

Management of safety critical structural fixings

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Bridge Owners Forum

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Management of safety critical fixings

- NCE survey of fixings
- CIRIA task – overlap/complementary work
- Proposed BOF task - update

NCE survey of fixings

Lack of confidence in concrete fixings revealed in NCE survey

An NCE survey has revealed alarmingly low levels of confidence that chemical and mechanical anchors are being installed properly on UK construction projects. Of the 1,309 engineers, contractors and sub-contractors who responded to the survey:

- 7% said they were not all confident that chemical fixings were being correctly installed on site
- 14% said they were 'slightly confident' that chemical fixings were being correctly installed on site
- 38% said they had not heard of BS8539:2012, the code of practice for the selection and installation of post-installed anchors in concrete and masonry

Correct anchor installation is particularly pertinent in light of recent failures which have resulted in fatalities, including lining failures in the Boston Big Dig Tunnel in 2006 and Japan's Sasago Tunnel in 2012.

"Installing fixings is a repetitive task and there is a risk that operatives will take short cuts to get the job done quicker," said one of the respondents to the survey.

To read the findings of the survey in full and read a selection of comments from engineers and contractors, [click here](#).

[Click here to read the findings in full](#)

FUTURE TECHNOLOGY: CONCRETE FIXINGS SURVEY

INDUSTRY FEARS OVER FIXINGS

A recent NCE survey revealed 21% of respondents have expressed doubts that chemical fixings are being properly installed on site. **Ben Cronin** reports.

An alarming number of engineers and contractors have a lack of confidence that chemical anchors are being properly installed on construction projects.

Over 7% of the 1,309 engineers, contractors and sub-contractors who completed a survey in NCE said they were 'not at all' confident while a further 14% said they were 'slightly confident' that chemical fixings are being correctly installed on site.

The purpose of the NCE survey, posted in June, was to establish the levels of knowledge about the selection and installation of fixings.

Correct chemical anchor installation is particularly pertinent in light of recent anchor failures which have resulted in fatalities, including lining failures in the Boston Big Dig Tunnel (2006) and Japan's Sasago Tunnel in 2012.

Eighty two per cent of those who responded to the survey described themselves as either a contractor, subcontractor, consultant or designer. In total, 86% described themselves as influencing the design and selection of fixings to varying degrees.

Alastair Soane, director of Structural Safety, an organisation which collects confidential data on the concerns of structural and civil engineers, welcomed the survey as an important step in recognising the safety critical aspects of chemical anchor systems. He said it gave the impression that fixture failures have been expe-

rienced by those who responded to the survey.

"Most respondents very often or often consider fixings to be safety critical [84%] but most are not confident that they are properly installed on site [55%]," he said.

Levels of awareness about BS 8539:2012, the code of practice for the selection and installation of post-installed anchors in concrete and masonry, were also surprisingly low. This seemed to be the case across the data set. 38% of those surveyed said they had not heard of the standard while 28% said they were "not sure" if they were aware of the standard.

Soane said that best practice is to work to BS 8539 and select fixings with a European Technical Approval (ETA).

"The British Standard is becoming increasingly well-known and its influence is valuable in helping to reduce failures," he said. He added that another vital aspect was to follow manufacturers' recommendations for installation.

There was more agreement

"We need new technology to address issues with cleaning holes. Hollow drill bits and tapered anchors help"

Robert Galliford-Tull, Laing O'Rourke



Fixings: Hole cleanliness is paramount for successful installation

when it came to a question about the most critical step in the installation of chemical fixings. 80% of those surveyed said that properly cleaning the hole before attaching the fixing was paramount.

This was corroborated by a selection of comments provided by those surveyed. Capita structural engineer Carl Bebbington said: "I think it would be a very good idea to educate engineers on how critical the installation is [by] showing the difference in capacity if say the hole was not adequately cleaned prior to chemical anchor installation."

"The biggest cause of failure I have experienced with chemical anchors has been due to insufficient depth of drilling and poor hole cleanliness," said Costain square works manager Andy Parkin.

Laing O'Rourke temporary works manager Robert

Garford-Tull suggested: "New technology to address issues with cleaning holes. Hollow drill bits and tapered anchors help".

Other engineers said there was a danger that main contractors were not taking chemical fixing installation seriously enough. "[It is] critical to ensure that 'as designed' fixings are installed, as often contractors will utilise cheaper alternatives without necessarily requesting designer approval," said Ramboll senior structural engineer James Drew.

