

AS 3850.1:2024



STANDARDS  
Australia



# Prefabricated concrete elements

## Part 1: General requirements



AS 3850.1:2024

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- Australasian Fire and Emergency Service Authorities Council
- Australian Council of Trade Unions (ACTU)
- Australian Engineered Fasteners and Anchors Council
- Australian Industry Group
- Australian Institute of Building Surveyors
- Australian Steel Institute
- Austroroads
- Better Regulation Division (Fair Trading, SafeWork NSW, TestSafe)
- Cement Concrete & Aggregates Australia — Cement
- Cement Concrete & Aggregates Australia — Concrete
- Concrete Institute of Australia
- Concrete Pipe Association of Australasia
- Consult Australia
- Curtin University
- Department of Transport and Main Roads (QLD)
- Engineers Australia
- Master Builders Australia
- National Precast Concrete Association Australia
- Steel Reinforcement Institute of Australia
- The Crane Industry Council of Australia
- The University of Sydney
- Victorian WorkCover Authority (WorkSafe Victoria)

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# Prefabricated concrete elements

## Part 1: General requirements

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## Preface

This Standard was prepared by the Standards Australia Committee BD-066, Tilt up Construction, to supersede AS 3850.1:2015, *Prefabricated concrete elements, Part 1: General requirements*.

The objective of this document is to provide requirements for the materials, components and equipment used in the manufacture of prefabricated concrete elements.

A list of all parts in the AS 3850 series can be found in the Standards Australia online catalogue.

The terms “normative” and “informative” have been used in this document to define the application of the appendix to which they apply. A “normative” appendix is an integral part of a Standard, whereas an “informative” appendix is only for information and guidance.

*This document includes commentary on some of the clauses of the Standard. The commentary directly follows the relevant clause is designated by “C” preceding the clause number and is printed in italics in a box. The commentary is for information and guidance and does not form part of the Standard.*

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## NOTES

# Australian Standard®

## Prefabricated concrete elements

### Part 1: General requirements

## 1 Scope and general

### 1.1 Scope

This Standard provides general requirements for the materials, components and equipment used in the manufacture of prefabricated concrete elements. This document does not cover the in-service design of these elements.

This document is intended to be read in conjunction with AS 3850.2, AS 3850.3 and AS 3600 or AS 5100.

### 1.2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document:

NOTE Documents for informative purposes are listed in the Bibliography.

AS 1012, *Methods of testing concrete*

AS 1110, *ISO metric precision hexagon bolts and screws*

AS 1111.1, *ISO metric hexagon bolts and screws — Product grade C-Bolts*

AS 1171, *Non-destructive testing — Magnetic particle testing of ferromagnetic products, components and structures*

AS 1199.1, *Sampling procedures for inspection by attributes, Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

AS 1379, *Specification and supply of concrete*

AS 1391, *Metallic materials — Tensile testing at ambient temperature*

AS 1733, *Methods for the determination of grain size in metals*

AS 2193, *Calibration and classification of force-measuring systems*

AS 2550, *Cranes, hoists and winches — Safe use*

AS 3600, *Concrete structures*

AS 3799, *Liquid membrane-forming curing compounds for concrete*

AS 3850.2, *Prefabricated concrete elements, Part 2: Building construction*

AS 3850.3, *Prefabricated concrete elements, Part 3: Civil construction*

AS 4100, *Steel structures*

AS 5100 (series), *Bridge design*

AS 5216, *Design of post-installed and cast-in fastenings in concrete*

AS/NZS 1214, *Hot-dip galvanized coatings on threaded fasteners (ISO 10684:2004, MOD)*

AS/NZS 1554, *Structural steel welding*

AS/NZS 4671, *Steel reinforcing materials*

AS/NZS 4680, *Hot-dip galvanized (zinc) coatings on fabricated ferrous articles*

AS ISO 3452 (all parts), *Non-destructive testing — Penetrant testing*

ASTM D618, *Standard Practice for Conditioning Plastics for Testing*

ASTM D695, *Standard Test Method for Compressive Properties of Rigid Plastics*

CEN/TR 15728:2016, *Design And Use Of Inserts For Lifting And Handling Of Precast Concrete — Elements*

CEN/TS 1992-4-2:2009, *Design of fastenings for use in concrete, Part 4-2: Headed fasteners*

ETAG 001, *Metal anchors for use in concrete*

### 1.3 Terms and definitions

For the purposes of this document, as well as AS 3850.2 and AS 3850.3, the terms in AS 3600, AS 5100 and the following terms and definitions apply.

