Capacity of Bracing Inserts

Presented by:
Emad Gad
Swinburne University of Technology
egad@swin.edu.au

IStructE Seminar 8 November 2018

AUSTRALIAN ENGINEERED FASTENERS AND ANCHORS COUNCIL
AEFAC Australian Engineered Fasteners and Anchors Council

OUTLINE

- Australian Engineered Fasteners and Anchors Council
- Design of anchors for use in concrete
- AS3850-2003
- AS3850.1
- AEFAC resources
- Summary

AUSTRALIAN ENGINEERED FASTENERS AND ANCHORS COUNCIL
AEFAC Australian Engineered Fasteners and Anchors Council

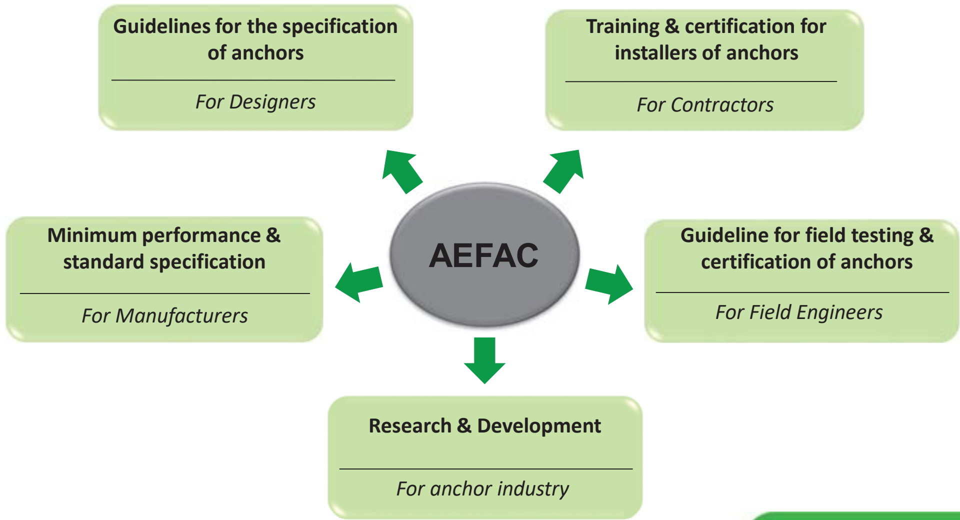
AEFAC Founding Board Members

Swinburne University of Technology, Hilti, Ancon Building Products, ramsetreid innovative construction solutions, Würth, StanleyBlack&Decker, Powers, Hobson Engineering

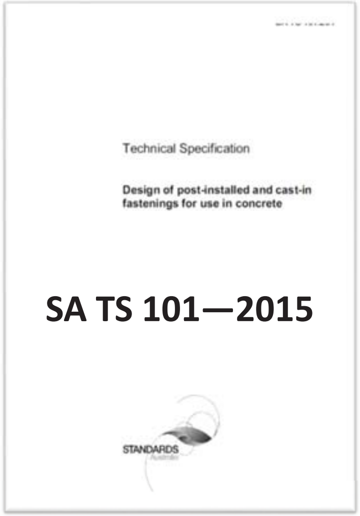
AEFAC Supporting Members

United Fasteners, Simpson Strong-Tie, Iccons, Allthread Industries

AUSTRALIAN ENGINEERED FASTENERS AND ANCHORS COUNCIL
AEFAC Australian Engineered Fasteners and Anchors Council

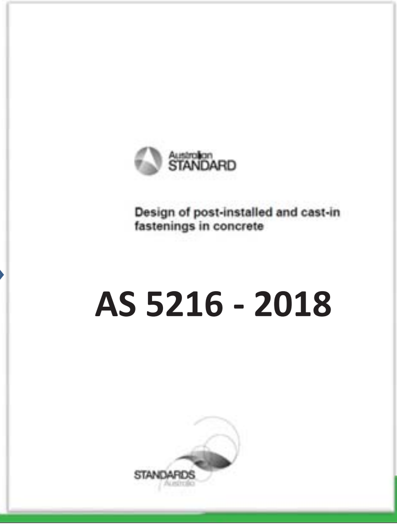


Design of Anchors for Use in Concrete


Technical Specification

Design of post-installed and cast-in fastenings for use in concrete

SA TS 101—2015


Australian STANDARD

Design of post-installed and cast-in fastenings in concrete

AS 5216 - 2018

AUSTRALIAN ENGINEERED FASTENERS AND ANCHORS COUNCIL
AEFAC Australian Engineered Fasteners and Anchors Council

SA TS 101 AND AS 5216



Overview

- Based on European guidelines
- Prequalification based on ETAG
- Referencing Australian standards for steel and concrete

Scope – safety-critical applications

- **Post-installed**
  - Mechanical anchors
  - Chemical anchors
- **Cast-in**
  - Anchor channel

Exclusions

- **Design of fasteners for lifting, transport and erection (brace inserts, lifting inserts, etc.) – refer to AS 3850**
- Seismic, fatigue, durability, fire
- Post installed rebar – refer AEFAC Technical Note

AUSTRALIAN ENGINEERED FASTENERS AND ANCHORS COUNCIL
AEFAC Australian Engineered Fasteners and Anchors Council

AS 3850 - 2003

The critical tensile capacity is the lesser of—

(a) the pullout load, usually concrete cone failure; or

(b) the 'first slip load' due to cyclic loads.

The critical shear capacity is the lesser of—

(i) the failure load of the steel bolt (or bolt and sleeve where applicable); or

(ii) the failure load due to edge breakout of the concrete where the anchor is close to an edge.