Kier site manager Ed Dwight explained that anchor design, selection and installation "is often an interface item that becomes [the] subcontractor's designed portion."

He argued that principal contractors "have to ensure it is designed and managed correctly".

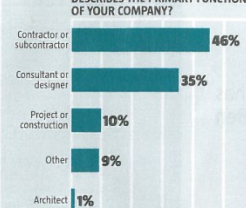
■ Download complete survey results at <http://bit.ly/1Uwqxj8>

In association with

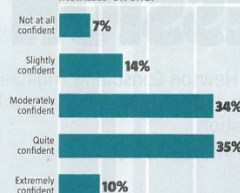


INDUSTRY REACTION

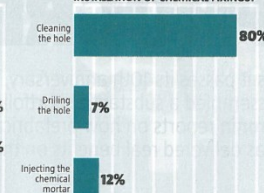
WHICH OF THE FOLLOWING BEST DESCRIBES THE PRIMARY FUNCTION OF YOUR COMPANY?



HOW CONFIDENT ARE YOU THAT CHEMICAL FIXINGS ARE PROPERLY INSTALLED ON SITE?



WHAT DO YOU CONSIDER TO BE THE MOST CRITICAL STEP IN THE INSTALLATION OF CHEMICAL FIXINGS?



THE INDUSTRY SPEAKS

"The confidence in the selection, design and installation as a designer is influenced by the confidence in the contractor to carry out the manufacturer's instructions correctly"

"When using subcontractors to perform the works it is essential that they are supervised correctly by a competent individual"

"It is critical to ensure that 'as designed' fixings are installed, as often contractors will utilise cheaper alternatives without necessarily requesting designer approval"

Paul Hutton section engineer, Costain

Rob Paul associate, WSP Parsons Brinckerhoff

James Drew senior structural engineer, Ramboll

"Contractors often wish to use other fixings than those specified which may be inferior for the planned use although they consider them 'similar'. Often without designer knowledge, installation quality is a concern"



Quality: Anchors installation is a work

Ross Hampton project engineer, Skanska

"Not all subcontractors have sufficient design experience capability in preparing calculations and preparing relevant shop drawings to consulting engineers or building control authorities for approval"

Paul Perry associate director, Sir William Halcrow and Partners

"Interim advice notes and specification appendices need to be written to better suit site construction"

"My general experience is that main contractors, subcontractors and their operatives do not fully appreciate the safety critical function of the fixings and the importance of strictly adhering to the manufacturer's instructions"

Gordon Wright senior principal engineer, Jacobs

Barry McCalliffe senior engineer, Consibee

"Most of my projects the contractors self-certify, so I have no control over site works. I know that if not applied correctly or if the design is changed onsite they are likely to fail and this has been a concern to me"

Neil Gwynne principal engineer, Jacobs

CIRIA task

- CIRIA for task on fixings very similar to the BOF task
- Has NR and Tubelines funding promised
- Duplication of effort, overlap
- Discussion with Kieran Tully from CIRIA, NR and Tubelines
- CIRIA agreed to modify proposal to focus on fixings in buildings and facilities such as stations
- Agreed to liaise to ensure work is complementary

Safety critical structural fixings

- Design issues – some guidance available
- Installation issues – some guidance available
- In-service issues – very little guidance available

Boston Tunnel - 2006

On 10 July 2006 precast concrete ceiling panels fixed with resin anchors collapsed, one person killed

Investigation by US National Transportation Safety Board concluded that the cause of the failure was excessive creep in the epoxy adhesive under sustained tensile loading

Boston Tunnel - 2006



Boston Tunnel - 2006

Prior to the Boston Tunnel collapse, epoxy resin anchors were permitted on HA structures as 'departures from standards' with requirements which included both short term and long term deformation limits and therefore mitigated the risk of creep related failure.

However, the tunnel collapse prompted the issue of an HA Interim Advice Note 104/07, which covered the previous requirements and called for a review of applications already in place on the HA network. The review is partially completed, but there is reasonable assurance that this type of resin has not been used. There is further work needed.