NOTE ISO and IEC maintain terminological databases for use in standardization at the following addresses:

IEC Electropedia: available at <https://www.electropedia.org/>

ISO Online browsing platform: available at <https://www.iso.org/obp>

#### 1.3.1

##### **axial insert loading**

load applied along the longitudinal axis of the insert

#### 1.3.2

##### **bending insert loading**

bending induced by a shear load applied with an eccentricity with respect to the centroid of resistance

#### 1.3.3

##### **blow-out failure**

spalling of the concrete on the side face of the anchorage component at the level of the embedded head, with no major breakout at the top concrete surface

Note 1 to entry: This is usually associated with inserts with small side cover and deep embedment [see [Figure A.4\(e\)](#)].

#### 1.3.4

##### **bondbreaker**

chemical product used to prevent bonding of freshly poured concrete to a concrete substrate

#### 1.3.5

##### **brace**

temporary support (which is usually inclined but may be horizontal in certain circumstances) that provide stability for vertical prefabricated concrete elements to prevent overturning, with both ends of the brace fitted with a pinned foot, allowing a degree of freedom for variable fixing angles

Note 1 to entry: Unless otherwise specified, a reference in this document to a brace means a primary brace.

#### 1.3.6

##### **brace insert**

component or system cast or post-installed into the prefabricated concrete element, or into a supporting member, for later attachment of a brace

**1.3.7****bracing feet or shoes**

ends of a brace that are typically pinned connections fixed to the inclined element of a brace

Note 1 to entry: These elements are used to fix braces onto a prefabricated concrete element and/or onto the bracing support.

**1.3.8****casting bed**

bed used for the manufacture of concrete elements with a flat underside

**1.3.9****characteristic compressive strength of concrete**

value of the concrete strength, as assessed by standard test, which is exceeded by 95 % of the concrete

**1.3.10****characteristic spacing**

spacing required to ensure the characteristic resistance of a single insert

**1.3.11****characteristic value**

5 % fractile (value with a 95 % probability of being exceeded, with a confidence of 90 %)

**1.3.12****cold worked****CW****CS**

cold-worked bars (e.g. by stretching) to achieve the minimum strength and ductility requirements of AS/NZS 4671

Note 1 to entry: They may have lower strengths and ductility than QT or MA bars, but all meet the minimum Ductility Class N requirements in AS/NZS 4671.

**1.3.13****compatible**

coordinated use of two (or more) separate components comprising a system without compromise to the working load limit (WLL) or utility of either component or the system and its design intent

**1.3.14****competent person**

person who has acquired through training, qualification or experience, or a combination of these, the knowledge and skills to enable that person to perform the required task

Note 1 to entry: See [Appendix B](#) of AS 3850.2 and AS 3850.3 for information on specific competent persons.

**1.3.15****component reinforcement**

reinforcement placed in conjunction with lifting, brace and fixing inserts and required to achieve the nominated capacities of the inserts

**1.3.16****concrete cone failure**

failure that corresponds to a wedge or cone of concrete surrounding the insert separating from the base material

Note 1 to entry: See [Figure A.4](#) (a)(b) and (c).

Note 2 to entry: Concrete cone failure occurs when a load is applied to an insert embedded in concrete until tensile failure of the concrete occurs and a “cone” or “wedge” of concrete is pulled from the main body of the element, together with the insert. See [Figure A.4\(a\)](#).

**1.3.17****concrete pry-out failure**

failure that corresponds to the formation of a concrete spall opposite to the loading direction under shear loading

Note 1 to entry: See [Figure A.5\(b\)](#).

**1.3.18****deadman****deadman footing**

object buried in, or secured to, the ground for the purpose of providing anchorage of a temporary support

**EXAMPLE**

Concrete pile or trench footing

**1.3.19****documentation****erection documentation**

installation documentation, drawings, arrangements, procedures and instructions for lifting and temporary support for above- and below-ground installation of elements

Note 1 to entry: Erection documentation is specified in Appendix A of AS 3850.2 and AS 3850.3.