AUSTRALIAN ENGINEERED FASTENERS AND ANCHORS COUNCIL
AEFAC Australian Engineered Fasteners and Anchors Council

AS 3850 - 2003

2.2 WORKING LOAD LIMIT (WLL)

The WLL shall be derived from one of the following, as appropriate:

By dividing the multiple of the mean value of the test results (x) (see Appendix A) and the capacity reduction factor (ϕ), by the limit state factor (LSF) and the sampling factor, k_s, i.e.

$$WLL = \frac{\phi x}{k_s\,(LSF)};\ \text{or}$$

the value of ϕ shall be chosen from the appropriate Australian Standard.

For the pull-out of a lifting insert, or cast-in ferrule, from concrete, the value of ϕ shall not be greater than 0.6.

$$WLL = \frac{x}{2.5}$$

AUSTRALIAN ENGINEERED FASTENERS AND ANCHORS COUNCIL

AEFAC Australian Engineered Fasteners and Anchors Council

AS 3850 - 2003

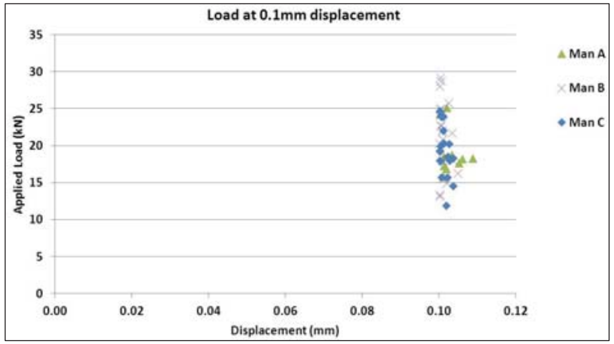
Expansion anchors Expansion anchors for brace fixing inserts shall be of the load-controlled type. Where these anchors are used, the WLL shall be limited to 0.65 of the 'first slip load', established in accordance with Appendix A.

AUSTRALIAN ENGINEERED FASTENERS AND ANCHORS COUNCIL

AEFAC Australian Engineered Fasteners and Anchors Council

AS 3850 - 2003

Expansion anchors Expansion anchors for brace fixing inserts shall be of the load-controlled type. Where these anchors are used, the WLL shall be limited to 0.65 of the 'first slip load', established in accordance with Appendix A.



- Load at approximately 0.1mm ranges between 12 – 29 kN.
- Significant scatter of load observed within a given product.

AUSTRALIAN ENGINEERED FASTENERS AND ANCHORS COUNCIL

AEFAC Australian Engineered Fasteners and Anchors Council

AS 3850 - 2003

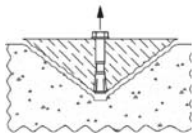
Sizes	20 x 115mm	
Bolt	M14 (class 8.8)	
Drill diameter	20mm	
Embedment depth	95mm	
Anchor spacing	200mm (nominal)	
Anchor edge distance	240mm (nominal)	
Fixture thickness	20mm (nominal)	
Fixture clearance hole	22 to 24mm	
Tightening torque	150Nm	
Performance in 20MPa concrete		
Tension	First slip load (0.1mm)	35.6kN
	R_{WLL} (0.65 x First Slip Load):	23.1kN

WLL = 2.3 T

AUSTRALIAN ENGINEERED FASTENERS AND ANCHORS COUNCIL

AEFAC Australian Engineered Fasteners and Anchors Council

For the same anchor, check its ultimate capacity for cone failure using Limit State Design



$$Characteristic \quad strength = 11.0\sqrt{f_c'}\,h_{ef}^{1.5}$$

$$Characteristic \quad strength = 11.0\sqrt{20}(80)^{1.5} = 35{,}200N = 35.2kN$$

Design Strength = ϕ * 35.2 = 0.67 * 35.2 = 23.6 kN

If WLL is based on characteristic strength rather than average strength
WLL = 35.2/2.5 = 14.1 kN (1.4T)

AS 3850.1 - 2015

Integrity tests:

Insert shall not fail by breakage or cause failure of the concrete when the application of twice the specified installation torque is applied.

Basic tension tests:

Apply tension load up to failure. Determine characterise strength (Ru) based on CoV and no of samples.

Cyclic tension tests:

Apply 1000 load cycles (up to 0.6 Ru). Residual displacement to be ≤ 0.25mm. Then apply tension to failure.

AUSTRALIAN ENGINEERED FASTENERS AND ANCHORS COUNCIL
AEFAC Australian Engineered Fasteners and Anchors Council

AS 3850.1 - 2015

TABLE A5

TESTS FOR POST-INSTALLED BRACE INSERT.

Test	Series	Age at installation, days	Age at test, days	Mean concrete strength, MPa	Drill bit diameter, mm	No. of tests
Torque	2	28	28	32–40	$d_{cut,m}$	5
Tension	1	7	7	20–36	$d_{cut,m}$	5
Cyclic	1	7	7–9	20–36 at 7 days*	$d_{cut,m}$	5
Shear	1	7	7	20–36	$d_{cut,m}$	5

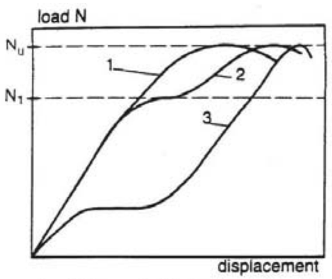
* Adjustment for higher concrete strength shall be made based on square-root of strength.

