Tilt-Up Concrete Construction to Prefabricated Concrete Elements – the changes to AS3850

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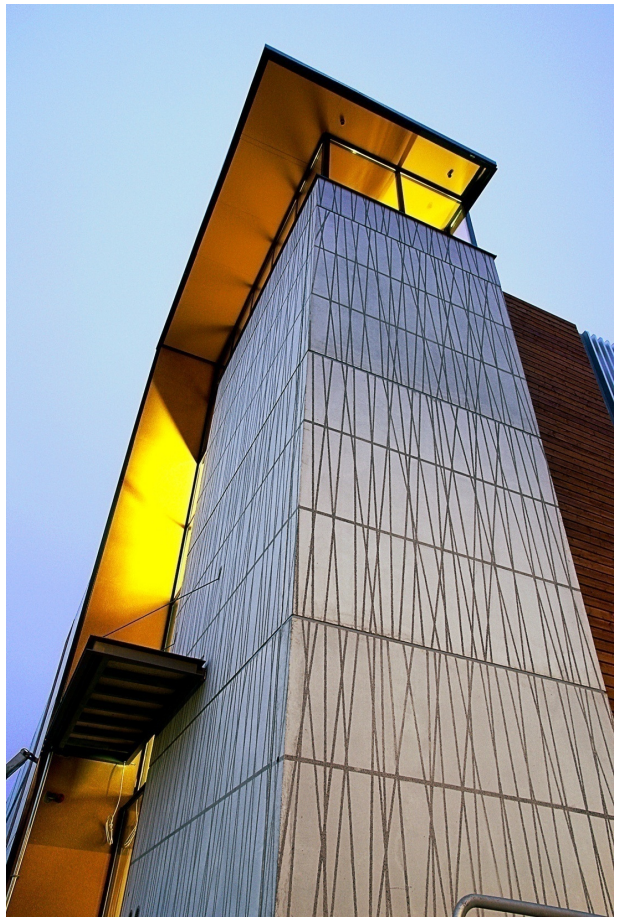
NATIONAL PRECAST
CONCRETE ASSOCIATION AUSTRALIA

Agenda

- The AS3850 journey
- Catalyst for updating the standard
- Major changes from 2003 to 2015
- Part 1: General Requirements
- Part 2: Building Construction
- High level summary by Stakeholder
- Alignment with the NCOP
- Questions



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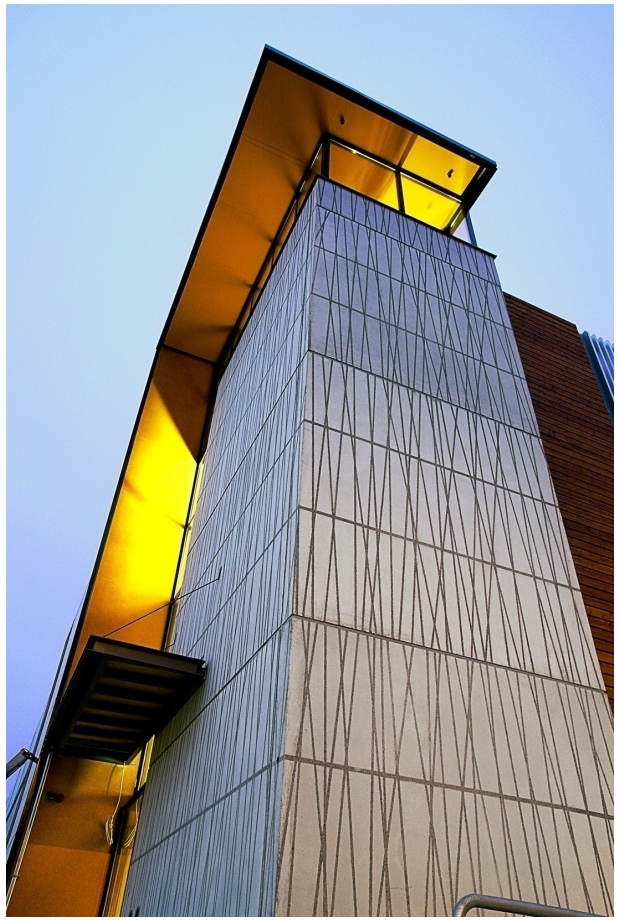

The AS3850 journey

- Recent version was published in 2003
- Focused on ‘Tilt-Up Concrete Construction’
- Safety critical issues with 2003 version
- Review started in July 2009
- BD-066 committee was led by Paul Uno
- Wide ranging participation on the committee
- Involvement with Safe Work Australia (SWA)
- Alignment in scope and definition to NCOP
- Draft went to public comment twice
- Finally published 3 September 2015

STANDARDS Australia

Associations Involved :

- Australasian Fire and Emergency Service Authorities Council
- Australian Council of Trade Unions
- Australian Institute of Building Surveyors
- Australian Steel Institute
- Building Designers Association of NSW
- Cement Concrete and Aggregates Australia
- Concrete Institute of Australia
- Concrete Pipe Association of Australasia
- Crane Industry Council of Australia
- Engineers Australia
- Master Builders Australia
- NATA
- National Precast (NPCAA)
- Steel Reinforcement Institute of Australia
- Sydney University
- WorkCover New South Wales
- WorkSafe Victoria