**1.3.19.1****product-specific documentation**

specification or data sheet provided by the manufacturer of a standard precast concrete element

**1.3.19.2****project-specific documentation**

engineering project drawings, shop drawings, layout plans and elevations provided by designers which detail the requirements of elements used for individual projects

**1.3.20****drop zone**

designated restricted area in and around a construction site where items, including prefabricated concrete elements, may potentially fall through or into

Note 1 to entry: The drop zone of each construction site is determined by, and detailed in, the builders Safe Work Method Statement

**1.3.21****ductile material**

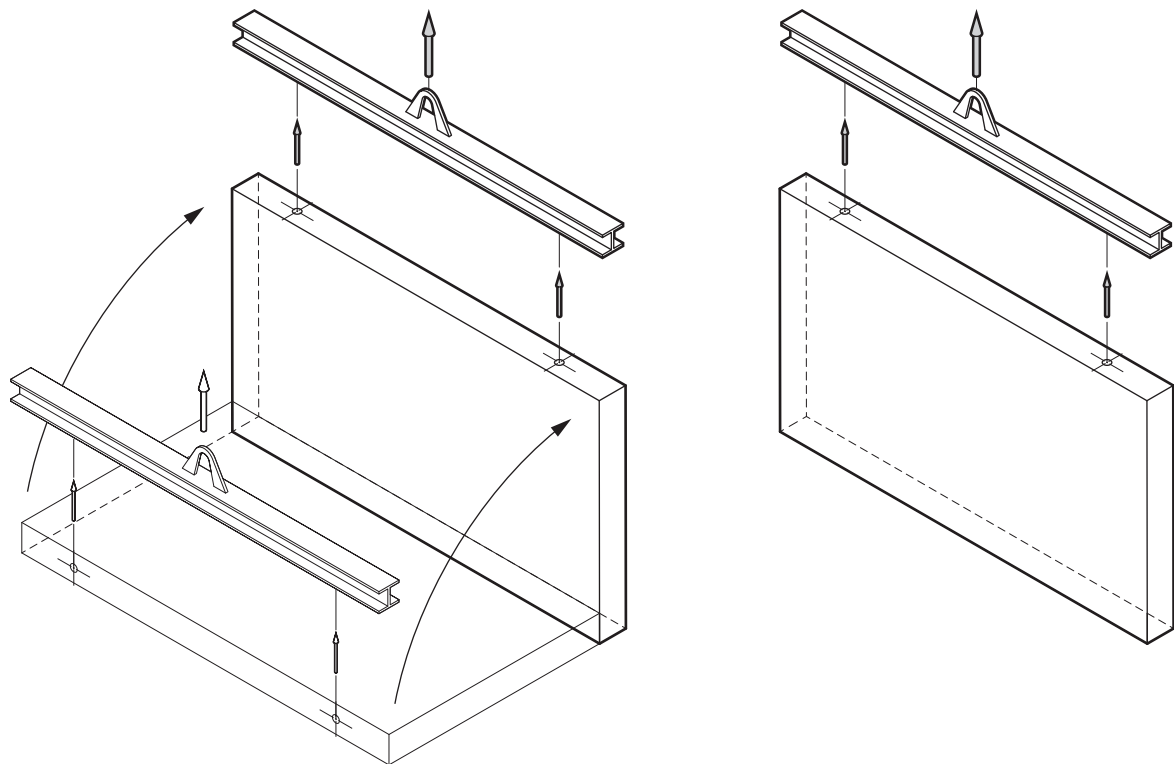
material that demonstrates plastic elongation after yielding

**1.3.22****edge distance**

distance from the edge of the concrete element to the centre of the insert

**1.3.23****edge lifting**

method of lifting a prefabricated concrete element with lifting inserts located in the thinnest edge of the element where the edge thickness is substantially less than its other dimensions (e.g. length, breadth)



(a) Horizontal and vertical edge lifting

(b) Edge lifting a panel-like element

**Figure 1.3.23 — Edge lifting a thin panel or panel-like element****1.3.24****effective embedment depth**

perpendicular distance from the concrete surface to the farthest point of an insert which is considered to effectively engage with the base material

Note 1 to entry: The effective embedment depth is generally smaller than the total length of the insert, see [Figures B.1](#) and [B.2](#).

**1.3.25****erection designer**

professional engineer who is a competent person responsible for the lifting design and erection design of the structure

**1.3.26****erection platform****crane pad****crane standing**

ground surface, temporary support structure, grillage, track, parking, or similar support, on or from which the crane is supported during operation

Note 1 to entry: Crane standing as defined in AS 2550.

