reasonable precautionary steps:

- Categorize the risk of bridges using Super-Ts; e.g. those that have used closed-flange type; bridges in a coastal environment; bridges subject to freeze-thaw environment especially where de-icing salts are used;
- Instigate an inspection plan of the cavities of any in the higher risk category that are 20 years old or more. This could be carried out using a cavity inspection camera or similar probe although if the voids are filled with foam this could be difficult.



SUBMIT REPORT>

SUBMIT FEEDBACK>

I INFORMATION

The **Warren Centre** has recently issued the following reports in its series on **Fire Safety Engineering**>:

- **The Roles Report** explores the future role, competencies, education, accreditation, audit and enforcement and regulatory controls for fire safety engineering in Australia.
- **The Competencies Report** summarises the education and on-the-job experience required for Fire Safety Engineers to fulfil their role on modern engineering projects in Australia.
- **The Comparison of FSE Guidance Documents and Assessment Criteria Report** provides a review of four international guidance documents for fire safety engineering to determine their suitability for use in Australia.

Engineers Australia (EA) has published a report, **Building Confidence: How to use engineers to improve building and construction**>, in response to the Shergold & Weir **Building Confidence Report**> that introduces two key professional engineering roles into the delivery and approval of a building project, viz. design and construction sign off by an Engineer of Record and verification of the design and building approval process by a Proof Engineer. Related to this is an EA webinar on **“Building Defects and Potential Solution”**> on 20 August – speakers are Bronwyn Weir (co-author of Building Confidence report) and Mal Wilson (a CROSS-AUS Panel member).

AUS-19: GFRP reinforcement in concrete structures

REPORT

A correspondent, who is a Chartered Structural Engineer with many years' experience in the civil / structural industry, has become aware of work being undertaken in the field of glass fibre reinforced polymer (GFRP) reinforcement as a substitute for steel rebar in concrete structures and is concerned by what they have observed. The correspondent raises the following issues of concern:

- There is a lack of recognition that GFRP bars are anisotropic with very low strength and stiffness in the radial direction. This is due to the glass fibres being aligned with the longitudinal direction only and material properties are consistently quoted for the fibre direction alone.
- When used in columns, the GFRP spirals are being compressed in their radial direction and the stiffness is, at best, the stiffness of the epoxy matrix around the glass fibres (e.g. around 3GPa versus 30GPa for concrete say). This may be considered as being analogous to wrapping rope around the main longitudinal bars.
- Thus, the GFRP spirals may create an annulus of weakness in the axial direction of the column because of the low radial stiffness. This appears to manifest as complete blow out and loss of the concrete cover zone through concrete buckling.
- Minimum and maximum longitudinal reinforcement ratios for columns appear to be taken directly from AS 3600 for steel reinforcement (1 and 4 % respectively), with no evidence as to the applicability of these design requirements. It is noted that the tensile capacity of GFRP bars is reported to be around 1200 to 1300 MPa and is more than double that of conventional steel rebar, hence these steel reinforcement ratios are not applicable for GFRP bars.
- There will be similar effects when GFRP reinforcement is used in beams. If AS3600 reinforcement ratios are adopted, this could lead to non-ductile failure of the compression zone; and the low radial stiffness of GFRP ligatures may create a weakening effect along the length of the member in the compression zone.

It is the correspondent's view that caution needs to be exercised when GFRP for steel reinforcement substitution is being considered. In particular, the effects of anisotropy and the crucial differences between the materials must be taken into account. In the opinion of the correspondent new combinations of materials must always be critically reviewed to ensure that design rules and test methods remain applicable.

COMMENTS

There is limited published information on the use of GFRP reinforcement bars in Australia and the reporter correctly notes that caution must be exercised when using any new material. The properties of the material must be understood and considered in the design and certainly one cannot treat the design as a straight substitution of GFRP bars for steel.