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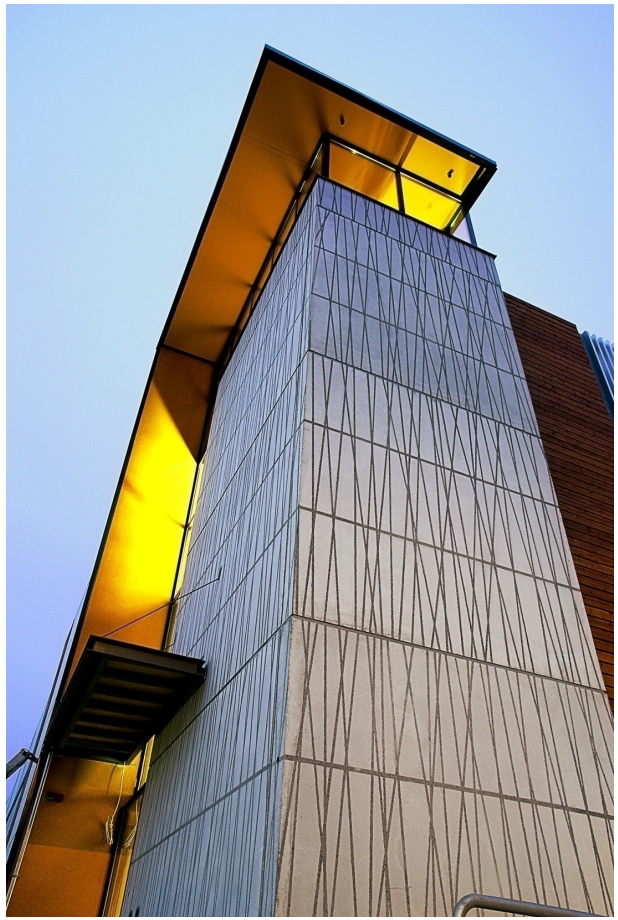
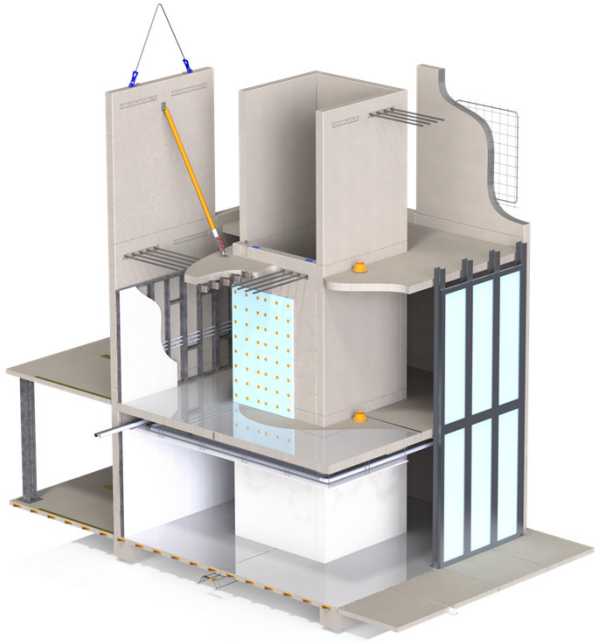


Catalyst for updating the standard

- 2003 version was becoming irrelevant
- Tilt-Up is a method of lifting rather than a type of prefabrication
- Significant growth in all forms of prefabricated concrete usage
- Scope of the NCOP covered all elements in Building Construction
- Safety critical issues identified in 2003 version
  - Errors in the statistical process
  - Factor of Safety (FoS) vs Limit State Factor (LSF)
  - Ambiguities around testing procedures



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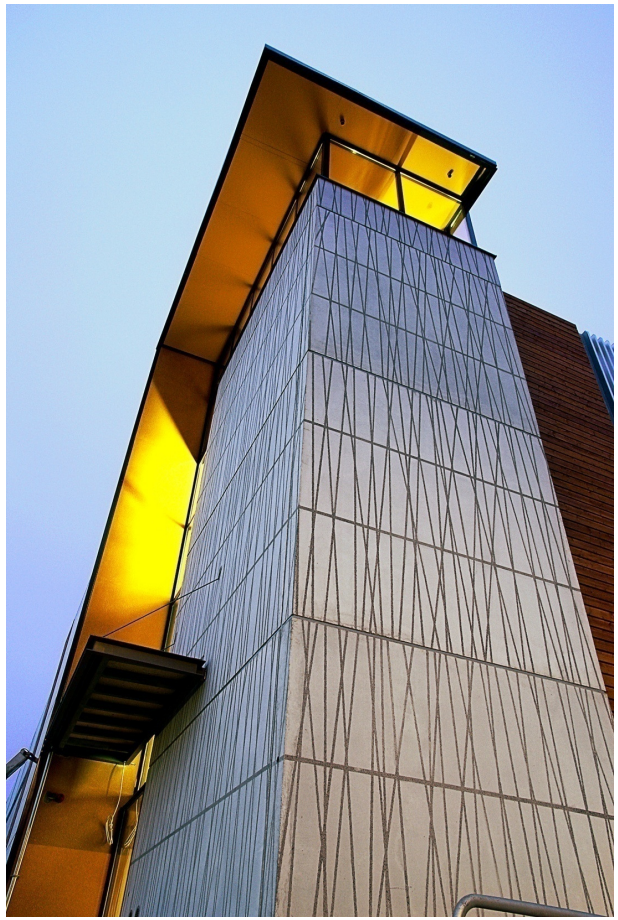

Major Changes from 2003 to 2015

- Title change to ‘Prefabricated Concrete Elements’
- Standard split into two (2) parts
  - Part 1: General Requirements
  - Part 2: Building Construction
- More comprehensive requirements for suppliers
- Greater guidance for Erection Design Engineers
- Greater guidance relating to manufacture & erection
- Alignment with NCOP – ‘technical’ vs ‘how to’
- Note that the new draft does not apply to civil products or small precast elements such as bricks, blocks and pavers.

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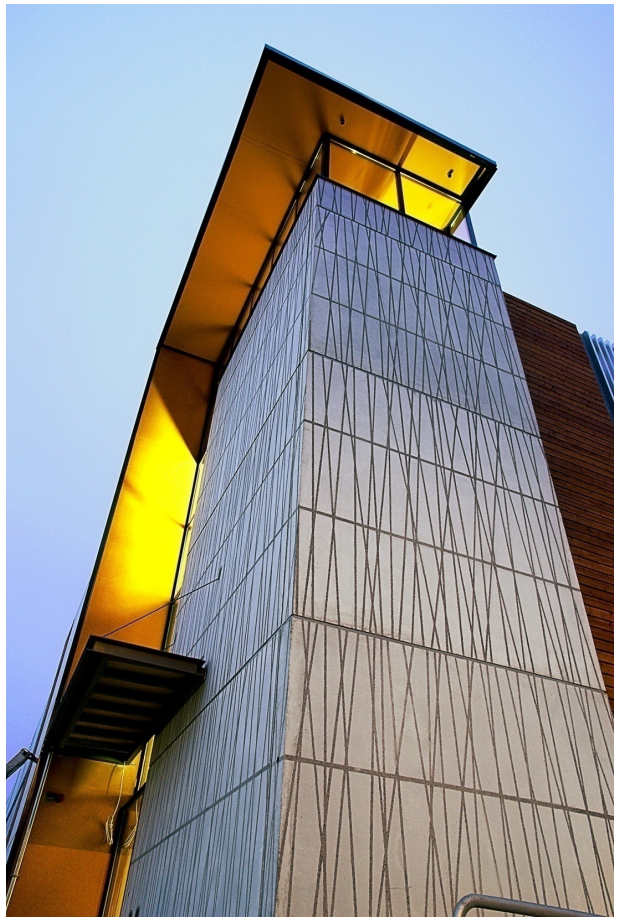


Part 1: General Requirements

- Sets out the General Requirements for materials, components and equipment
- Removal of the confusing LSF factors
- Introduction of

$$\boldsymbol{WLL = R_u / FoS}$$

- R_u = critical characteristic load

- FoS = Working Load Limit Factor

- Introduction of characteristic load, 5% fractile, 90% confidence (normal dist)
- Testing, Concrete Capacity Design (CCD) & Shape Modification factors (Appendix B)