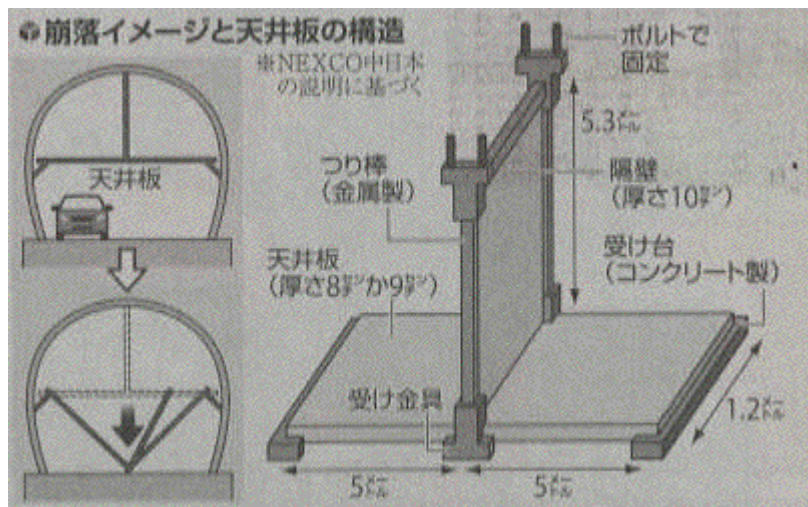
Safety critical structural fixings

- **SCOSS Headlines**
- 'Failure of epoxy fixings due to high temperature'
- 'Collapse of recently installed suspended ceiling'
- 'Glass panel fixings failure'
- 'Ceiling failure'
- Etc.

Safety critical structural fixings

Japanese tunnel collapse – 2nd December 2012

- At a press briefing on Monday, the Executive Officer of the Operator of Japan's Sasago Tunnel – which experienced a catastrophic collapse of its ventilation 'false' ceiling over a length of 110m on Sunday, killing nine motorists – said that it appeared some 'anchor bolts' used to secure the concrete slabs to the tunnel roof were missing.
- “There were parts of concrete where bolts had fallen off,” Ryoichi Yoshizawa confirmed, according to a spokesman for Central Japan Expressway Company or NEXCO-Central. Yoshizawa added, “The aging of the bolts or the concrete slabs could be a potential cause.”



Safety critical structural fixings

Parapet damage – Axx 16th December 2012

- A parapet impact on the Axx has resulted in anchorage failure at one post position rather than failure of the post itself.
- Although it would be premature to jump to conclusions, this tends to imply that the anchorage may have failed at a significantly lower load than anticipated.
- If this is the case then this raises questions regarding the capacity of other post anchorages on this (and perhaps other) structures.



Safety critical structural fixings

Issues

- Are our design rules robust?
- Compatibility with Europe?
- Do we know where we have used fixings?
- Do we have materials and test records?
- Extra functionality in asset information systems?
- Do we inspect or test safety critical fixings in-service?
- Particular problems – tunnel panels and equipment, cladding, signage?
- Do we need a National Structures Programme for safety critical fixings? Code of Practice and Standards

Safety critical structural fixings

Highways England IAN104/15 published (design of fixings)

- IAN 104 sets out requirements for post-installed anchors and reinforcing bars in concrete.
- Existing IAN published in 2007 heavily used. Prior to publication there were between 75 and 100 Departures per year for resin anchors and the like - resource intensive for HA/supply chain. Very few departures in the five years since publication of IAN 104/07.
- Since IAN 104/07 published - major developments in standards and guidance at a UK and European level. C
- Certain parts of IAN 104/07 are no longer compatible with the latest European design methods - likely that this will lead to a high volume of future Departures unless IAN updated.
- HA have been urged by key players in the industry to update IAN - it is cited as a requirement by various client organisations.
- There have been a number of high profile failures of anchors resulting in fatalities internationally. For example, the Boston Massachusetts Tunnel and very recently the tunnel in Japan, although the cause in the latter case has not been confirmed. SCOSS have also identified anchors as an area requiring particular attention. Against this background it is important that are requirements are based on current best practice.

Safety critical structural fixings

IAN10415 now published

- The updated IAN is more concise than IAN 104/07, taking advantage of the UK and European documentation that now exists rather than setting out detailed HA specific requirements.
- It is mandatory for anchors used on HE structures to have a European Technical Approval (ETA) - greater assurance regarding the products used.
- Avoid having to set out comprehensive testing and assessment criteria within the IAN as we can defer to the ETA, in relation to the Construction Products Regulations.
- (This is potentially a controversial move because some smaller suppliers have indicated that obtaining an ETA is prohibitively expensive).
- However, when IAN 104/07 was published 5 years ago we stated in the IAN that it was our intention to make ETA mandatory in the future, so the industry has had plenty of warning and most of the major players have already obtained ETA's.
- Existing IAN 104/07 does not consider resin and mechanical anchors on a level playing field. This was due to a number of historic concerns regarding mechanical anchors - fortunately never challenged.
- IAN 104/15 extended to include mechanical anchors in addition to resin anchors. Any anchor (resin or mechanical) will have to have an ETA in order to be used on HA's structures.
- European standards relating to anchors are still under development, and are expected to be incorporated into Eurocodes in the not too distant future - it would be premature to publish our requirements in DMRB/MCHW, so a revision to the IAN is considered to be appropriate at this stage.

