CROSS AUS
COLLABORATIVE REPORTING FOR SAFER STRUCTURES

The Institution of Structural Engineers

CROSS Newsletter

CROSS-AUS Newsletter 10 | **November 2023**

Incorrect use of software for wind loads on solar panels

Risk of failure of untested vibration isolators with seismic restraint

Underpinning using screw piles

Installation of epoxy resin adhesive for reinforcing bar anchors

Share knowledge to help create a safer built environment

Editorial

This is the 10th CROSS-AUS Newsletter since our inaugural edition in December 2018.

We have now published 47 reports, covering a wide range of subjects in design and construction, primarily aiming to draw attention to safety issues in structural, civil and geotechnical engineering, and to alert our reader to lessons that can be learned.

We welcome once again all our regular subscribers, readers and reporters, and we trust you will find the materials of interest and enriching to your general knowledge. We encourage you to help us by passing this Newsletter on to all your contacts and to ask them to register on the CROSS-AUS website. These reports are a readily available source of free information and may assist you in your future projects.

When you come across a similar situation to one described in a CROSS report, it may remind you to avoid repeating the same mistakes. This will benefit the community at large - a community that all professional engineers serve.

For those accessing the Newsletter for the first time, please note the search function on the front page of our website, **www.cross-aus.org.au>**. This search function allows you to access a common database with over a thousand reports from CROSS-UK and CROSS-US, as well as CROSS-AUS.

For example, on 10th October 2023, an extensive fire in the UK's **Luton Airport's terminal car park>** destroyed over 1,400 cars and resulted in structural collapse. A search using the keywords "car park fire" in our website will come up with several reports on multi-storey car parks that are worth reading. In particular, attention is drawn to the **CROSS Safety Alert, Fire in multi-storey car parks>** published in 2018.

Another recent example is the failure of reinforced autoclaved aerated concrete (RAAC) planks that is causing concern in the UK. Several CROSS reports relate to this product. This has resulted in the creation of a **CROSS Theme Page>** to provide a knowledge hub for safety related information on RAAC planks.

Structure and fire are inseparable engineering topics in the building design and construction industry. With the expansion of CROSS's remit in the UK to cover fire safety following the Grenfell Tower tragedy in 2017, CROSS-AUS is considering whether a parallel system for fire should be established here to promote understanding and provide a platform to interact with likeminded professionals.

Anyone with an interest in this area who would like to be involved, please send your contact details to **team.aus@cross-safety.org>**.

In September, we called for expressions of interest for individuals to join a working group to assist with increasing awareness and use of CROSS-AUS. We received an excellent response, and we are arranging an initial online meeting to establish this working group.

The four reports in this Newsletter cover different areas of practice but they share common themes: lack of understanding of structural behaviour, misinformation, and misuse of materials and software that could lead to unsafe outcomes.

The wider our reports are spread to all concerned with the aim to produce safer structures, the better our professions can serve our clients and the wider community.

We rely on your continuing support and promotion within your circles of influence.

Dr Peter Ho AM

Secretary & Director, CROSS-AUS LTD

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Incorrect use of software for wind loads on solar panels

CROSS Safety Report   Report ID: 1212

The adoption of software for structural analysis is not a substitute for the designer having an understanding of structural behaviour.

Key Learning Outcomes

For civil and structural engineers:

- Always check the limitations of any software used for analysis and/or design, and that any assumptions in the software and/or input data are appropriate for its intended use
- Do not use software where there is any doubt about its limitations/assumptions or whether it is fit for purpose for the intended analysis/design task

R Full Report

The reporter's concern is the tendency for designers to rely completely on the output of software for structural analysis when they do not fully understand the requirements for data input.

The reporter is aware of a commercially available item of software, for the determination of wind actions on buildings, which is used by structural engineers and non-structural engineers working in the design and installation of solar panels at roof top level.

The software is relatively straightforward to use. The user enters the building parameters, orientation, and location which the software uses to determine the terrain category, shielding and topography. It then determines the site wind speeds for the eight compass points. The software calculates the design wind actions on the walls and roof for each face of the building in accordance with AS1170.2, as well as quantifying the wind actions on the RC1, RA1, and RA2 local roof zones.