Part 1: General Requirements

- Updated Factors of Safety (FoS) to reflect new statistical process

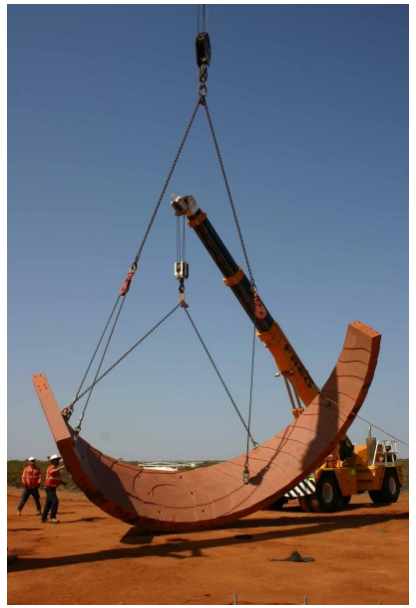
TABLE 2.1

WORKING LOAD LIMIT (WLL) FACTOR

Component type	*FoS*
Cast-in ferrules and brace inserts	2.25
Post-installed brace fixing	2.25
Cast-in lifting inserts	2.25
Lifting clutches	4.00
Levelling pads and shims	2.00
Steel or aluminium alloy temporary supports for vertical elements—braces	2.00
Steel or aluminium alloy temporary supports for horizontal elements—props and frames	2.00

Part 1: General Requirements - cont

- Expanded definitions & notation, incl:
  - Erection Designer
  - In-service Designer
  - Competent person
  - $f'_{c,age}$
  - Many more to reflect updated requirements
- Compatibility (Clause 2.1)

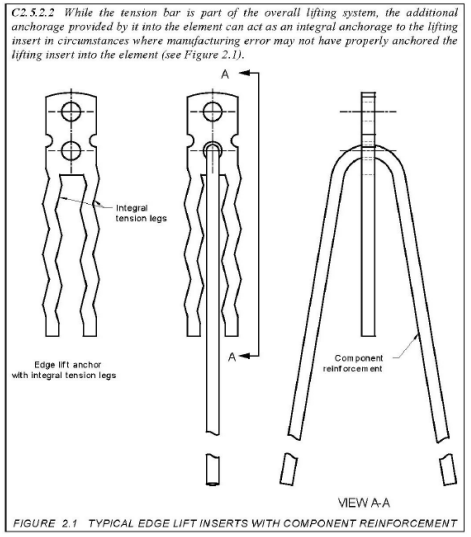


"All components to be used on site within the system shall be compatible. Different proprietary components shall not be mixed without verification of compatibility. Verification of compatibility shall be proved by testing, and such testing shall be documented and certified by a competent engineer."

Part 1: General Requirements - cont

Lifting Anchors (Clause 2.5.2)

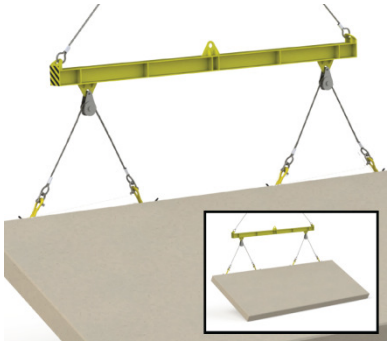
- Engineered solutions with focus on testing
- Minimum material properties added to ensure ductility
- Requirement for tension bars in edge lift anchors
    - Including integral tension legs
- Test to prove nett increase in anchor capacity from tension bar
- Component reinforcement as per AS/NZS 4671
- Requirement for system testing in concrete
- Additional testing in Appendix A – A6 & A7



Part 1: General Requirements - cont

Lifting Clutches (Clause 2.6)

- 100% fluorescent magnetic particle testing
- New traceability requirements – unique identifier, manufacturer name/symbol & WLL or compatible anchor identifier
- Proof load test 2 x WLL and annual 1.2 x WLL load test from date of first use
- Failure of the anchorage without fracture of the clutch
- New test requirements in Appendix A – A8



Part 1: General Requirements - cont

Post Installed Brace Anchors (Clause 2.5.3)

- Committee worked closely with AEFAC*
- Completely new test regime in Appendix A – A9
- Test regime now includes cyclic testing
    - Expected downgrade in capacities
- Addresses one of the main areas of ambiguity in the 2003 edition
- Notes added on importance of correct drilling of holes & tightening to correct torque
- Visible identification of supplier after installation

* AEFAC – Australian Engineered Fasteners & Anchors Council (Swinburne University Melbourne)

Part 1: General Requirements - cont

Cast-in Inserts - Ferrules (Clause 2.5.4)

- Bolt lengths, grades & torques to be provided

Ferrule size d_b	Ferrule OD (mm)	Tightening Torque (N.m)		Ferrule length L (mm)	Effective depth h (mm)	Thread length L_1 (mm)	Cross hole to suit	Part No.		
		Gr4.6 Bolt	Gr8.8 Bolt					Z_n	Gal	316SS
M10	16	17	30	45	41	20	R8	FE10045		FE10045SS
M12	17	30	50	55	51	25	R8	FE12055	FE12055GH	FE12055SS
				95	91		R10	FE12095	FE12095GH	
M16	22	75	125	70	66	32	N12	FE16070	FE16070GH	FE16070SS
				95	91			FE16095	FE16095GH	
M20	26	144	240	70	66	35	N12	FE20070	FE20070GH	
				95	91	38		FE20095	FE20095GH	FE20095SS
M24	32	250	415	95	91	50	N12	FE24095	FE24095GH	

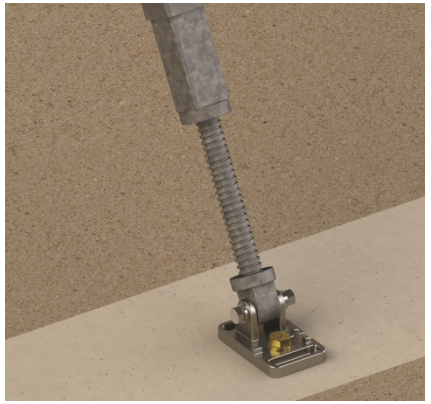
Effective depth, h (mm). Read value from "Description and Part Numbers" table
Note: for 316SS ferrules, use the grade 8.8 torques

- Information to be included in erection documentation
- Minimum steel capacity (in tension) of the insert greater than a 4.6 grade bolt
- Importance of matching threads – insert & bolt
- Additional test requirements in Appendix A – A7

Part 1: General Requirements - cont

Braces (Clause 2.7)