AUSTRALIAN ENGINEERED FASTENERS AND ANCHORS COUNCIL
AEFAC Australian Engineered Fasteners and Anchors Council

AS 3850.1 - 2015

In determining the ultimate capacity of anchor in tension we now consider:

- Cone failure
- Steel failure
- Pull out failure
- Uncontrolled slip
- Residual displacement due to cyclic loading



1 and 2 acceptable function
3 non–acceptable function

WLL = Characteristic strength/2.25

AUSTRALIAN ENGINEERED FASTENERS AND ANCHORS COUNCIL
AEFAC Australian Engineered Fasteners and Anchors Council

AEFAC RESOURCES

FAQ

- Refer to AEFAC's website www.aefac.org.au for FREQUENTLY ASKED QUESTIONS on SA TS 101

AEFAC Technical Note – Engineering General Notes

Design for post-installed rebar for development length

Design as per AS 3600

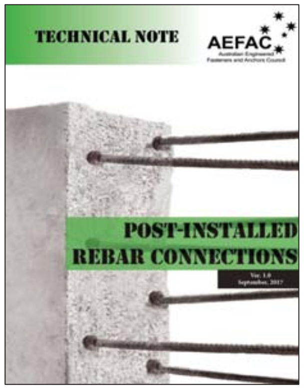
$$L_{sy.t} = \frac{(0.5k_1 k_3 f_{sy} d_b)}{k_2 \sqrt{f_c'}} \geq 29 k_1 d_b$$

This formula is for cast-in rebar

For post-installed rebar to act as cast-in rebar, system need to be be qualified to ***EOTA TR 023***

Installation is ***critical***:

- Tools required
- Deep cleaning
- Installer must be ***competent*** and trained for specific application



Summary

- Bracing inserts testing and evaluation methods in AS3850 – 2003 lacked consistency and rigour
- The modified testing and evaluation methods in AS3850.1-2015 follow best practice and established design processes.
- There is a reduction in rated WLL for inserts due to the new testing and evaluation methods by about 30%.

AEFAC Founding Board Members

AEFAC Supporting Members

IStructE Technical Meeting

Lifting Anchor Design in Accordance with AS 3850

Andreas Boomkamp
Ancon Building Products

November 8, 2018
Swinburne University of Technology

Content

- Concrete Precast is all around us
- Lifting Systems
- Codes and standards
- Lifting design according to AS 3850:2015

Precast Concrete is all around us …


Perth Stadium, Perth, WA


Ravenhall Prison, Ravenhall, VIC


Mill Road Skyhouse Liverpool, NSW

Precast Concrete is all around us …


Wheatstone LNG Project, Wheatstone, WA

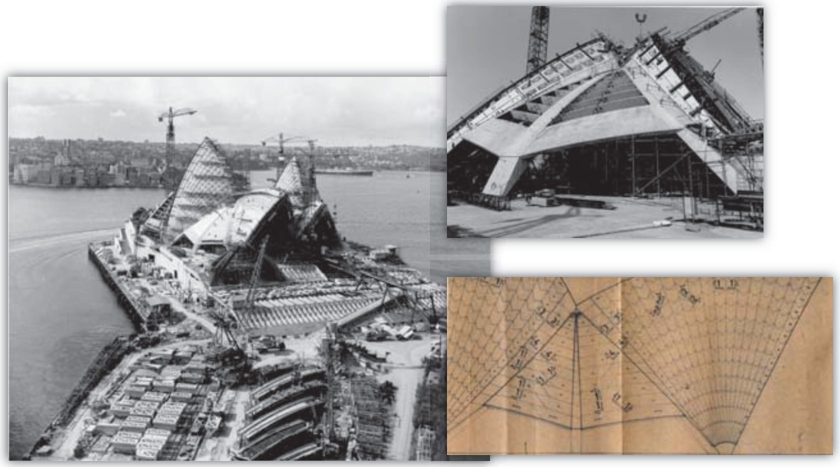

Retaining Wall


Swinburne University, VIC

… even if you don't recognize it as precast.

Opera House, Sydney, NSW

Building a landmark with Precast!



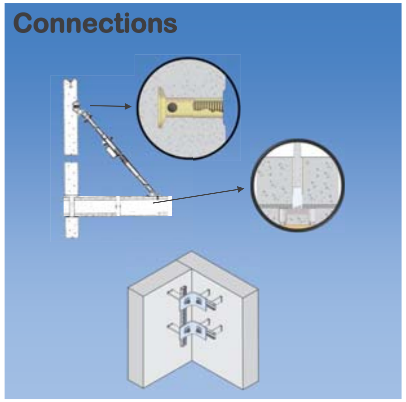
Advantages of Precast Concrete

- Higher quality as produced in controlled environment
- Lower cost due to optimisation of work flow
- Reduction of weather influence on speed and quality
- Speeds up the construction process on site
- Cost reduction through re-use of formwork
- Accelerated curing through heating the precast parts
- With the ability to tightly control the process more durable concrete can be achieved

Content

- Concrete Precast is all around us
- **Lifting Systems**
- Codes and standards
- Lifting design according to AS 3850:2015

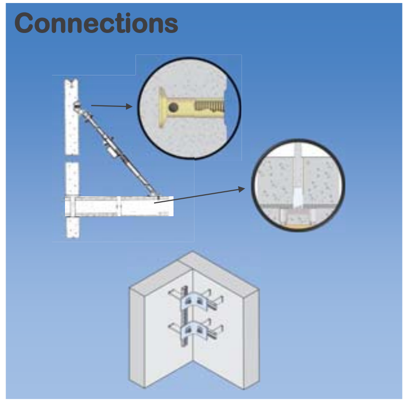
Unique Challenges of Precast Concrete



Connections in precast

- For transportation bulky concrete members to be divided in multiple items
- Load bearing permanent connections are required on site
- Temporary connections are needed to resist wind loads.