There has been considerable experience in the use of GFRP reinforcement in Canada, Europe, Japan and the USA and to quote from a paper by **Feeser and Brown: Guide Examples for Design of Concrete Reinforced with FRP Bars**>:

"A direct substitution between FRP and steel reinforcement is not possible due to differences in the mechanical properties of the two materials. The modulus of elasticity of FRP is much lower than that of steel; thus, larger strains are needed to develop comparable tensile stresses in the reinforcement. If a direct substitution of FRP for steel reinforcement was used, FRP reinforced sections would have larger deflections and crack widths than comparable steel reinforced sections."

For use in building structures, reference can be made to American Concrete Institute (ACI) publication **440.1R-15 "Guide for the Design and Construction of Structural Concrete Reinforced with Fiber-Reinforced Polymer Bars"**>. From this guide the following should be noted:
"The mechanical behaviour of FRP reinforcement differs from the behaviour of conventional steel reinforcement. Accordingly, a change in the traditional design philosophy of concrete structures is needed for FRP reinforcement. FRP materials are anisotropic and are characterized by

INFORMATION

The Steel Reinforcement Institute of Australia (SRIA) has published **The Guide to Historical Steel Reinforcement in Australia**> that includes the properties of steel reinforcement, concrete materials, and construction practices from 1895 to present in Australia. This will be a useful resource for engineers involved in the assessment of existing reinforced concrete structures.

The National Precast Concrete Association of Australia (NPPCA) has published **"Understanding Grouted Precast Joints - A guide for engineers and building contractors"**>. There have been several failures of grouted joints in recent years and this publication should be a must read for anyone involved in the design and erection of precast concrete.

The report **Severe Weather in a Changing Climate**> by the Insurance Australia Group (IAG) and the National Center for Atmospheric Research, USA (NCAR) reviews the latest climate science to understand how climate change is impacting the severity and frequency of weather events including tropical cyclones, bushfires, hailstorms and rainfall in Australia. The report should be read by all engineers who are concerned about the potential increased risks from extreme weather events.

high tensile strength only in the direction of the reinforcing fibres. This anisotropic behaviour affects the shear strength and dowel action of FRP bars as well as the bond performance. Furthermore, FRP materials do not yield; rather, they are elastic until failure. Design procedures must account for a lack of ductility in structural concrete members reinforced with FRP bars."

A direct substitution between FRP and steel reinforcement is not possible due to differences in the mechanical properties of the two materials.

Thus, as pointed out by the reporter, there are significant differences in behaviour when GFRP bars are used in reinforced concrete when compared with steel reinforcement as a result of their anisotropic behaviour, low modulus of elasticity and lack of ductility that results in brittle failure of members in bending and in most cases deflection will control the design. It is also noted from the ACI Guide that FRP reinforcement has significantly lower compressive strength than tensile strength and it recommends that the strength of FRP bars in compression should be ignored in design. Caution is therefore required by designers who may not be familiar with the performance of GFRP bars.

Although not raised by the reporter, the behaviour in fire of GFRP reinforced concrete must also be considered. The ACI Guide referenced above contains a section on the effects of high temperature and fire and notes that the type of FRP reinforcement, the aggregate type and concrete cover will all influence the behaviour in fire and the loss of bond due to the softening of the resin is critical. For further work in this area reference can be made to a recent ASCE Technical Paper, **GFRP-Reinforced Concrete Slabs: Fire Resistance and Design Efficiency**>. At present in Australia it is unlikely that the material would achieve an acceptable fire rating for use in building structures, without demonstrating its acceptance in accordance the **ABCB Performance Solutions for Structural Safety**>.



SUBMIT REPORT>



SUBMIT FEEDBACK>

N NEWS

The Australian Building Codes Board (ABCB) has issued the following consultation papers:

- **Definition for building complexity**> that has been developed in response to the **Building Ministers' Forum (BMF)**> decision regarding the design, construction and certification of complex buildings. The **Exposure Draft**> is open for comment until **Sunday 1 November 2020**.
- **National Registration Framework (NRF) for Building Practitioners**> that has been developed in response to the Shergold & Weir **Building Confidence Report**> recommendations 1 and 2. Responses to the discussion paper are invited until **Sunday 23 August 2020**.