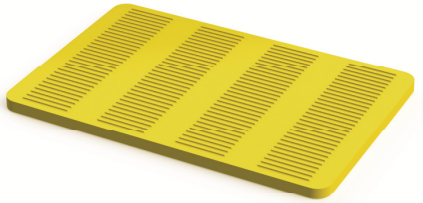
- Additional safety/anti-tampering requirements
  - Shear pins can’t be undone without a tool
- Brace feet designed to prevent lateral displacement
- Information available on site for erection crew
- New Inspection & Maintenance requirements
  - Repair work to be approved by competent person
- New testing requirements in Appendix A – A10
  - ‘Worse case scenario’ with braces horizontal
  - Brace feet at specified inclined angles

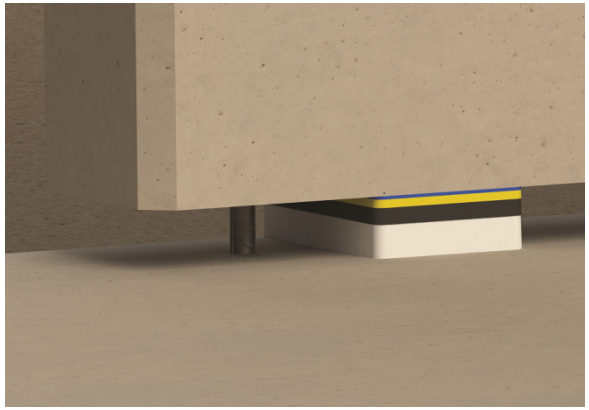


Part 1: General Requirements - cont

Shims (Clause 2.8)

- Shall be permanently marked to be traceable and have a marked WLL
- Consideration of temporary vs permanent support
- Minimum width 100mm, length 150mm
  - or width/length of element if less
- Maximum total height not to exceed 40mm
- New testing requirements in Appendix A – A11
  - Focused on minimising creep & plastic shrinkage





Part 1: General Requirements - cont

Testing Roadmap

TABLE A1

DETAILS OF THE TESTS REQUIRED

Product	Test required	Relevant paragraphs
Lifting inserts	Design validation to determine R_u	A2, A3, A4, A6 and A7
	Production validation	A3, A4 and A5
Lifting clutches	Design validation to determine R_u	A3, A4 and A8
	Production validation	A3, A4 and A5
Cast-in inserts (ferrules)	Design validation to determine R_u	A2, A3, A4 and A7
	Production validation	A3, A4 and A5
Shims	Design validation to determine R_u	A3, A4 and A11
	Production validation	A3, A4 and A5
Post-installed brace inserts	Design validation to determine R_u	A3, A4 and A9
	Production validation	A3, A4 and A5
Braces	Design validation to determine R_u	A3, A4 and A10
	Production validation	A3, A4 and A5

Part 1: General Requirements - cont

Other General points

- Expanded test report requirements
- 5% fractile at a 90% confidence level using a Normal Distribution to validate the Design ('Design Validation')
- High level production validation requirements ('Production Validation')
- Introduction of Appendix B (CCD Method – EN/TS 1992-4-2:2009)

  Concrete Capacity Design for Cast-In Lifting & Brace Inserts
- Appendix B can be used for standard headed inserts (reference insert) + inserts with a shape modification factor

Part 1: General Requirements - cont

SUMMARY

Industry should have greater confidence in the products that they are specifying and using

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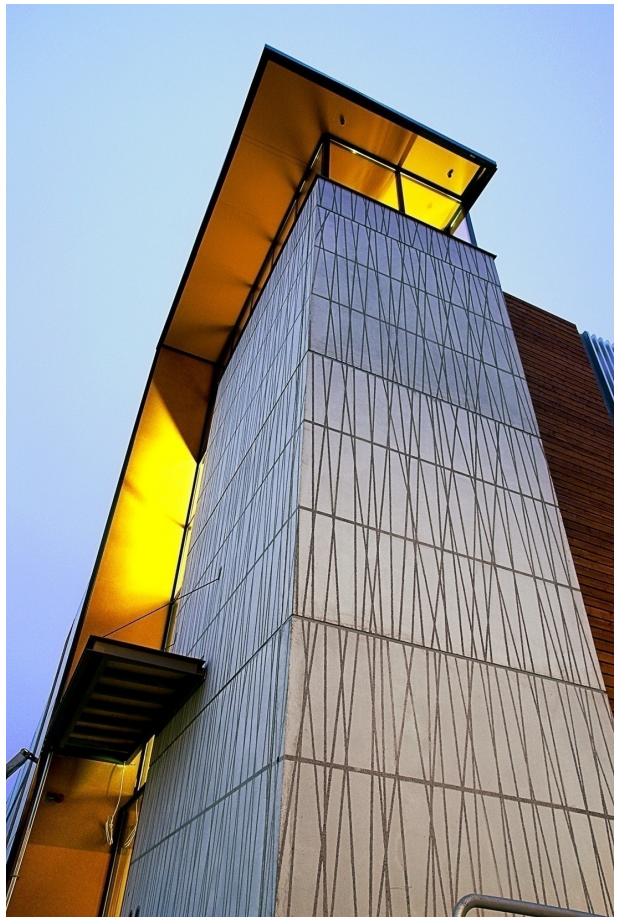
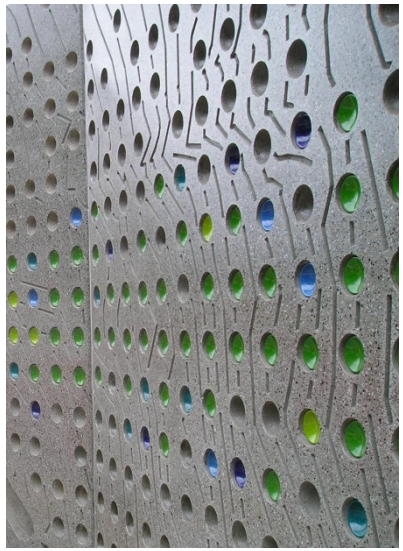


Part 2: Building Construction



- Covers all prefabricated concrete elements

  (excludes civil and small precast items bricks, blocks)
- Alignment of scope with the NCOP
- Introduces the terms:

  In-service Designer – responsible for the In-service Design

  Erection Designer – responsible for the Erection Design
- Part 2 is focused on the Erection Design only
- Focuses on the interrelation of the various stages of manufacture, construction, transport and erection
- Includes new terminology, particularly around concrete strength/time
- Highlights importance of stability & avoiding progressive collapse

Part 2: Building Construction – cont.