The reporter is concerned that default values within the software for wind direction factor Md in Regions B2, C, and D (0.9), and values for the action combination factors Kc,e and Kc,i (0.9) assume the software is being used for overall building design and not for cladding, its immediate supports, or roof top solar panels. Thus, there is a risk that fixings for mounting solar panels may be overloaded and, in such a case, the solar panels may become detached from the roof.

In the reporter's opinion it is assumed, even amongst engineers, that software in general is set up to provide 'the answer' automatically. Significant trust is placed in the software output. However, it is incumbent upon the user to have sufficient knowledge to understand the input values appropriate for each relevant variable. The use of software is not a suitable substitute for an understanding of structural behaviour.

Fire Safety and CROSS-AUS

With the successful expansion of CROSS's remit in the UK to cover fire safety, CROSS-AUS is considering whether a parallel system for fire should also be established in Australasia to promote understanding and provide a platform to interact with likeminded professionals.

Anyone with an interest in this area who would like to be involved, please send your contact details to **team.aus@cross-safety.org>**.

Feedback on CROSS-AUS reports

If you have had similar experience to any of our reports, we encourage you to share your experience by simply completing the form at the end of each report or by email to **team.aus@cross-safety.org>**.

Some recent examples of feedback include:

- **Report 956 - Inspection and maintenance of Super-T bridge girders>**
- **Report 1056 - Production of as-constructed drawings>**

C Expert Panel Comments

The use of computer software for the analysis of structures and assessment of structural design loads has been commonplace for decades. As with the use of all tools, appropriate levels of supervision and checking, including self-checking, are essential. In the case of engineering analysis, it is good practice to validate design software independently before it is adopted for wholesale use.

In this particular case, the reporter has raised a situation where the software has been adopted for the assessment of loads for which it was not meant to evaluate. This demonstrates a significant, and worrying, lack of understanding by the designers of the overall requirements of the design codes, and the software inputs and/or limitations. It is an example of the uninformed use of software, undertaken without checks to ensure the software is fit for purpose for its intended use.

With respect to the assessment of design wind loads on solar panels, it is noted that the latest version of AS1170.2 (2021) includes the latest research with respect to wind effects on solar panel arrays. This has effectively been introduced into Australian law since the introduction of the National Construction Code (NCC) 2022 in September 2022.

Circumstances in which the misuse of engineering software could lead to unsafe structures have been noted in several previous CROSS reports. Typing "software" in the search function on the **Safety Information>** page on the CROSS-AUS website produces 44 such reports, with similar comments, such as:

- Users without adequate structural engineering knowledge or training may carry out structural analysis
- There may be communication gaps between the design initiator, the computer program developer, and the user
- A program may be used out of context
- The checking process may not be sufficiently rigorous
- The limitations of the program may not be sufficiently apparent to the user
- For unusual structures, even experienced engineers may not have the ability to spot weaknesses in programs for analysis and detailing

This report highlights the need for designers to have an appropriate understanding of structural behaviour and requirements, of the applicability and limitations of software packages used in design, and the need for them to check software is appropriate for its intended use.

In one sense, computer software can be compared with a modern motor car. Both can be complex but require a good understanding of principles and rules before being used safely. No sensible person would try to drive a car without knowing what the pedals and switches do, how fast it might travel, how quickly it might stop, or what the flashing lights mean, especially the blue ones on top of the car behind!

In short, if there is doubt about any aspect of using software where structural safety is involved then another engineer or specialist should be consulted.

Submit Report

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News & Information

RAAC - Reinforced Autoclaved Aerated Concrete planks

Widespread concerns over the safety of RAAC roof planks in buildings in the UK have required safety measures to be put in place, including closures to over 200 schools, and inspections of schools, hospitals, and other buildings are continuing in the UK.

Following reports of failures of structures in the UK employing such planks, CROSS published a **Safety Alert>** in 2019. This was followed in 2022 by the publication of the Institution of Structural Engineers (IStructE) **Guidance on the investigation and assessment of RAAC planks>** and the creation of a **CROSS Theme Page>** to provide a knowledge hub for safety-related information on RAAC planks.