AUS-18: High rise balustrade design

REPORT

It has come to this reporter's attention, over a number of recent cases, that designers of balustrades on high rise buildings (i.e. not Class 1 or 10 buildings under the NCC) may not be considering the more onerous case of wind load on the balustrade, particularly when the balustrade infill panels are solid (such as glass panels).

The reporter notes that the Live Load requirement for balustrades can be easily obtained from the relevant standard (i.e. AS1170.1) but for taller buildings the designer must also calculate the appropriate wind load and apply the appropriate net pressure coefficients (as can be found in the **AWES Wind loading handbook (AWES-HB-001-2012)**> to the balustrade elements. In the reporter's experience, wind loads of 4 to 5 kPa (or more) on balustrades can easily be achieved on high rise buildings, particularly where balconies are placed at the edges of towers.

This is relevant to both new buildings and refurbished buildings where grill type balustrades are being replaced with glass infill balustrades. In addition, the reporter would caution designers of balustrades that are to be placed at the edges of balconies, to not use monolithic toughened glass in these locations. This is due to the well-recognized risk of spontaneous failure of toughened glass due to nickel sulphide inclusions and the likelihood that the failed glass will vacate the balustrade and fall to levels below. The reporter also notes that this was the topic of a recent SCOSS Alert on Structural Safety of Glass in Balustrades (December 2019) but which had a UK focus.

COMMENTS

This is certainly a matter of serious concern and we note that the **Queensland Building and Construction Commission (QBCC)**> conducted an investigation in 2018 of glass-balustraded balconies at 18 multi-storey residential buildings in southeast Queensland. It was discovered that the glass used on many was not properly certified; and that certification paperwork was signed off by people with the wrong qualifications. The design of all such balustrades should be carried out by a qualified structural engineer.

As the reporter highlights the very high local wind forces that can occur around the exterior of high-rise buildings may be the more onerous design case. Additionally, the dynamic effects from fluctuating forces around the corners of buildings must be considered.

The design and installation of glass balustrades must consider the total assembly, including glass type, method of supporting the glass and the fixing of supports into the base structure. Each of these areas must be addressed and the SCOSS Alert of December 2019, **Structural Safety of Glass in Balustrades**>, noted by the reporter contains much useful guidance. The fasteners into the base structure should comply with **AS5216:2018** - Design of post-installed and cast-in fastenings in concrete.

Failures arising from nickel sulphide inclusions in toughened glass have been well documented, e.g. **Managing Health & Safety Risks (No. 53): Nickel sulphide failure in toughened glass**>, published in The Structural Engineer, August 2016; and, there has been a requirement in the Building Code of Australia (BCA) since 2011 for balustrade glass more than 5m above the ground to be heat soaked in accordance with AS1288 Amendment 2.

It is often the case that responsibility for the safety of balustrades is split between designers, suppliers, and contractors so there should be single party responsible for co-ordinating the structural aspects and all of those parties should share information, co-operate and co-ordinate activities to ensure the safety of those balustrades.

NEWS

Standards Australia has published the revised ceiling standard **AS/NZS 2785:2020**> *Suspended ceilings - Design and installation* that replaces the 20 year old standard and has been significantly upgraded particularly in designing for seismic loads and fasteners.

The design and installation of glass balustrades must consider the total assembly, including glass type, method of supporting the glass and the fixing of supports into the base structure.



SUBMIT REPORT >

SUBMIT FEEDBACK >

AUS-22: Light gauge steel fabrication

REPORT

A reporter refers to Report AUS-4 published in CROSS-AUS Newsletter 3 of Feb 2020 entitled **Light steel truss issues**>. The reporter, who has many years' experience working with light gauge steel as a designer, has been looking into thin gauge high tensile steel, as used in the prefabrication industry to manufacture trusses. In addition to the points raised in the article, the reporter also has concern about the low ductility of the high tensile steel, with respect to connection design and capacity.