Design for Manufacture, Handling & Erection (Clause 2.5)

- Weight of the element is considered the 'dead load'
- Greater clarity on additional factors during lifting/handling
  - Sling Angle Factor
  - Dynamic Factor (updated factors)
  - Suction Factor
  - Service Life Factor (NEW)

  } = Applied Load <u>per lifting point</u>

- 'Dead load' to be multiplied by appropriate factors at different stages:
  - At the time of lift-off from casting bed
    - Applied load = Dead load x Suction factor x Sling Angle factor
  - After lift-off from the bed
    - Applied load = Dead load x Dynamic factor x Sling Angle factor x Service life factor

Part 2: Building Construction – cont.

Design for Manufacture, Handling & Erection (Clause 2.5) – cont.

- Scale of additional factors needs to be considered:
  - Suction factor – could be > 100% of dead load
  - Dynamic factor – could be > 500% of dead load
  - Sling Angle Factor – could be > 200% of dead load

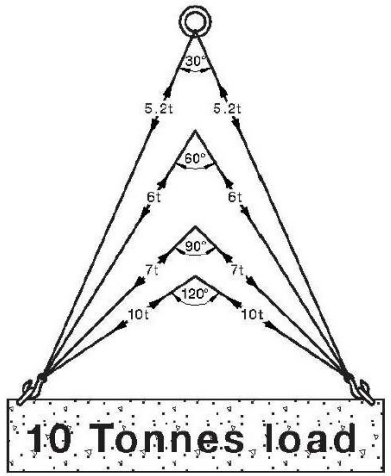


FIGURE 2.1 SLING ANGLE FACTOR

TABLE 2.3

DYNAMIC FACTORS APPLIED TO THE ELEMENT AND LIFTING POINTS

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 an even surface	≥1.4
Tracked mobile lifting equipment travelling with the suspended load on an even surface*	≥1.7
Non-tracked mobile lifting equipment (including rubber-tyred) travelling with the suspended load on an even surface*	≥2.0
All mobile equipment travelling with the load suspended on uneven surfaces*	≥5.0

* Mobile lifting equipment travelling with a suspended load shall be operated according to the manufacturer's instructions, paying particular attention to the travelling speed and surface condition. Refer also AS 2550.1 which states a maximum travelling speed with a suspended load.

Part 2: Building Construction – cont.

Design for Manufacture, Handling & Erection (Clause 2.5) – cont.

- Service Life Factor*:

"Where the application of the PCE (Prefabricated Concrete Element) requires that it be lifted repetitively during its service life, a service life factor of 1.6 shall be used"

- The re-use of lifting inserts:

"Provided that the lifting inserts have never been loaded past their WLL, there is no physical deformation or corrosion of the insert, the concrete is still sound and in its original state, and the loads are and have been applied at low speeds and at low frequency, the lifting inserts will continue to perform their design task."

* Does not include the normal multi-handling required in manufacture, handling and erection

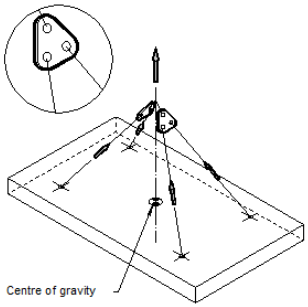
Part 2: Building Construction – cont.

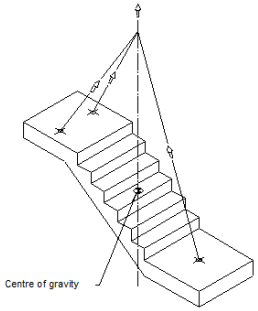
Design for Manufacture, Handling & Erection (Clause 2.5) – cont.

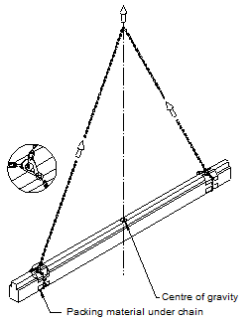
- Introduction of additional types of lifting:
  - Flat lifting
  - Edge lifting
  - Face lifting ('Tilt-Up' method)
  - Mid-air rotation

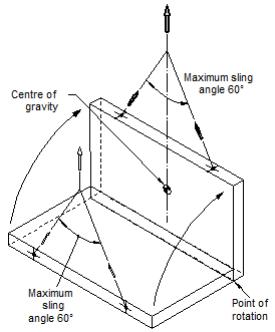
Critical to ensure that the lifting anchor positions and rigging systems are designed to equalise the loads

- Numerous additional examples of typical rigging configurations









Part 2: Building Construction – cont.

Design for Manufacture, Handling & Erection (Clause 2.5) – cont.

- Important rigging/lifting insert position considerations (not full list)
  - Fixed leg slings to a common point ≠ load equalisation
  - Included angle between legs of multi-leg slings ≤ 120^0
  - Load transfer to single lifting inserts in mid-air rotation could ≥ 75%
  - Rigging systems design to ensure no operators in drop zone
  - Importance of correct snatch block if rotation is required
  - Geometric centre of lifting inserts vs centre of gravity of element
  - Face-lifted elements should be designed to hang ≤ 10^0 from vertical
  - Slenderness of element and possible need for additional support

Part 2: Building Construction – cont.

Design for Manufacture, Handling & Erection (Clause 2.5) – cont.

- Lifting insert capacity

"Bars placed around the foot of the lifting insert typically provide no additional lifting capacity to the insert"

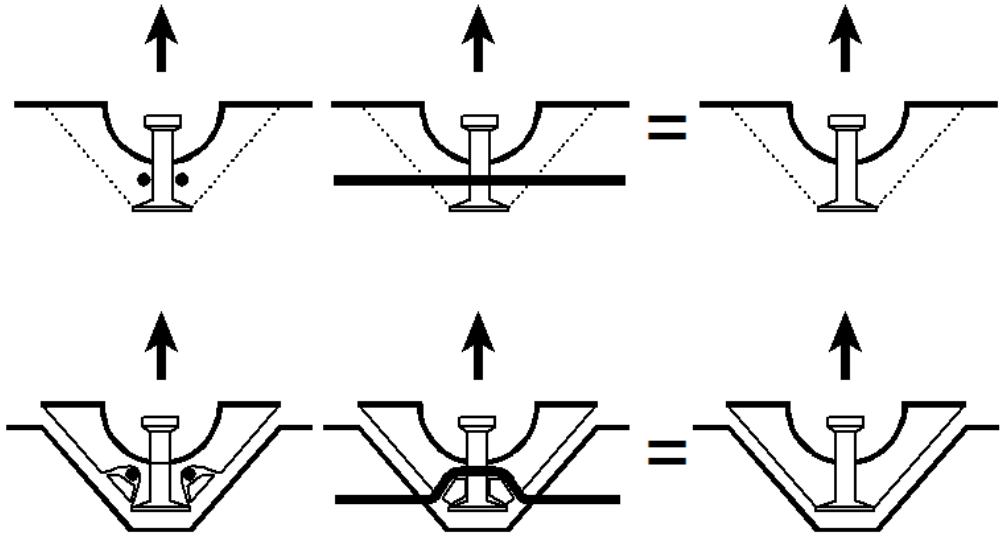
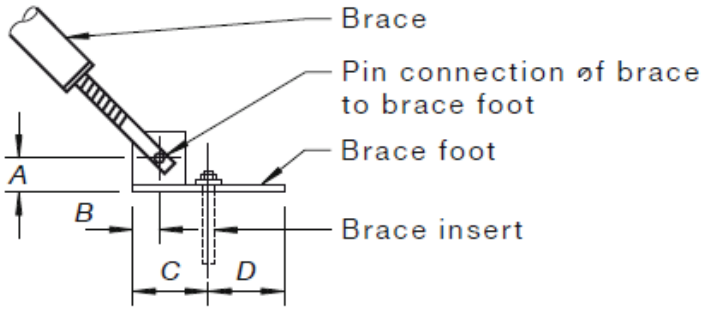