Safety critical structural fixings

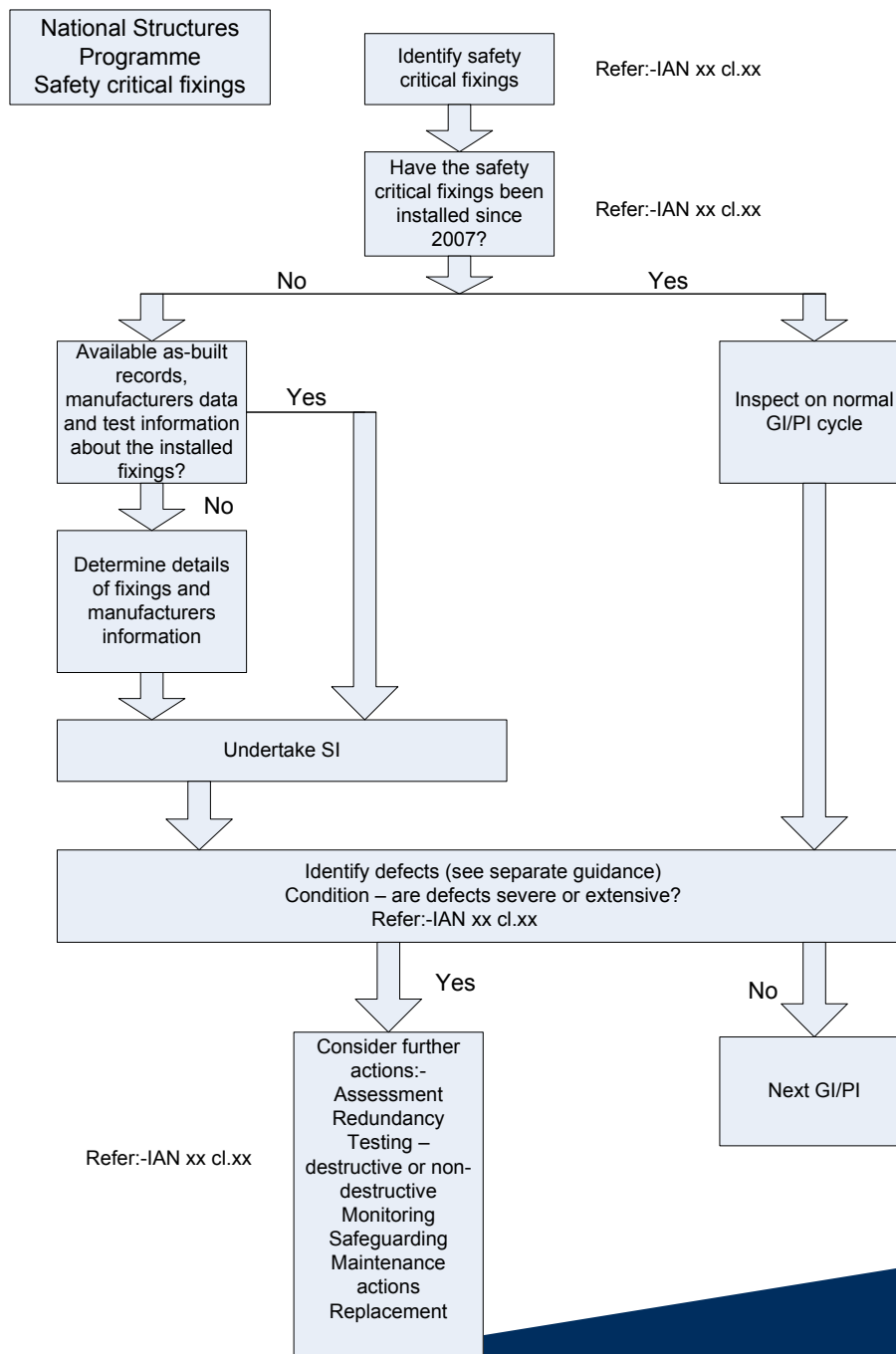
IAN104/15 Possible issues

- Where anchors are hidden from view (e.g. anchors above suspended precast panels in a tunnel), removable access panels should be provided to facilitate future inspection/testing.
- Records of proof load testing undertaken during installation should be included in the Maintenance Manual or Structure File.