The reporter's experience is that it is not uncommon for these steels to have an elongation less than 2%, and for certain gauges AS1397 does not specify a minimum elongation. Thus, fracture of the joints is a serious concern, particularly as most testing would only consider short term loading scenarios. The reporter agrees with the concerns around the points raised in Report AUS-4, and that these members are likely to fail at a very localised area around the heel if not designed accordingly.

COMMENTS

This report is a good example of the need for designers to understand the properties of the materials they are dealing with and the environment in which they will be used. When materials with low ductility, such as thin gauge high tensile steel, are being used there will be less warning of failure as the ultimate load is approached and with cyclic or fluctuating loads such as wind loading, fatigue failure becomes a critical issue especially at connections.

When materials with low ductility, such as thin gauge high tensile steel, are being used there will be less warning of failure as the ultimate load is approached and with cyclic or fluctuating loads such as wind loading, fatigue failure becomes a critical issue especially at connections.

Thus it is important that industry guidelines and standards that have been verified by testing are closely adhered to and any departure from these either in the material being used or the loading being applied should be verified by further testing that replicates the actual situation. It is our understanding that some high strength light gauge steel truss systems have been tested under cyclic loading representative of wind loading from tropical cyclones and reference should be made to the specialist suppliers of these systems or to the **Cyclone Testing Station**> for further advice in this area.

Behaviour in fire is also an important consideration as thin gauge high tensile steel exhibits very different behaviour than mild steel sections and if it is to be used in a fire rated assembly, there should be test evidence available to allow the engineer, and the regulatory authorities, to assess its suitability.

NEWS

The Board of Professional Engineers Queensland (BPEQ) May E-news> includes an item on the relevance of **Queensland Non-Conforming Building Product Laws for Engineers** where it notes: "As an engineer the heart of your responsibility is to design to ensure safety of consumers and the public generally. Likewise, the heart of the Non-Conforming Building Products laws introduced in Queensland in November 2017 is to ensure the safety of consumers and the public generally in relation to building products; therefore, making our buildings safer."



SUBMIT REPORT>

SUBMIT FEEDBACK>

AUS-14: Overloading metal decking in temporary state

R REPORT

During construction of steel structures with composite concrete and metal decking floor slabs, a reporter has observed numerous occasions when the metal decking was close to being overloaded. The reporter has highlighted three examples from the same construction site at different times.

In the first example, the concrete floor slab had been partially constructed leaving an area of exposed metal decking with reinforcement in place but not yet concreted. The propping for a concrete beam at the level above was placed partly on the concrete slab and partly on the reinforcing bars bearing directly on to the metal deck. It is the reporter's opinion that the subcontractor did not understand that without the hardened and cured concrete the metal decking would not have been able to transfer the propping loads back to the main steel structure.

In the second example formwork had been temporarily stacked on the partially completed slab and was again partly supported on the concrete slab and partly supported on the reinforcement over the metal decking. The reporter notes that in addition to possible damage to the metal decking, these types of stacking loads can cause overloading of the structure resulting in cracking of the concrete structure or excessive deflection of the floor system.

During construction of steel structures with composite concrete and metal decking floor slabs, a reporter has observed numerous occasions when the metal decking was close to being overloaded.

In the third example an area of metal decking and reinforcement were being prepared for concreting and a concrete skip had been placed directly on the reinforcing bars over the metal deck. The reporter is concerned that when the skip is placed and lifted off, there is a brief moment when the majority of the load will be concentrated at the edge of the skip and this could cause overloading on the metal decking or worse, punch through it. It is the reporter's view that these examples highlight the lack of understanding of how composite floor systems work and there needs to be better management of construction material and stacking loads on site. Issues such as these can lead to incidents on site if not understood and managed correctly.

C COMMENTS

It is common practice with composite floor systems for the profiled metal decking to be used to carry temporary construction loads but this must be done in accordance with the manufacturers' recommendations for allowable loads and arrangement of temporary propping; and the parties involved in the construction should be familiar with these.