FIGURE 2.8(a) EXAMPLES OF REINFORCEMENT THAT HAVE NO EFFECT ON THE CAPACITY OF LIFTING INSERTS

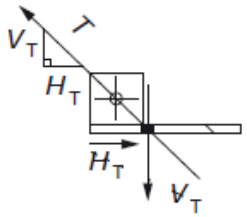
Part 2: Building Construction – cont.

Design for Manufacture, Handling & Erection (Clause 2.5) – cont.

- Greater focus/commentary on stability
- Effects of eccentric loads on capacity of brace inserts/feet



Dimensions of brace foot required to calculate brace insert load



Ideal brace angle of inclination

Braces axis passes through fixing hole centreline on underside of brace (Bolt tension = V_T)

- Cast-in inserts to be specified by an engineer and included in documentation
- Factors to consider when specifying type, loads and locations of inserts

Part 2: Building Construction – cont.

Design for Manufacture, Handling & Erection (Clause 2.5) – cont.

- Updated section and commentary on Wind loads for temporary supports
  - Reference to Tables F1 and F2 of Appendix F of AS/NZS 1170.0:2002
  - Terrain category, region, wind speed to be included in documentation
- Design of elements for manufacture, transport and erection
  - Must consider bending stresses – cracked vs un-cracked sections
  - Importance of crack width if designing on basis of cracked section
  - Wall panels (to be transported) should include at least one continuous perimeter bar
  - Additional considerations where extra reinforcement may be required

Part 2: Building Construction – cont.

Design for Manufacture, Handling & Erection (Clause 2.5) – cont.

- Bracing for both horizontal & vertical elements – Braces vs Props
  - Significantly expanded list of factors to consider in the design
  - Expanded commentary on the design/selection/use of braces/props
    - Particular commentary on pre-stressed members & change in load distribution on prop supports/frames
    - Importance of considering construction loads
- Location (to be specified) and number of localised supports
  - Columns – one
  - Thin elements – two
  - Wide horizontal elements – three

Need to consider load eccentricities on discrete supports/footings

Part 2: Building Construction – cont.

Footings (Clause 2.7)

- Permanent vs Temporary
- Importance of correct shims to take the load
    - Overall shim area > bearing strength of footing
- Erection sequence & eccentric loads
- Geotech reports for soil conditions
    - Particularly if using screw piles as temporary supports
- Concrete specification vs brace insert strength at time of bracing
    - Commonly requires early-age strength concrete
- Size of footings to consider things such as edge distances of post-installed anchors, vertical and horizontal loads

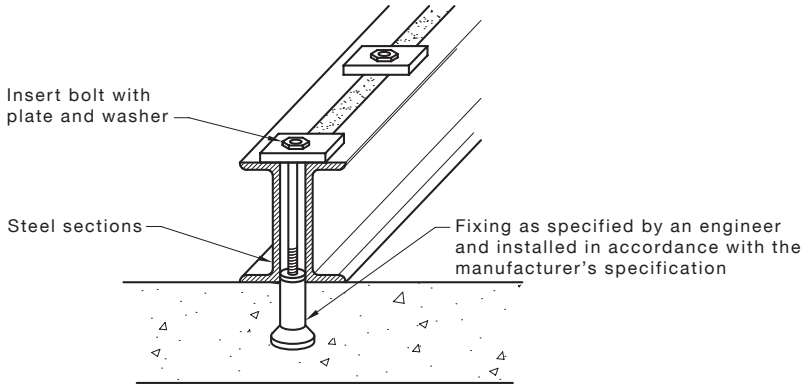
Part 2: Building Construction – cont.

Connections (Clause 2.8)

- Horizontal restraint at the base of elements during construction
- Fixing system to be used to resist in-service loads
    - Superimposed loads and their impact on braces/props

Strongbacks (Clause 2.9)

- Can be required to reduce deflection and/or control movement
- Preference for cast-in inserts
- Anti-loosening devices recommended under head of bolt



(b) Strongback—Steel

Part 2: Building Construction – cont.

Documentation (Clause 2.10)

- Structural vs Manufacture vs Erection drawings
  - Manufacture and erection drawings can be one in the same
  - Note that Manufacturing drawings are often referred to as Shop drawings
- Appendix A provides guidance on requirements
- Manufacture drawings to be approved by In-Service and Erection Designer
- Erection drawings to be provided/certified by the Erection Designer

Part 2: Building Construction – cont.

Sample of Appendix A

APPENDIX A

INFORMATION REQUIRED ON DRAWINGS

(Normative)