Safety critical structural fixings

Management of in-service safety critical fixings

- Under development
- Further IAN? Yes
- Design, records, inspection, testing, maintenance, reuse, replacement
- Risk based procedure for managing
- Key defects identified
- National Structures Programme?



Safety critical structural fixings

Safety critical fixings – inspection guidance

- Defects to be identified during inspection
- a) Condition of fixing/anchorage
- Failure of fixings or anchorage – loose fixing in substrate, loose connection, movement detected
- Corrosion of fixing
- Degradation of resin – physical, water damage, loss of bond, chemical, degradation, UV
- b) Condition of connection
- Failure - bolts, nuts
- Loose nuts
- Corrosion of connection
- Degradation
- Physical damage
- Chemical damage

Safety critical structural fixings

- c) Condition of supported asset eg. column, sign etc.
- Physical damage – accident, impact, vandalism, fire
- Chemical damage
- Corrosion
- Other defects
- d) Condition of substrate
- Condition of surrounding concrete – delamination, scaling, cracking, ASR, freeze thaw, voids, other
- Water damage
- Water present
- Evidence of reinforcement corrosion
- e) Other factors such as changed environment, increased loading, increased risks

New BOF task

- Project management – Santosh Sansoa and Neil Loudon
- Brief – drafted, circulated and comments incorporated, and thanks for contributions
- Procurement – T-TEAR framework, has been allocated to one of four main suppliers, and is now underway, tender return on 27th October (it takes about 8 weeks to let in total)
- Tender review undertaken and award imminent
- **‘Confidentially’ to be let to WSP/PB**
- Start date – mid November 2015
- Duration – 9 months

Collaborative funding

- Paul Thomas – Railway Paths Ltd – £2k 2016/17? Require confirmation
- Liam Duffy – Transport Infrastructure Ireland - £10k 2015/16 Email confirmation received
- Wayne Hindshaw – Transport Scotland - £5k increased to £10k (2015/16) Email confirmation received
- Jason Hibbert – Welsh Government - £5k (2016/17) Email confirmation received
- Steve Berry – DfT - £45k (£25k 2015/16 £20k 2016/17) Letter to confirm received, paid quarterly in arrears
- John McRobert – Northern Ireland Roads Service - £5k 2016/17 Email confirmation received
- Neil Loudon - Highways England - £13k balance probably paid in 2016/17
- Other offers – Network Rail?
- Financial arrangements – invoicing, purchase orders etc.

Project management

- Steering Group – funding partners plus (suggest Network Rail and ADEPT??)
- Consultation – Bridge Owner's Forum and Bridges Board members
- Inception meeting -The Task Contractor will organise and hold an Inception Meeting with the Project Manager, Assistant Project Manager and the Steering Group at the beginning of the task, and then every three months, with a final review meeting. Additional meetings may be arranged if and when required.
- There will be a review of the scope of the task at the inception meeting, and of the outputs at the final meeting.
- The skeleton of the Final Report should be tabled at the inception meeting.
- Short interim progress reports, meeting minutes, briefing/discussion papers shall be produced at 3 monthly intervals.
- The Task Contractor will arrange industry workshops to obtain input and case studies.
- There has already been contact with the Construction Fixings Association.
- There will need to be liaison with CIRIA
- The Task Contractor shall make all arrangements and cover costs for publication of the final approved guidance. This could be published by CIRIA?

Outputs

- The Contractor shall produce interim reports as specified. A final report shall be produced and published at the conclusion of the task.
- Twenty hard copies of the published report will be required together with electronic copies in PDF and Word formats.
- Available via internet (free download)
- The Contractor shall also produce draft client documentation eg. Highways England Interim Advice Note and Local Authority guidance to be included in the Code of Practice for Well Managed Structures (or other documents as required).
- Also preparation of a Powerpoint slide deck of the project outputs.
- Presentations to Bridges Board and Bridge Owners Forum

Safety critical structural fixings

Thanks and questions