For example, although **AS3610 Formwork for concrete** > specifies a design load of 4.0 kPa for stacked materials prior to concreting, the allowable load for stacked material in the manufacturers' published literature is generally much less – typically 1.0 or 1.5 kPa - and AS3610 further notes that any limitations on the magnitude and locations of stacked materials must be included in the project documentation.

Any departure from the manufacturer's recommendations should be referred to the manufacturer for advice or be checked by a qualified structural engineer with experience of the system being used. The examples reported of concentrated loads from props and stacked materials being partly on the exposed metal decking would certainly fall into this latter category.

It would appear that in the reported cases, no damage occurred and there was no failure, and it therefore raises the question should cases such as this be reported to CROSS-AUS? The answer is yes, as the reporting of any concern for structural safety is important, and we can learn as much from near-misses as we can from actual failures. When failures do occur in such cases, it is often due to a lack of understanding of the products being used and/or the construction techniques required by the builder to use them.

In the event that damage or a failure occurred, such an incident would likely be required to be reported to the relevant work health and safety regulator and an investigation would commence with enforcement action a probable consequence.



SUBMIT REPORT >



SUBMIT FEEDBACK >

AUS-15: Insufficient attention to the construction of tower crane bases

REPORT

While working on construction sites a reporter was involved with tower crane bases supported on piles with pile caps and pedestals with cast-in anchors for the tower crane. Unfortunately, several crane bases had significant construction defects and the reporter gives the following examples.

The first involves concrete workmanship where the concrete to a pedestal was found to have a large void after stripping the formwork and the subcontractor wanted to move right ahead with erection of the crane due to tight deadlines for crane erection. The reporter notes that in such cases tight deadlines are usually agreed, with road closures and traffic control in place for agreed dates and periods of time. This places pressure on construction personnel and in this example on the engineer to allow crane erection to proceed prior to completion of the rectification. However, in this case the erection of the tower crane had to be called off until the base was rectified.

Unfortunately, several crane bases had significant construction defects.

The second example involved problems with the piles and reinforcement to another crane base. The reporter notes that although the piles had a 75mm positional tolerance, 3 out of the 4 piles were at least 100mm out of position; and the projecting starter bars from 2 piles into the pile cap were too short and had to be extended with couplers. Furthermore, there were errors with the reinforcement scheduling such that the diameter of the reinforcement cage was 100mm smaller than that specified. This meant that the fabricated steel tower crane anchor assembly that required 600mm square clearance could not be placed in the reinforcement cage of the pedestal. The anchor manufacturer and the temporary works designer were able to find a way to modify the anchor so the crane base could be constructed; however, the crane erection was delayed on this occasion as well.

The reporter's third example involved piles that were installed so far out of tolerance that the whole pile cap had to be completely re-designed once this was discovered. And again, the crane erection was delayed. In the reporter's opinion these examples demonstrate that there was a lack of supervision knowledge combined with bad workmanship and poor-quality control in place in these instances. Furthermore, the reporter observes that the importance of temporary works is often overlooked because it contains the word temporary and there have been many failures of tower cranes due to various reasons. Although there were no failures on this occasion, the reporter is concerned that construction personnel are often under pressure to meet programme deadlines resulting in poor execution of construction works.

COMMENTS

While we acknowledge that construction is never perfect and groundworks can present particular difficulties, it is regrettable that the examples reported appear to be all too common in the construction industry. However, in this case, it is encouraging that the defects were identified and corrected before significant loading was applied or further damage occurred. While this is not ideal, it demonstrates what should happen in such cases, viz. that there was a competent person on site with the integrity and standing to resist the commercial pressure and to ensure that rectification was carried out before further works proceeded. The question arises what would have happened if the temporary works engineer had not been on site? Would the time and cost pressure on the builder to minimise any delay to the project, mean that the defects would have been covered up? It is not uncommon for investigations undertaken in the aftermath of incidents at construction sites to reveal construction programme scheduling and pressure as a causal factor.