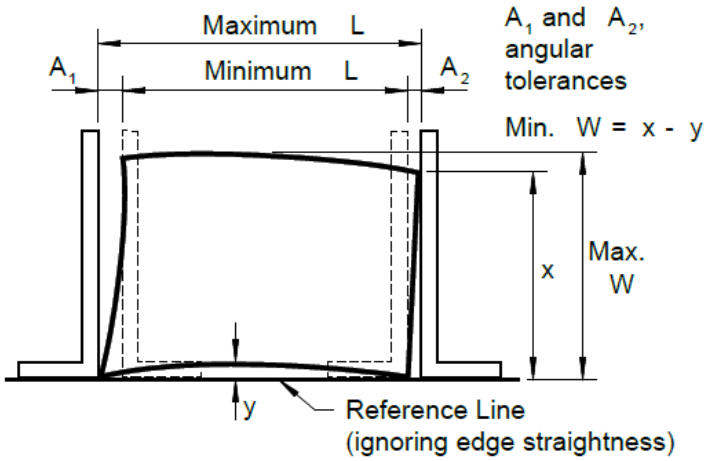
Required information	Drawings (may be combined)		
	Structural layout plans	Manufacture (shop)	Erection
Date and issue number of the drawing	Y	Y	Y
Project location	Y	Y	Y
Plans and elevations clearly indicating the structural framing and location and orientation of each element on a layout (marking) plan	Y	Y	Y
Structurally critical dimensions	Y		Y
Erection sequence	Y		Y
Minimum crane capacities			Y
Crane position			Y
Truck and crane access			Y
Position of any critical supports required for the erection of the elements (e.g. support walls, columns and beams)	Y		Y
The concrete specification of the elements, minimum concrete strength for lifting, handling and the connection of temporary supports during erection		Y	Y
Concrete strength of the footings and temporary support elements (e.g. deadmen) required at the time of erection			Y
Surface finish of each element		Y	
Special tolerance limits for the element if required		Y	
Rigging details for handling prior to delivery		Y	
Rigging details for handling and erection			Y
The maximum value of the initial lift load, including an allowance for suction when lifting off the casting beds If the anticipated lifting load, including suction, exceeds the element mass, this should also be noted on the shop drawings This is particularly relevant for flat lifting and provides the crane operator with a maximum load to be expected		Y (in factory lifting)	Y (on-site lifting)

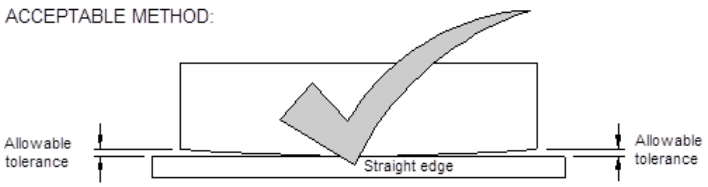
NOTE: The columns in the above table are in order of process but the design work does not occur in that order (e.g. crane rigging to be known at the time of locating the lifting inserts in the manufacture details and the brace layout to be determined before locating brace inserts in the manufacture details).

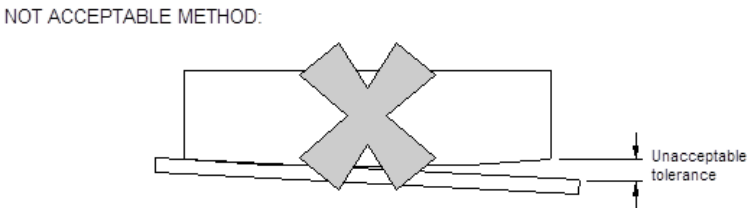
Part 2: Building Construction – cont.

Tolerances (Clause 2.11)

- Tolerances from AS3610 and the Precast Concrete Handbook (NPCAA) introduced
- Pre-stressed element tolerances added
- Tolerances for a completed structure added
- Techniques added to measure







- Total accumulation of tolerances ≤ 20mm

Part 2: Building Construction – cont.

Casting (Section 3)

- Wording change to include all elements
- Manufacture to approved shop drawings
- Selection of appropriate surface finish
- All elements to be uniquely marked
- Introduces digital photography to support QA
- Section on compaction added
- Element release from casting bed added
- Written authorization suggested for changes

Part 2: Building Construction – cont.

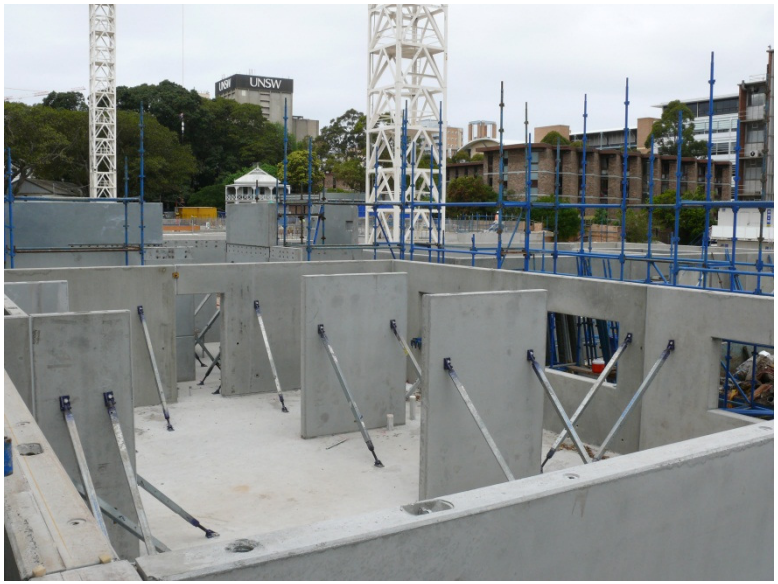
Transport, Cranage & Erection (Section 4)

- Focus on stability of the element/load
- Expanded ‘Erection Preparation’ checklist
  - Design of ground supports/platforms
- Expanded commentary of lifting & placing
  - Especially if edge-lifting & storing
- Crane specification incl load indicators
- Rigging system as per erection documentation
- Importance of element inspection prior to unloading/lifting
- Ideally braces should be fixed to element prior to lifting
- Checklist to help ensure safe lifting and placement

Part 2: Building Construction – cont.

Temporary Supports (Sections 5 & 6)

- Focus on following the Erection documentation unless approved otherwise
- Importance of not moving/removing without correct approvals
- Application of correct tightening torques
- Additional superimposed loads
- Shims as per new test procedures
- Specification of grout required on Erection documentation
- Progressive inspections of the structure to ensure stability prior to removal of any temporary supports



Part 2: Building Construction – cont.

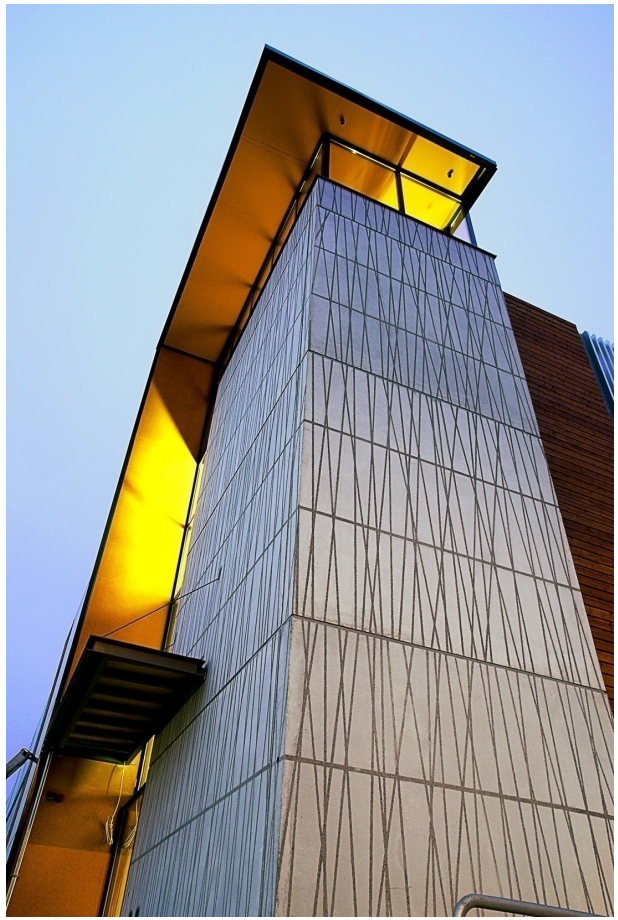
SUMMARY

Part 2 is specifically for the construction design and documentation of prefabricated concrete elements in building construction. The key is the