Special connections (permanent and temporary) required!



Lifting of Precast Concrete

- Concrete parts produced away from the building site
- Orientation of the item often different for production, transportation, placement

Special items for lifting required!

Lifting of Precast Concrete

"Handmade" solutions to lift precast

"Handmade Lifting Systems" can cause catastrophic failures!

Lifting Systems

Cone Anchor System

- Based on a system developed by Dr. Häussler in Germany
- Quick, safe connection
- Cannot disconnect under load
- Recessed below the surface, no damage
- No obstruction, Visual connection confirmation
- Engineered design

Lifting Systems

Edge Lifting Systems

- Systems to allow handling wall elements that are casted flat
- Proprietary lifting anchors
- Capacities based on testing

Lifting Loops

- Steel cable loops
- Proprietary lifting anchors
- Used for heavy precast items like bridge beams

Content

- Concrete Precast is all around us
- Lifting Systems
- Codes and standards
- Lifting design according to AS 3850:2015

When precast became more popular …

… more accidents happened!

Design of Prefabricated Concrete Elements

In-service Design:

- Design for the service life of the structure
- According to AS 3600
- Loading according to AS 1170
- Using characteristic capacity and reduction factors
- Performed by design engineer (in-service designer)

Erection Design:

- Design of the erection an temporary support until completion
- Includes all de-moulding, storage, transport, lifting, bracing, propping
- According to AS 3850 and National Code of practice
- Loading according to AS 1170
- Using Working Load Limit approach
- Performed by erection design engineer

AS 3850 – Prefabricated Concrete Elements

Implementation:

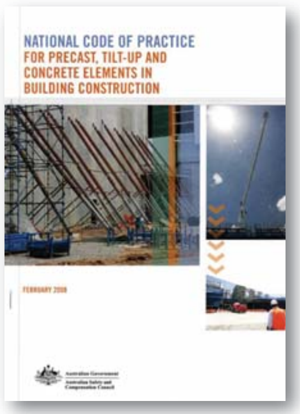
- First released in 1990
- Multiple revisions in 1992, 2003 and 2009
- Current revision released in 2015
- Amendments for Part 1 and 2 to be released later in 2018

Scope:

- Part 1: General – Amendment towards end of 2018
  Materials, components and equipment
- Part 2: Building Construction – Amendment within the next weeks
  - Planning, construction, design, casing, transportation, erection and incorporation into the final structure
  - wall, floor & façade elements, columns, beams, stairs, planters, …
- Part 3: Civil Construction (Currently under development – to be released 2020)
  - Civil construction (box culverts, bridge beams, pipes, …)

National Code of Practice

Currently being revised for consistence with AS3850:2015



Road Authority Requirements

Technical Specifications available by road authorities like TMR (QLD)

Content

- Concrete Precast is all around us
- Lifting Systems
- Codes and standards
- **Lifting design according to AS 3850:2015**

Lifting Design – Step-by-Step Guide

Design Steps for a lifting Design:

Step 1 Determine the number of lifting points required for stability
Step 2 Calculate the mass of the element
Step 3 Define the optimum rigging system
Step 4 Determine the static load at each lifting point
Step 5 Calculation of the design tension load N*
Step 6 Select the required anchor
Step 7 Design the precast element for all actions imposed during lifting, transportation and installation

Lifting Design – Step-by-Step Guide

Step 1: Determine the number of lifting points required for stability

The number of lifting points depends on the type of the precast element:


Beam

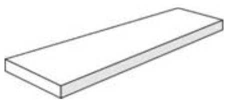
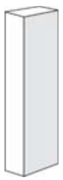
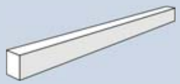
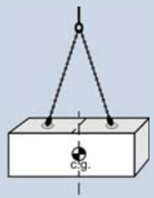


Plate-like


Column

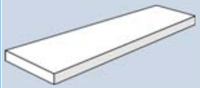
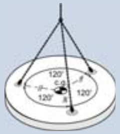
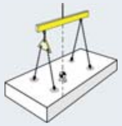
Lifting Design – Step-by-Step Guide

Step 1: Determine the number of lifting points required for stability

Type		Min. lifting points for stability	Rigging sample
Beam		2	

Lifting Design – Step-by-Step Guide

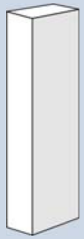
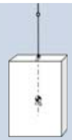
Step 1: Determine the number of lifting points required for stability

Type		Min. lifting points for stability	Rigging sample
Plate-Like		3*	
		4	

* Not recommended

Lifting Design – Step-by-Step Guide

Step 1: Determine the number of lifting points required for stability

Type		Min. lifting points for stability	Rigging sample
Column-Like		1*	
		2	

* Not recommended

Lifting Design – Step-by-Step Guide

Step 2: Calculation of the concrete element weight

Volume x Density = Weight

Density of normal reinforced concrete: 2,500 kg/m^3

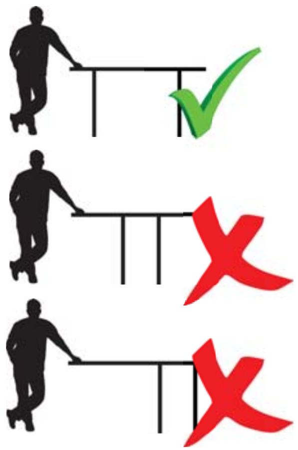
Lifting Design – Step-by-Step Guide

Step 3: Define the optimum rigging system

Main functions of the correct rigging system:

- Ensure equalised loading between the Lifting points
- Provide Stability

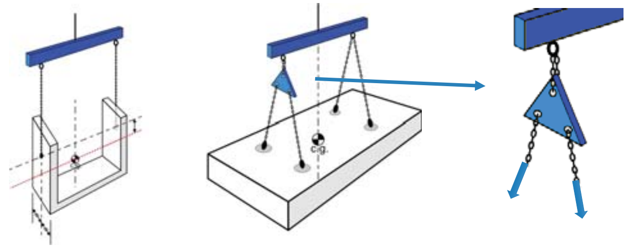
→ The centre of lift of the lifting points should be as close as possible to the centre of gravity of the object



Lifting Design – Step-by-Step Guide

Step 3: Define the optimum rigging system

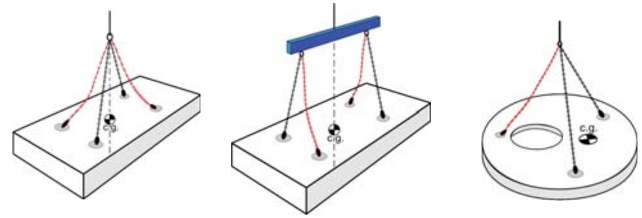
Systems that provide stability while distributing the loads equally to the lifting points:



Lifting Design – Step-by-Step Guide

Step 3: Define the optimum rigging system

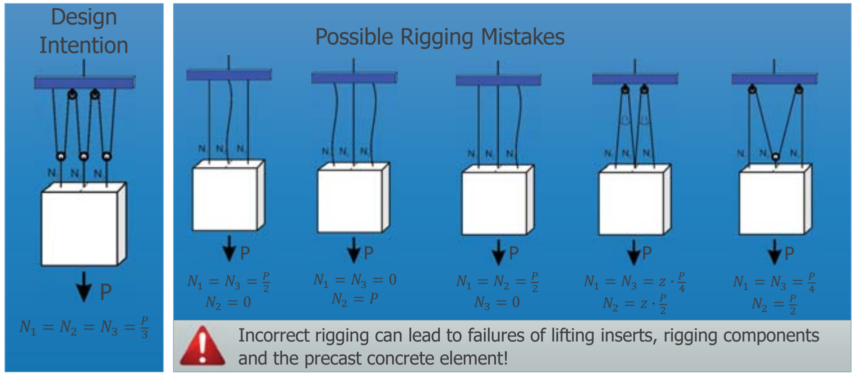
Systems that do <u>not</u> equally distribute the loads:



The red chains will <u>not</u> take over loads.

Lifting Design – Step-by-Step Guide

Step 3: Define the optimum rigging system



Lifting Design – Step-by-Step Guide

Step 4: Determine the static load at each lifting point

The static load N_s is calculated as follows:

$$N_s = Z \cdot \frac{P}{n}$$

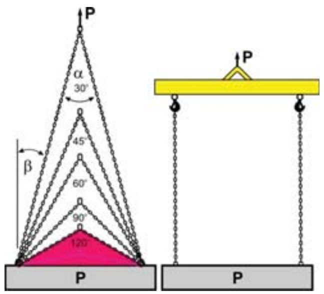
With:

- N_s Static Load on the lifting insert
- Z Sling angle factor
- P Weight of the precast concrete element
- n Number of equally loaded lifting inserts

Lifting Design – Step-by-Step Guide

Step 4: Determine the static load at each lifting point

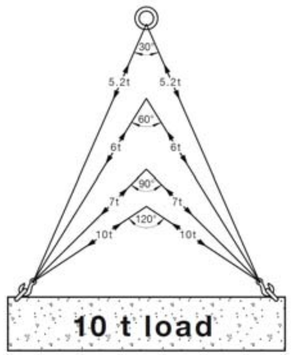
Sling angle α	Angle at anchor β = α/2	Sling angle factor "Z"
0°	-	1.00
15°	7.5°	1.01
30°	15°	1.04
45°	22.5°	1.08
60°	30°	1.16
90°	45°	1.42
120°	60°	2.00



Sling angles greater than 120° are not permitted!
(AS 3850.2:2015 – 2.5.2)

Lifting Design – Step-by-Step Guide

Step 4: Determine the static load at each lifting point



Changes to the sling angle have a big influence on the sling forces!

Lifting Design – Step-by-Step Guide

Step 5: Calculation of the design tension load N*

The load N* includes the multiplying factors for suction ξ for the load case de-moulding and the dynamic effects Ψ_{dyn}, and service life Ψ_{sl} for the transportation / installation:

Load Case de-moulding:

$$N^* = \xi \cdot N_s$$

Load Case Transport / Installation:

$$N^* = \psi_{dyn} \cdot \psi_{sl} \cdot N_s$$

AS 3850.2:2015 – Chapter 2.5.1

Lifting Design – Step-by-Step Guide

Step 5: Calculation of the design tension load N*

Suction Factor ξ :

- Consideration of suction and friction between precast element and formwork
- Depending on formwork surface and preparation
- Only for first lift of the casting bed
- Specified in AS 3850.2 – Table 2.2

TABLE 2.2

SUCTION FACTORS APPLIED TO THE ELEMENT AND LIFTING POINTS

Suction condition	Suction factor
When calculating insert loads and bending moments at the point of element lift-off from a concrete casting bed with an effective bond-breaker	≥1.4
When calculating insert loads and bending moments at the point of element lift-off from a smooth, oiled steel casting bed	≥1.2
Other casting surfaces to account for the effects of suction and adhesion (e.g. form liners)	As appropriate