We are not aware of problems with RAAC in Australasia, but we wish to raise awareness of the possibility of such issues. If you have any experience or knowledge of the use of RAAC planks in Australia and/or New Zealand, we ask you to send brief details to **team.aus@cross-safety.org>**. Alternatively, if you have any safety issues or concerns, you can submit a confidential report.

Structural robustness and disproportionate collapse in buildings (2nd Edition) – new from IStructE

The first edition of this guidance provided a background to the fundamental attributes of robustness and an interpretation of, and practical guidance to, the regulations being followed in the UK at the time, with more detailed guidance on each of the main materials (in situ concrete, precast concrete, steel, timber, and masonry).

This **second edition builds on the first>**, with new chapters about risk, alterations to existing buildings, classification of existing buildings, and considers 'lightweight steel frame' as a

Risk of failure of untested vibration isolators with seismic restraint

CROSS Safety Report   Report ID: 1230

A reporter found apparently counterfeit copies of devices used to protect and isolate mechanical equipment from seismic vibration. These copies are being marketed as original equipment and appear identical to the original brand. They are being supplied with test data for seismic restraint from the manufacturer of the genuine product.

The reporter notes that, if the performance of a vibration isolator has not been tested under appropriate conditions, there is a significant risk the equipment will fail when it is most needed. This could result in catastrophic failure of a critical life-safety system.

Key Learning Outcomes

For all design engineers:

- Ensure that, if specifying a non-structural product where an equivalent is permitted, the specification should state the 'product or an independently certified approved equivalent'

For certifying engineers/building authorities:

- Conduct inspections on site to ensure the non-structural product, or an independently certified approved equivalent, has been installed and has authentic paperwork to support its installation

R Full Report

A reporter found apparently counterfeit copies of devices used to protect and isolate mechanical equipment from seismic vibration. The copies are being supplied with test data for seismic restraint from the manufacturer of the genuine product and look identical to the original brand except for some small differences between models which would only be identified by a specialist.

Vibration isolators are typically installed under chilling equipment, diesel generators, and other mechanical plant and equipment used for life-safety systems (e.g. in hospitals). The reporter is concerned purchasers may be unaware they are not receiving genuine products and may install those products to protect equipment in their projects.

There is a significant risk the equipment will fail when it is most needed if the performance of a vibration isolator from seismic restraint has not been tested under appropriate conditions. This could, depending on the importance level of the structure, result in catastrophic failure of a critical life-safety system.

In the reporter's opinion, independent third party testing must be undertaken to ensure the adequacy of systems for vibration control and isolation under seismic conditions.

material distinct from steel. There is an emphasis on modern methods of construction (MMC) and a selection of new worked examples within each of the material-specific chapters. There are many references to CROSS reports which are used as case studies throughout.

Australasian Certification Authority for Reinforcing and Structural Steels (ACRS)

Through its certification schemes, **ACRS>** provides traceability of product from manufacturer to end user. For example, refer to the recent ACRS news item: **Protecting against fraudulent certification claims>**

Registration of Engineers in South Australia

The Government of South Australia recently sought input into a mandatory Professional Engineers Registration Scheme before introducing a draft bill to parliament for the scheme's establishment.

For further details refer to the **Professional Engineers Registration Scheme>**.

Concrete Design Academy – a proposal by John Woodside

In a paper presented at Concrete 2023 in September, CROSS-AUS Expert Panel member John Woodside stressed that we need to significantly lift the quality of design and construction of concrete in Australia. To rectify this, John introduced the concept of a Concrete Design Academy that would be established and run by the concrete industry in Australia in conjunction with one of the universities. The curriculum and course work would set by the concrete industry to provide a high-quality and keenly sought-after post-graduate degree in concrete design. The paper will be published in the Concrete 2023 Proceedings.

C Expert Panel Comments

This report is of particular interest in that it deals with fixings to equipment considered to be in the category of non-structural building components.

In their keynote address, **Seismic Design of Nonstructural Building Components: The New Frontier of Earthquake Engineering>**, for the **2020 Australian Earthquake Engineering Society Virtual Conference>**, Prof. A. Filiatrault of the School for Advanced Studies IUSS Pavia, Italy, points out that in typical cases:

"the investment in non-structural components and building contents is far greater than that of structural components and framing". Moreover, since "damage to non-structural components occurs at seismic intensities much lower than those required to produce structural damage, … in many past earthquakes losses from damage to non-structural components have exceeded losses from structural damage".