**1.3.27****expansion anchors**

anchors placed in appropriately sized holes drilled in hardened concrete, which rely on expansion devices interacting with the sides of the hole to prevent pull-out under design load

Note 1 to entry: The two types of expansion anchors are the following:

- (a) *Deformation-controlled* — anchors that are expanded only during installation. Application of load to the anchor does not increase the expansion forces.
- (b) *Torque-controlled (also referred to as load-controlled)* — anchors that have a wedge and expansion-shield system where the wedge is directly connected to the applied load. Increases in load above the retained preload (obtained from initial torque) will increase the expansion force.

### 1.3.28

#### **face-lifting**

method of lifting a prefabricated concrete element using lifting inserts located in the “as cast” upper surface of the element

Note 1 to entry: See Figure 2.5.3 and Figure D1 of AS 3850.2.

### 1.3.29

#### **ferrule**

cast-in insert to accept a threaded bolt

Note 1 to entry: A ferrule is a commonly used fixing insert.

### 1.3.30

#### **fixing insert**

component or system cast or post-installed into the prefabricated concrete element and subsequently used to bolt the structure together or support or suspend other architectural or structural members and/or services

Note 1 to entry: a fixing insert is referred to as a fastener in AS 5216.

### 1.3.31

#### **fracture (surface)**

##### **fibrous fracture**

typical of ductile metal failure, the fracture surface has a dull “woody” appearance resulting from dimple failure, when viewed under a microscope

Note 1 to entry: This surface results from micro-void coalescence.

#### 1.3.31.1

##### **cleavage fracture**

typical of brittle metal failure, the fracture surface has a bright, specular appearance commonly referred to as “crystalline”

Note 1 to entry: This surface results from low energy, brittle crystal cleavage mechanisms.

### 1.3.32

#### **flat-lifting**

lifting a prefabricated concrete element where the orientation of the element does not change throughout the lift

Note 1 to entry: See Figures 2.5.3 and Figure D.1 of AS 3850.2.

### 1.3.33

#### **headed insert**

type of insert with an enlarged cast-in end that is installed before placing concrete, which transfers load to the concrete by way of mechanical interlock at the insert head

### 1.3.34

#### **innovative insert**

any insert that does not conform to the requirements of a reference insert

### 1.3.35

#### **insert spacing**

distance between the centre-lines of the inserts

**1.3.36****in-service designer**

professional engineer who is a competent person responsible for design of the structure or element to resist the load that the building or structure will experience in its lifetime subsequent to completion of construction

Note 1 to entry: The in-service engineer ensures that the design is constructible.

**1.3.37****knee brace**

element, which is part of a secondary bracing system, that reduces the effective length of a primary brace, with the secondary bracing system having a positive connection to each end and usually connecting at mid-span of main brace

Note 1 to entry: Cross-lacing may be incorporated to complete the system.

**1.3.38****leg (rigging)**

length of chain or sling

**1.3.39****levelling pad**

packing used as a means of temporarily levelling, aligning and supporting prefabricated concrete elements, which is removed after the installation of the grout

**1.3.40****lifting****lifting design**

design by a competent professional engineer of the system for lifting a prefabricated concrete element

Note 1 to entry: Lifting design forms part of erection design

**1.3.41****lifting clutch**

re-usable device used to connect the crane rigging to a compatible lifting insert

**1.3.42****lifting equipment**

machines specifically designed for lifting

Note 1 to entry: Design is in accordance with AS 1418.5.

**1.3.43****lifting insert**

component or system cast or post-installed into the prefabricated concrete element for later attachment of the lifting device

**1.3.44****mass block**

block of reinforced concrete of verifiable concrete strength

**1.3.45****may**

indicates the existence of an option

**1.3.46****micro-alloy****MA**

hot-rolled steels alloyed to achieve the desired properties

Note 1 to entry: Some grades meet AS/NZS 4671, Ductility Class E requirements for seismic applications.

**1.3.47****minimum element thickness**

minimum element thickness in which an insert can be installed

**1.3.48****mould**

casting surface used for the manufacture of prefabricated concrete elements

**1.3.49****plate style edge lift insert**

insert, essentially planar in form, that is shaped to provide concrete interlock

Note 1 to entry: For typical edge lift insert, see [Figure C2.5.2.2](#).