Lifting Design – Step-by-Step Guide

Step 5: Calculation of the design tension load N*

Dynamic Factor Ψ_{dyn} :

- Consideration of dynamic effects like "bouncing" of suspended loads
- Significant impact when travelling over ground
- Different dynamic factors can apply for different lifting procedures of the same item
- Specified in AS 3850.2 – Table 2.3

TABLE 2.3

DYNAMIC FACTORS APPLIED TO THE ELEMENT AND LIFTING POINTS (UNLESS VERIFIED BY OTHER MEANS)

Means of transportation	Dynamic factor
A stationary crane, including an overhead gantry crane, a crane standing on outriggers or a tower crane	≥1.2
Transport by truck on a prepared even surface	≥1.4
Tracked mobile lifting equipment travelling with the suspended load on a prepared even surface (see Note 1)	≥1.7
Non-tracked mobile lifting equipment (including rubber-tyred) travelling with the suspended load on a prepared even surface (see Note 1)	≥2.0
All mobile equipment travelling with the load suspended on unprepared uneven surfaces (see Note 1)	≥5.0

Lifting Design – Step-by-Step Guide

Step 5: Calculation of the design tension load N*

Service Life Factor Ψ_{sl} :

- Consideration of reoccurring lifts other than what is needed for manufacture, delivery and installation

Design Lifting condition	Load factor
Lifting and handling during all stages of manufacture, delivery and installation	$\Psi_{sl} \geq 1.0$
Applications requiring repetitive re-lifting of a concrete element during its service life (e.g. concrete road barriers) – AS 3850.2:2015 Table 2.4	$\Psi_{sl} \geq 1.6$

AS 3850.1:2015 – Chapter 2.5.3.2

Lifting Design – Step-by-Step Guide

Step 6: Select the required Lifting Insert

Selection of the required Lifting Insert based on:

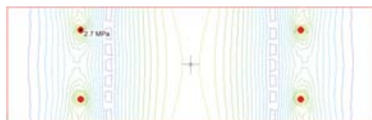
- **Working Load Limit (WLL) for the steel of the insert itself**
- **Working Load Limit (WLL) for the concrete the insert is installed in**
- **Factor of Safety (FoS) for both capacities is 2.25 in accordance with AS 3850**
- **Concrete capacity based on CCD method (unreinforced concrete) or supplier testing (reinforced concrete)**

Lifting Design – Step-by-Step Guide

Step 6: Design of precast element for all actions imposed during lifting, transportation and installation

Design considerations:

- **Erection design engineer must ensure that element strength is sufficient to withstand all imposed loads during all lifting procedures**
- **Design for unreinforced concrete limiting the tension to** $0.41 \cdot \sqrt{f'_{c.age}}$
- **To limit tension loads refer to reinforced concrete design (according to AS 3600) or add strongbacks**



Thank you !

iStructE Technical Meeting

AS3850.1 – 2015 Bracing Design

Neil Hollingshead
AEFAC Technical Committee Chair
Group Product Manager – ramsetreidTM

November 8, 2018
Swinburne University of Technology

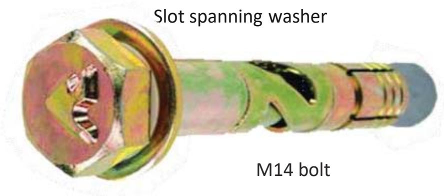
Preamble

- AS3850.1 – 2015 introduced a number of changes to capacity derivation methods previously utilised in AS3850 – 2003
- These changes have resulted in reductions to published capacities for post installed brace inserts
- These reductions constitute decreases of up to 30%
- How does this impact Precast Panel construction?

Agenda

- Review the 2003 approach to post installed brace insert capacity derivation techniques.
- Review and contrast the 2015 approach.
- Explore a dataset of 100 Precast Panel projects to understand impacts of the changes on the # braces required.

Post installed brace anchors



Post installed brace anchors – why call them out?

- Precast panel bracing is a unique application
- Inserts used in pairs - no redundancy in use
- Load case is wind loads
- Temporary / short term use

Post installed brace anchors – why call them out?

AS3850 – 2003: Capacity derivation

2.2 WORKING LOAD LIMIT (WLL)

The WLL shall be derived from one of the following, as appropriate:

(a) The relevant Australian Standard.

(b) By dividing ϕR_u, obtained from the relevant Australian Standard, by the limit state factor (LSF).

(c) By dividing the multiple of the mean value of the test results (x) (see Appendix A) and the capacity reduction factor (ϕ), by the limit state factor (LSF) and the sampling factor, k_s, i.e.

$$\text{WLL} = \frac{\phi x}{k_s\,(LSF)}\text{; or}$$

the value of ϕ shall be chosen from the appropriate Australian Standard.

For the pull-out of a lifting insert, or cast-in ferrule, from concrete, the value of ϕ shall not be greater than 0.6.

AS3850 – 2003: Capacity derivation

- What is this Limit State Factor (LSF)?

1.3.13 LSF (limit state factor)

The sum of each of the appropriate load components multiplied by the appropriate load factors, divided by the sum of the unfactored load components.

- Interesting use of a design action effect measure in a capacity derivation model…

AS3850 – 2003: Capacity derivation

A8.2 Testing parameters for expansion anchors to be used as brace inserts

A8.2.1 *General*

The WLL of panel brace fixings shall be determined by measuring the residual preload in tension 14 days after setting into 20 ±2 MPa concrete. The anchors are then loaded in tension until failure, and the characteristic ultimate tensile capacity calculated from the results.

- The concrete reference is ambiguous and is susceptible to interpretation...