Therefore, even if the structure survives a seismic event relatively intact, *"failure of architectural, mechanical or electrical components can lower the performance level of the entire building system"*. Furthermore, *'the failure of non-structural components can become a safety hazard or can hamper the safe movement of occupants evacuating buildings, or of rescue workers entering buildings"*.

It is noted that, while the Australian Standard relating to earthquake loading (AS1170.4) nominates requirements for design restraint of non-structural elements, structural design engineers generally exclude responsibility for such details on the basis that they are outside of scope. A contractual risk assessment identifying which party is ultimately responsible for such devices should be a consideration for the contract manager and client body. It also raises questions outside the contractual framework such as reliance, whether there was an objectively real risk of a foreseeable consequence and a risk assessment of the potential severity and magnitude of the consequence that might have to be taken into account. In the paper quoted above, the author proposes a separate appointment of a specialist *"non-structural coordinator"* to fulfil this role.

In the particular case raised by the reporter, it would appear seismic restraint details have been nominated by the services designer by virtue of the particular equipment specified – equipment that, if supplied as nominated, would be provided with the relevant test certificates. However, the reporter has suggested that counterfeit copies of the equipment may have been supplied, along with test certificates pertaining to the genuine equipment. This raises the issue of fraud, misrepresentation and non-compliance regarding the installation of potentially untested equipment, along with other risks.

In such a situation, the relevant parties to the contract should consider whether misleading or deceptive conduct, or even fraudulent activity, has occurred and whether they should report it to the relevant regulators, statutory authorities (e.g. SafeWork NSW, WorkSafe QLD/VIC, WorkSafe NZ, etc) and/or the manufacturer of the original equipment for further action.

Furthermore, the practice often adopted of specifying 'product xx or equivalent' could be better served by specifying instead 'product xx or **independently certified approved** equivalent' so that a measure of review is introduced.

Another important implication that comes from this report is the need for inspectors to know first hand what measures suppliers have taken to differentiate their products in the marketplace and action taken to verify compliance on site. This report demonstrates that simply viewing the relevant paperwork may not be a suitable substitute for hands on verification.

Unfortunately, this is not an isolated incident and an earlier CROSS Alert **Anomalous documentation for proprietary products>** published in February 2013 noted that there had been a number of instances reported to CROSS where certification accompanying proprietary products had stated compliance with standards or specified requirements, but the products were found not to be in

The importance of collaborative reporting to ensure structural and fire safety: NCE's *The Engineers Collective* podcast

In **this recent podcast>**, CROSS-UK scheme manager Paul Livesey talks about the establishment of CROSS, the sector's response and how it has developed over its nearly 50 years in existence, including its expansion into fire safety and how it has grown internationally in countries such as Australia and the USA.

Article: As structural engineers, safety must be our highest priority

An **interesting article>** by Arup's Andrew Lawrence, Ishan Abeysekera, and Andrew Smith

'During the 20th century, structural engineers practically eliminated building collapses in most developed countries, through the development of rigorous building codes. However, both confidential industry reporting and legal claims suggest that design errors are now increasing, and consequently that structural safety is deteriorating across the world. Why is this happening and how can the errors be reduced?'

Structural Safety – Theory & Practice by Allan Mann

Allan Mann's magnificent new book, *Structural Safety - Theory & Practice* is **now available to buy>** from Whittles Publishing. The book covers every aspect of the reasons why buildings and structures fail from basic misunderstandings of principles to the consequences of extreme events.

It encapsulates a lifetime of deep understanding of engineering with his experience of real-life collapses to enable others to learn. This work, which includes many references to CROSS and descriptions of many of the world's building disasters in recent years, will appeal to those who seek to know more about the theory and mechanics of structural safety.

accordance with those specifications. On several occasions, this has led to premature structural failure of the components at loads well below the intended design capacity.

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Newsletters from other CROSS regions

The UK published their latest Newsletter in September and will publish another in December. Make sure to **take a look**> for applicable lessons learned from these international safety reports.