ERECTION DESIGN *and the* ***ERECTION DESIGNER***

Agenda

- The AS3850 journey
- Catalyst for updating the standard
- Major changes from 2003 to 2015
- Part 1: General Requirements
- Part 2: Building Construction
- High level summary by Stakeholder
- Alignment with the NCOP
- Questions



High level summary by Stakeholder

In-Service Designer

- Design to incorporate the benefits of prefabricated concrete
- Provide at least one safe method of construction

Erection Designer

- Early consultation and finalisation of erection design prior to work commencing
- Communication of erection design to all stakeholders is critical to success

Prefabricated Concrete Element Manufacturer

- Follow the approved manufacture (shop) drawings
- Seek approval from Erection Designer before altering anything

High level summary by Stakeholder – cont.

Erection Crew

- Follow the approved Erection Documentation
- Ensure compatibility of components (lifting, bracing & fixing)

Component Supplier/Manufacturer

- Update performance specifications inline with new testing requirements
- Work with industry to ensure a smooth transition of new information/products

Industry Associations/Unions

- Organise educational sessions to promote the new standard
- Work with industry to assist in a smooth transition to the new requirements

Agenda

- The AS3850 journey
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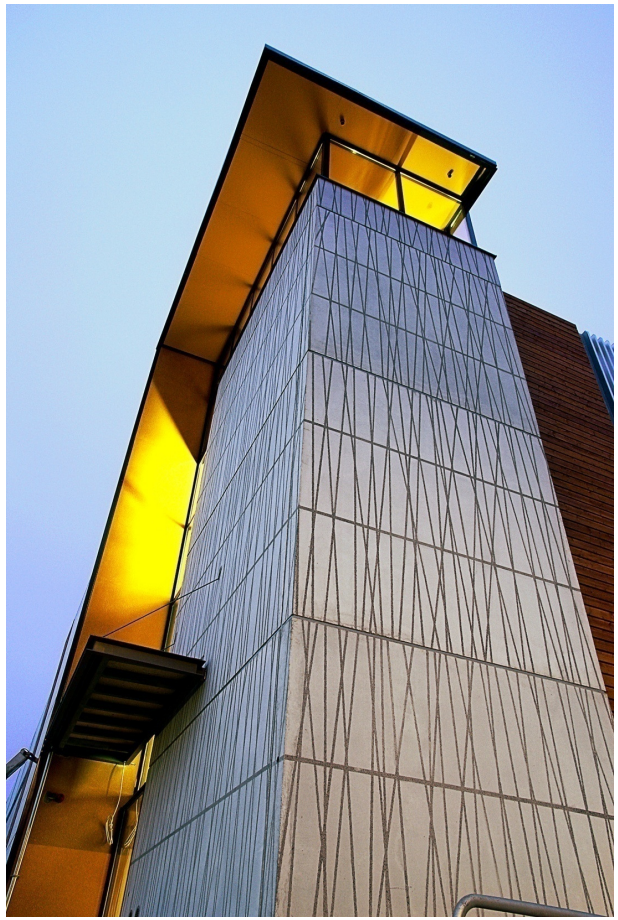

Alignment with the NCOP

- Committee worked closely with SWA
- Standard = ‘Technical’
- NCOP = ‘How to’
- Common language and definitions
- Common scope
- BD-066 provided input to new draft
- Latest information is that NCOP may become a Guide

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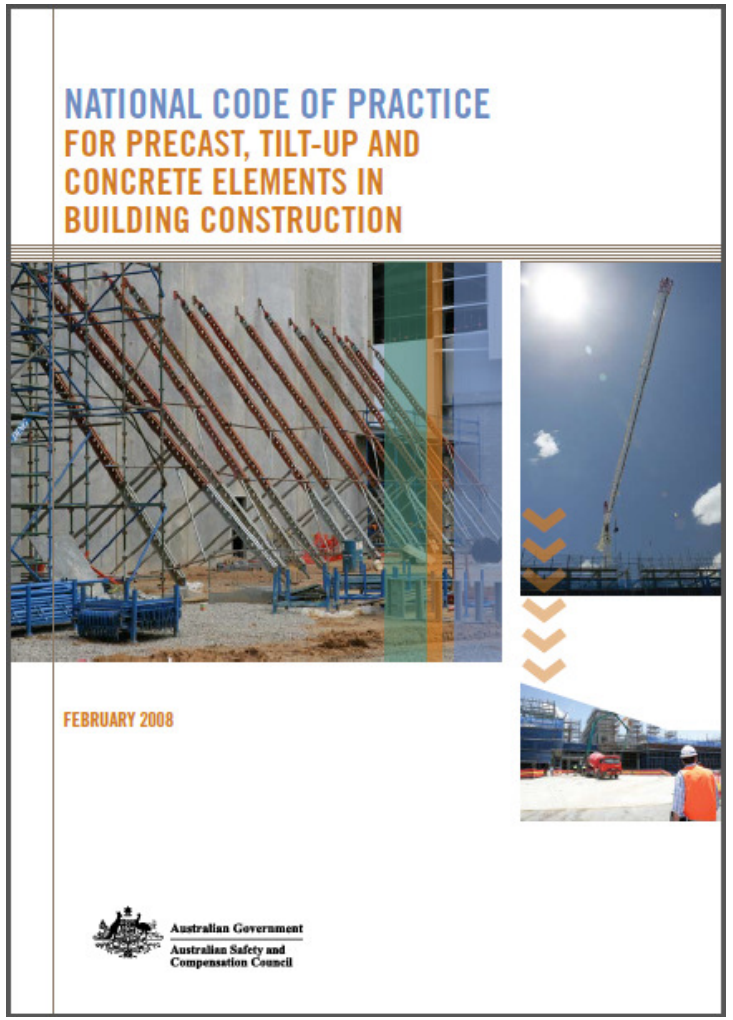

Thank you and are there any questions

I would like to acknowledge National Precast and Reid Construction Systems for their support of my participation in the update of the standard

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