- Infers published capacity applicable at 20MPa concrete strength

AS3850 – 2003: Capacity derivation

A8.2.3 *Setting*

Hole diameter shall be the nominal drill bit diameter +0.3 mm to +0.4 mm. The anchor shall be inserted into the hole in the concrete through a fixture. The fixture shall be a 20 mm thick × 100 mm diameter steel cylinder with a hole in the centre with a diameter equal to the nominal outer diameter of the anchor +2 mm to +4 mm. The fixture shall be fitted with a 16 mm diameter × 100 mm long handle extending radially from its upper surface. A steel sheet with minimum thickness 0.5 mm, hot-dip zinc coated to AS 1397, with the same dimensions as the fixture, shall be inserted between the steel fixture and the concrete. Ensure that the fixture does not rotate while the anchor is being tightened.

The anchor shall remain undisturbed for a period not less than 14 days from the date of installation.

A8.2.4 *Sample size*

A minimum of 10 anchors shall be tested.

AS3850 – 2003: Capacity derivation

A8.2.5 *Test method*

Anchors shall be loaded after 14 days to remove the residual preload. Preload is equalized when the fixture plate can be rotated by application of a load of 1 kg to the end of the handle. The load required to equalize the clamping force shall be recorded as the 'residual clamping load'. The anchors shall then be tested to failure.

- Premise of this method is that preload is a direct measure of resistance to applied load, the 14 days period allowing for concrete creep effects over the typical duration of a panel braced on a site

AS3850 – 2003: Capacity derivation

- Load is applied carefully while a spotter looks for movement of the 'saucepan' handle.
- Many variables influence the outcome:
  - Concrete surface roughness
  - Co-ordination of spotting and recording
  - Galv. Plate
    - Thickness
    - Finish
    - Cleanliness
- Highly 'susceptible' test setup

AS3850 – 2003: Capacity derivation

- Unfortunately an older reference to 'first slip load' remains – allowing another means of calculating capacity

A8.2.6 *Expansion anchors*

Expansion anchors shall be tested to determine the first slip load. The procedure shall be as follows:

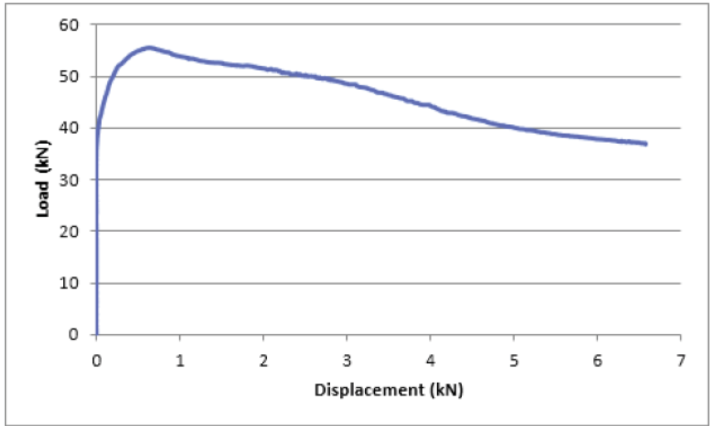
(a) Install the anchor in accordance with the manufacturer's recommendations, paying particular attention to the correct drilling of holes and the correct installation torque.

(a) Progressively apply the load until the fixing has moved 0.1 mm.

(b) Record this load as the first slip load.

(iii) *Expansion anchors* Expansion anchors for brace fixing inserts shall be of the load-controlled type. Where these anchors are used, the WLL shall be limited to 0.65 of the 'first slip load', established in accordance with Appendix A.

AS3850 – 2003: Capacity derivation



AS3850 – 2003: Summary

- Agricultural test methodology
  - Uses indirect measures
  - Susceptible to interpretation
- Conflicting capacity derivation methods
  - First slip vs retained preload methods
- Incorporation of LSF in capacity equation

AS3850.1 – 2015: Capacity derivation

2.2 WORKING LOAD LIMIT (WLL) CALCULATION

The working load limit shall be calculated as follows:

$WLL = R_u / FoS$

Where R_u is the critical characteristic load for the components listed in Table 2.2, it shall be determined from one of the following methods:

(a) Testing in accordance with Appendix A.

(b) The CCD method and steel failure for headed inserts in accordance with Appendix B.

(c) The CCD method and steel failure with a shape modification factor for other inserts in accordance with Paragraph A7, Appendix A, and Appendix B.

NOTE: The terms 'CCD method' (American approach) and 'CC method' (European approach) are equivalent in this Standard.

FoS factors shall be as given in Table 2.1.

NOTE: These factors are appropriate for concrete, steel or aluminium alloy failure and may not be applicable where other materials are used.

TABLE 2.1

WORKING LOAD LIMIT (WLL) FACTOR

Component type	*FoS*
Cast-in ferrules and brace inserts	2.25
Post-installed brace fixing	2.25

AS3850.1 – 2015: Capacity derivation

TABLE A5

TESTS FOR POST-INSTALLED BRACE INSERT.

Test	Series	Age at installation, days	Age at test, days	Mean concrete strength, MPa	Drill bit diameter, mm	No. of tests
Torque	2	28	28	32–40	$d_{cut,m}$	5
Tension	1	7	7	20–36	$d_{cut,m}$	5
Cyclic	1	7	7–9	20–36 at 7 days*	$d_{cut,m}$	5
Shear	1	7	7	20–36	$d_{cut,m}$	5

* Adjustment for higher concrete strength shall be made based on square-root of strength.

AS3850.1 – 2015: Capacity derivation

- Basic tension test

A9.5.3 *Strength in tension obtained from basic tension tests*

A9.5.3.1 *Mode of failure*

The failure mode of each specimen shall be identified from the following:

(a) Steel failure.