Press Roundup

In every interval between CROSS Newsletters, failures of some kind or incidents related to structural and fire safety are reported in the press. Here are some accompanied by a brief comment:

1. New RAAC schools list of buildings with unsafe concrete>

The UK government has published an updated list of 214 schools and colleges in England it says have crumbling concrete.

It is a rise of 40 on a previous tally of buildings affected by reinforced autoclaved aerated concrete (RAAC). The government said 43 new schools had been added since the last update, while three others had been confirmed not to have RAAC after further testing.

2. Parking garage collapse >

A parking garage collapsed in lower Manhattan. This has been taken as indicative of a pattern of structural degradation over time. Dan Krauth, for ABC 7 New York, reported: *“Parking garages endure wear and tear that other buildings don’t. The concrete and steel is exposed to the elements, to salt, and to exhaust all year round.”*

Underpinning using screw piles

CROSS Safety Report   Report ID: 1175

A reporter is concerned that inclined screw piles used for underpinning may be subject to significant bending moments that compromise their capacity.

Key Learning Outcomes

For civil and structural engineers:

- Avoid, if possible, the use of inclined screw piles where loads are eccentric to the pile, and generate bending moments and shear forces within the pile
- Where inclined screw piles are considered, ensure there is a geotechnical report that covers this situation, and that the subsoil conditions and soil structure interaction are fully understood
- Ensure that the response of screw pile foundations to seasonal changes in water level is similar to that of other foundations in the same structure

For contractors:

- Review the stability provisions advised by the designer, and contact the designer as a matter of urgency if there are any concerns or ambiguities
- Adhere to all hold points for inspection, monitoring requirements, or limitations specified by the designer
- Keep meticulous records of the construction works and all communications
- Stop work immediately if untoward movement or new cracking is detected

R Full Report

The reporter was involved in a review of works involving the stabilisation of a brickwork wall forming the gable end of a terraced house. The wall had settled, rotated outwards and presented with several major cracks. The review revealed the wall had been underpinned using a combination of mass concrete and inclined screw piles.

The reporter's concern is that the use of inclined screw piles resulted in significant eccentricity of loading to the piles, requiring them to resist a combination of axial force and bending moment. The reporter notes the situation was further compounded by the geotechnical reports for the site, which identified the top 1400mm of soil as poor quality, low-strength fill which was highly vulnerable to further loss of strength once it became wet. There were no pile load test results confirming the screw piles would be capable of resisting the loads in these ground conditions and the reporter concludes the underpinning was unlikely to prevent further settlement, which could lead to possible collapse of the wall.

The reporter previously encountered similar uses of screw piles in underpinning works, which required the screw piles to resist substantial bending moments induced due to eccentricities between the screw pile and the centre line of the underpinned wall. While the reporter does not have an issue using screw piles in lightly loaded systems for resisting vertical tension and compression loads, they do have serious concerns with their effectiveness when required to resist substantial bending moments or lateral forces.

3. Motorway bridge demolished >

The German Lüdenscheid motorway bridge was demolished because its safety was prejudiced by degradation. The bridge was around 60 years old. This incident highlights the importance of detailing structures to assure durability and thereafter, through life maintenance.

4. Balcony collapse >

The failure of balconies is quite common and CROSS highlighted the risks in a **Safety Alert>**. Another sudden balcony collapse has been reported from apartments in Florida. Following inspections, the whole concrete building was then deemed unsafe.

5. Luton Airport Car Park Fire>

The ability of fires to initiate and then spread was further illustrated by a very significant fire at the multistorey car park at Luton Airport. Altogether it appears as if 1,400 vehicles were destroyed and the car park itself will have to be demolished. The fire's appearance shows similarities with the fire that devastated the Liverpool Echo Arena car park in 2018.

More from CROSS

Request a CPD talk from CROSS-AUS

The CROSS Team is available to give presentations to firms and organisations. These give insight into the work of CROSS and include examples of failures and the lessons that can be learned. To request a talk, please email us and we will be in touch to organise: **team.aus@cross-safety.org>**

It is the reporter's opinion that, although underpinning with inclined screw piles may appear to be an easier alternative to traditional underpinning with mass concrete and/or bored piers, it is not an appropriate design unless it can be shown (by suitable calculation and testing) that it will achieve the desired outcome.