CROSS-UK has examples of crane failures (which can be found by entering "crane" into the Quick search box at the top of any page on the website <https://www.cross-aus.org.au/>)> and an extreme example is given in report **316 Tower crane collapse through foundation failure**>.

The CIRIA report **Tower crane stability (C654)**> gives recommendations on the design of foundations.



SUBMIT REPORT >

SUBMIT FEEDBACK >

AUS-20: Collapse of a large reinforcing cage

REPORT

A blade pier for an overpass bridge was under construction. The reinforcing cage for the pier was nearly complete when it collapsed without warning. Fortunately, no one was working on the site at the time and there were no injuries. The reporter's opinion is that the stability of large reinforcing assemblies such as this should not be the responsibility of the steel fixers. Large reinforcing assemblies should be treated as temporary works and should have a designed system of stability certified by a practising structural engineer. Subsequently, the reporter came across this issue in CROSS Newsletter No 30, April 2013 where it is well dealt with in reports 327 and 357. However, the reporter believes that drawing attention to this again would be a timely reminder for Australian engineers.

COMMENTS

As the reporter has noted this is not a new problem, but it is one that needs a regular reminder that when large reinforcement cages are to be assembled on site they should be treated as temporary works and subject to a stability design assessment prior to their assembly. The reporter also notes that **CROSS Newsletter No. 30 of April 2013** contained two reports (nos. 327 and 357) on this topic. These reports highlighted that although there had been several such cases, there was a lack of awareness of the temporary stability issues involved and raised questions about where responsibility should lie. It was also noted that there was limited advice generally available at the

time. However this was followed up by the Temporary Works forum (TWf) in the UK who subsequently published its **TWf Safety Bulletin - Stability of reinforcement prior to concreting (TW15.116, 16.10.15)**.

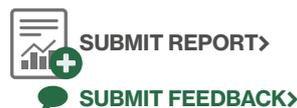
The commentary to Report 357 also noted similar concerns in the USA, leading to a Caltrans research project **Stability of Bridge Rebar Column Cages during Construction** that contains several examples with recommendations.

In 2013 the American Society of Civil Engineers (ASCE) published the book **Rebar Cage Construction and Safety: Best Practices** that presents guidelines for the safe handling of steel reinforcing-bar (rebar) cages throughout the design, fabrication, and erection process. The focus is on rebar cages used for large, cast-in-place concrete columns in a variety of settings, including bridge piers, elevated highway sections, and high-rise buildings. These cages are inherently unstable, usually held together by tie-wire alone. They are challenging to fabricate, to lift from the horizontal to the vertical position, and to support in the temporary condition until concrete is cast.

Engineered temporary support systems, such as bracing or cable-guy systems, can mitigate the instability of standing rebar cages and resist lateral loads, ensuring better safety for construction workers.

When large reinforcement cages are to be assembled on site they should be treated as temporary works and subject to a stability design assessment prior to their assembly.

The Steel Reinforcement Institute of Australia (SRIA) recommends the use of welded joints to **AS/NZS 1554.3, Welding of Reinforcing Steel**, rather than wire tying in large prefabricated cages wherever possible, in accordance with its Technical Note 4, **Fabrication and Site Handling of Reinforcing Bars**. However, it is recognised that is not always possible with large cages such as bridge piers that are assembled on site. In which case there are specific types of wire tie arrangements that must be employed depending on the bar arrangement and bar size, and they must be treated as temporary structures and their stability should be properly designed to prevent collapse during site lifting, erection and concreting.



PARTICIPATION

The success of the CROSS-AUS scheme depends on receiving reports, and individuals and firms are encouraged to participate by sending reports on safety issues in confidence to **CROSS-AUS**.

FEEDBACK

If you have any comments or questions regarding this CROSS-AUS Newsletter, please **Submit Feedback**.

CPD PRESENTATIONS

CROSS-AUS is giving online presentations to organisations who are interested in learning more about the work that CROSS-AUS does, including our relationship with CROSS International, and sharing examples of safety issues to learn from.

For more information contact **administrator@cross-aus.org.au**.

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