(b) Concrete cone failure.

(c) Pull-out failure.

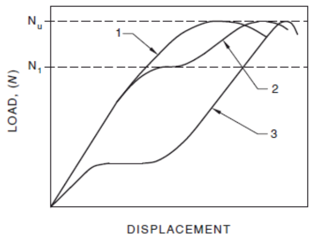
The mean tensile strength determined from basic tests ($N_{m,bas}$) and characteristic tensile strength determined from basic tests ($N_{u,bas}$) shall be calculated for each failure mode if more than one failure mode exists. The failure mode with the lowest characteristic value shall be decisive as follows:

$$N_{m,bas} = \min(N_{m,s,bas}, N_{m,c,bas}, N_{m,p,bas}) \quad \text{... A9.5.3.1(1)}$$

$$N_{u,bas} = \min(N_{u,s,bas}, N_{u,c,bas}, N_{u,p,bas}) \quad \text{... A9.5.3.1(2)}$$

AS3850.1 – 2015: Capacity derivation

- Basic tension test
  - Additional acceptance criteria
  - N1 = lesser of 0.8 Nu, $A_s f_{sy}$
  - Uncontrolled displacement not permitted below N1
  - Results normalised for 20MPa concrete compressive strength



LEGEND:
1 and 2 Acceptable function
3 Non-acceptable function

AS3850.1 – 2015: Capacity derivation

- Cyclic tension test
  - 1,000 cycles
  - Load cycled from $0.02R_u$,N to $0.6R_u$,N – R_u,N from basic tensile tests
  - Cycling rate = 1 to 2 Hz
  - Residual displacement post test < 0.25mm
- This approach relates to the ultimate one hour wind loading condition for a 100 YRP event.
- Results normalised for 20MPa concrete compressive strength

AS3850.1 – 2015: Capacity derivation

Cyclic Testing Methodology for Temporary Propping of Tilt-up Panels for Wind Loading Effects

Nicholas Haritos[1], David Heath[2], Emad F Gad[3] and John L Wilson[4]

A much simplified method, labelled here as the dynamic Simplified Testing Procedure, or STP, uses 1000 cycles at 1-2 Hz ranging from 0 to 60% of ultimate prop force on the prop-fixture test assembly as the prequalification test of anchor systems in panel propping applications. This procedure can be related to the ultimate one-hour wind loading condition following cycle counting via a rainflow investigation of this simulated ultimate wind loading condition. It is found from the sample panel investigation performed in this paper that 1 in 7 cycle counts at ultimate exceed the peak load associated with the STP, which infers that 6 out of 7 cycles are below this peak.

AS3850.1 – 2015: Capacity derivation

- Torque test
  - Evaluates insert ability to resist over torque during install
  - Criteria
    - Torque = 1.3 x Install torque applied
    - Induced tensile load recorded
      - 95% fractile of tensile load < Bolt yield (A_s f_{sy})
    - Insert shall be removable from drilled hole
  - If criteria not met, reset test (lowering torque)
    - All series 1 tests are then repeated using reduced torque value

AS3850.1 – 2015: Summary

- Simplified, more direct testing program
- Unambiguous calculation of capacity
- Probabilistic approach to cyclic test method
- Normalised to 20MPa concrete strength

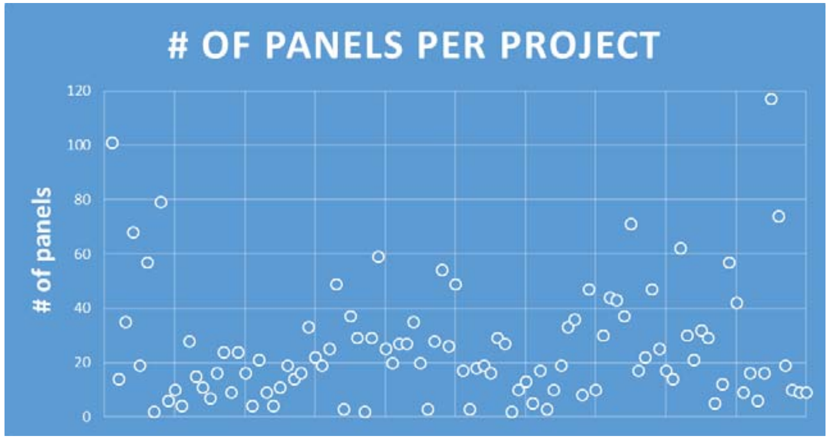
100 Projects – impact on # of braces required

- If brace insert capacity has been reduced by up to 30%, how does this impact the # of braces required?
- To help answer this question, a sample set of 100 randomly selected Precast Panel projects was investigated.
- Impact assessment based on change to # braces only, no re – design of panel configuration (optimisation) is considered

100 Projects – impact on # of braces required

State	# Projects	# Panels
ACT	1	19
NSW	10	333
NT	3	45
QLD	12	253
VIC	40	1110
WA	34	788
Grand Total	**100**	**2548**

100 Projects – impact on # of braces required



100 Projects – impact on # of braces required

	# projects	# braces		
		2003	2015	% change
Total	100	5,279	5,621	6.5%
Impacted	30	2,024	2,366	16.9%
No change	70	3,255	3,255	0.0%
Brace insert capacity (kN)		22.6	16.2	-28.3%

100 Projects – impact on # of braces required

- Overall increase in # of braces is not proportional to the reduction in published capacity
- Implies brace insert capacity not being fully utilised – brace capacity is often the limiting factor

Thank you !