C Expert Panel Comments

Once again, this report illustrates the importance of understanding what is being designed and the actions that must be resisted.

Screw piles are typically used for load transfer in their axial direction, not for transverse (shear) loading or for bending moment transfer. The arrangement usually considers screw pile heads to be nominally pinned with reinforced pile caps or crossheads. However, the application described by the reporter involves eccentrically loaded screw piles, requiring a transfer of bending moment between both foundation and screw pile elements. As noted by the reporter, the adoption of a screw pile solution in this type of situation therefore requires design of the screw pile and of its head connection to accommodate such bending moments, and the checking of the foundation for its capacity to accommodate a similar moment.

The tops of screw piles are normally fitted with large steel angle sections which are often bolted to the foundations. In situations where movement caused by the eccentricity of the pile can be rectified using cross beams (such as waffle slabs), the problem of bending of the pile may not be present. In many other situations, the eccentricity will be real and bending in the pile shaft will be resisted to some extent by the soil. This interaction is clearly complex, and made more so as the soil providing resistance is disturbed by the screw itself.

As a note of caution, while the practice of underpinning is generally appropriate where uncontrolled fill or other forms of inadequate bearing capacity are present, there have been cases of localised underpinning carried out on reactive clay sites where the underpinning process caused more cracking than that which it intended to address. If foundations are all moving with moisture variation, founding a portion of the building on rock is unlikely to provide a permanent solution to masonry cracking.

Further, attention should be given to the life cycle differential between steel screw piles and the underpinned masonry structure, with adequate provision of durability protection for the former in order to provide some level of compatibility between the elements. In earthquake environments, consideration should also be given to the possibility and potential consequences of decoupling of the piles from the main structure.

There has been some research into the use of inclined screw piles, such as the **Post-installation performance of eccentric screw pile underpinning systems for residential foundations>** by Konstantin G. Ashkinadze, Consulting Engineer, Edmonton, AB, Canada.

For further information on the use of screw piles in general, we suggest reviewing IPENZ's **Practice Note 28 - Screw Piles: Guidelines for Design, Construction & Installation>**.

If you have any experience on the use of, or know of any research into, inclined screw piles for underpinning, please get in touch via our **Contact CROSS-AUS>** form on our website or the Feedback Form below.

Our general recommendations below can serve as useful guidance of some of the potential risk areas associated with underpinning and combined foundation arrangements.

Designers should:

- Assess the stability at every stage of construction. For example, additional temporary shoring of the wall may be necessary
- Consider the recommendations in the geotechnical report or, if one is not available, undertake sufficient testing to ensure the soil conditions are well understood and the combined cast in situ reinforced concrete and screw pile combination will be effective. Often the use of shrinkage corrected grouts or expansive grouts, jacking, or other means of pre-load are required. Cracks in walls are usually repaired only after the foundations have stabilised
- Evaluate the settlement potential of the completed integrated solution
- Specify any additional controls that may be necessary to mitigate risk including, but not limited to, movement and monitoring settlement and cracks in walls. Note that this is often extended to two years after construction to account for seasonal fluctuation of groundwater levels

Contractors should:

- Review the stability provisions advised by the designer, and contact the designer as a matter of urgency if there are any concerns or ambiguities
- Adhere to all hold points for inspection, monitoring requirements, or limitations specified by the designer
- Keep meticulous records of the construction works and all communications
- Stop work immediately if untoward movement or new cracking is detected

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Installation of epoxy resin adhesive for reinforcing bar anchors

CROSS Safety Report Report ID: 1225

The reporter encountered an unsafe procedure for the installation of epoxy resin fixed reinforcement bars. The correct procedure involves the insertion of epoxy resin to a pre-determined depth within a pre-drilled hole followed by the insertion of the reinforcement bars to the correct depth.

In the case of the unsafe procedure, the bars were inserted first and then a small amount of epoxy resin had been placed around the top of the hole. This gave the appearance of a correctly installed connection. This is a serious concern as the connections would have almost no structural strength and could fail catastrophically.

Key Learning Outcomes

For civil and structural engineers:

- Encourage designers to carry out periodic inspections on-site to verify and validate the quality of site work, including use of simple pull-out tests
- Consider on-site checks for depths and diameters of holes, techniques for clean out, dryness of holes, techniques for inserting rebars, and types of adhesive
- Consider specifying installation of anchors by certified entities only, with specified hold points, recording measures and load testing of independently selected anchors

For building authorities:

- Consider the introduction of mandatory certification of installers

For contractors:

- Ensure installation is carried out by trained, experienced installers familiar with the product and method of installation
- Refer to the Australian Engineered Fasteners and Anchors Council (AEFAC) **program for certification of installers>**

R Full Report

The reporter, a structural engineer working in a design consultancy, encountered two situations on separate sites where reinforcement bars had been fixed by means of epoxy resin adhesive using a potentially unsafe procedure.

The correct procedure involves the insertion of epoxy resin to full depth within a pre-drilled hole (of specified depth), followed by the insertion of reinforcement bars to the correct depth as required in the specification. In the case of the unsafe procedure, the bars were inserted first (into an empty hole) and then a small amount of epoxy resin had been placed around the top of the hole which gave the appearance of a correctly installed connection.

Site engineers from the consulting firm had noticed the bars extended out from the concrete further than was expected. When pulled by hand the bars came loose. The joints were severely under capacity and would have the potential to fail in service if not rectified. This raised a serious concern as the connections would have almost no structural strength and could fail catastrophically if not identified and rectified before the casting of wet concrete.

In the reporter's opinion, these instances could have been deliberate attempts to save time and cost on site. They highlight that inspection after the fact is not possible as everything becomes buried in concrete and, if the bars had not been noticed and pulled out by the site engineers, the underlying defects would not have been detected.

The reporter notes that *AS5216:2021 - Design of post-installed and cast-in fastenings in concrete* has been recently introduced to include design of this type of connection. However, it does not specify any requirements for site inspection, testing, and quality control. The reporter believes this Australian Standard should be amended to include installation requirements similar to procedures for welding, such as supervision, inspection and testing.

Also, the reporter considers there should be an education program about the dangers of not installing these bars correctly, so that engineers and builders can put adequate inspection and testing regimes in place.

C Expert Panel Comments

Not only does this report illustrate, yet again, the deficiencies in quality control in parts of the building and construction industry, it also introduces the unfortunate issue of potentially reckless behaviour.

While the responsibility for construction compliance clearly lies with the contractor and the installer (and **not** the design consultant), it nevertheless highlights the need for quality assurance compliance such as the attendance by designers to carry out periodic inspections to provide an indication of the contractor's quality, where observed, and of the construction progress. It may also serve as an indicator of the need for increased independent verification and validation of the quality of site work.

With respect to the installation of post-fixed anchors and reinforcing bars, critical considerations include depth and diameter of holes, technique for clean out, dryness of holes, technique for inserting rebars, and type of adhesive. Installation should always be carried out by trained, experienced installers familiar with the product and method of installation. The Australian Engineered Fasteners and Anchors Council (AEFAC) conducts a **program for certification of installers>**, and it may be that building authorities should consider making this mandatory for installers in the industry.

In general, the designer should consider specifying installation of anchors by certified entities only; and should specify hold points, recording measures and load testing of independently selected samples for items when:

- there is a critical stage of load transfer that relies heavily on one or more key details
- integrity of an individual connection is critical – i.e. load redistribution and/or secondary pathways are not possible
- there may be deficiencies in procedures of quality control for highly critical elements of load transfer
- a risk of construction non-compliance is suspected

In addition, where reckless activity is suspected, the relevant parties to the Contract should consider whether they should report it to the relevant statutory authorities (e.g. SafeWork NSW, WorkSafe QLD/VIC, WorkSafe NZ etc) for further action, and also to Engineers Australia for consideration as a possible breach of professional ethics.

There have been several previous CROSS reports related to the incorrect installation of post-drilled resin fixings that have led to structural collapse. This led to the publication of CROSS Alert **Tension systems and post-drilled resin fixings>** in March 2014. Since that time searching the CROSS database for resin fixings produces several more reports. Clearly, this is a continuing problem.

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About CROSS-AUS

We help professionals to make structures safer. We do this by publishing safety information based on the reports we receive and information in the public domain.

We are a trusted provider of free safety information for the built environment.

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How we are structured

The Institution of Structural Engineers

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