**1.3.50****precast element**

prefabricated concrete element

**1.3.51****prefabricated concrete element**

concrete element manufactured at a place different from its final place of installation

**C1.4.39** *Prefabricated elements may be manufactured on or off site and essentially include all concrete elements that are not cast in situ.*

**1.3.52****prepared, even surface**

surface, e.g. ground, which has been graded and rolled or otherwise compacted so as to facilitate the smooth travel of vehicles over the surface

**1.3.53****professional engineer**

engineer who is either —

- (a) a member of a scheme established under Professional Standards Legislation in the relevant jurisdiction;
- (b) registered in a relevant area of practice on the National Engineering Register;
- (c) a Chartered Professional Engineer (CPEng) or possesses equivalent qualifications recognized by Engineers Australia with experience in a relevant area of practice; or
- (d) a person eligible for the grade of Member of Engineers Australia as a Professional Engineer (MIEAust) with experience in the relevant area of practice

**1.3.54****progressive collapse**

continuous sequence of failures initiated by the local failure of one part of the structure

**1.3.55****prop**

temporary supports for prefabricated concrete elements perpendicular to the surface of the elements, primarily for supporting gravity and construction loads, and usually vertical

**1.3.56****proprietary product**

product, component or system of components for which the intellectual property, technology, design intent, design specifications for dimensions and their tolerances, materials and their properties, methods and processes of manufacture are the property of an individual person (including a corporate entity)

Note 1 to entry: The design and manufacture of a proprietary item may not be covered by an Australian Standard or other accepted Standard.

**1.3.57****pull-out failure**

failure mode in which the insert pulls out of the concrete without development of a concrete cone

Note 1 to entry: For a depiction of pull-out failure, see [Figure A.4\(d\)](#).

**1.3.58****quenched and self tempered****QT****QST**

hot-rolled low carbon steels which are thermally treated by quenching and self-tempering to provide high strength and ductility

**1.3.59****reference insert**

round body headed insert with a minimum net bearing area of four times the cross-sectional area of the body of the insert in accordance with Clause 13.1.4 of AS 3600 and AS 5100, and a head diameter at least equal to 2.4 times the shaft diameter (i.e.  $d_h > 2.4 d_s$ ) in accordance with Clause 8.3.2 of CEN/TR 15728:2016

Note 1 to entry: The bearing area is the head area less the shaft area, see [Figure B.1](#).

**1.3.60****release agent**

chemical product used to prevent bonding of the freshly poured concrete to a substrate other than concrete

**1.3.61****re-usable lifting equipment**

device that connects the rigging directly to the element or a lifting insert

Note 1 to entry: Examples are a lifting clutch, eye bolt, shackle and bolt-on brackets.

**1.3.62****screw-bolt**

bolt with an external helical thread designed to be directly screwed into a hole drilled in concrete

**1.2.63****shall**

indicates that a statement is mandatory

**1.3.64****shear insert loading**

shear induced by a load applied perpendicular to the longitudinal axis of the insert

**1.3.65****shim**

plastic polymer shims used as a means of temporarily levelling, aligning and supporting prefabricated concrete elements, which remain in place after the installation of the grout

**1.3.66****shop drawing**

drawings, diagrams including schedules and other data which define elements used for construction

Note 1 to entry: Typically prepared from an engineering and architectural project drawing.

**1.3.67****should**

indicates a recommendation

**1.3.68****side lifting**

lifting a prefabricated concrete element with lifting inserts located in the vertical or near-vertical sides of the element where the side length is not substantially less than the breadth or width of the element, i.e. not a panel-like element

**1.3.69****slenderness ratio of a brace (temporary support)**

effective length of the brace divided by the minimum radius of gyration at the mid-point of the brace

**1.3.70****splitting failure**

concrete failure mode in which the concrete fractures along a plane passing through the axis of the insert or inserts

Note 1 to entry: For a depiction of splitting failure, see [Figure A.4\(f\)](#).

**1.3.71****stack casting**

casting one prefabricated concrete element on top of another

**1.3.72****strongback**

temporary member used to provide localized strengthening, support or a suitable tilting edge for prefabricated concrete elements

**1.3.73****structural reinforcement**

reinforcement, including reinforcing steel and prestressing tendons, provided for crack control or to resist forces caused by in-service loading and thermal and shrinkage movements

**1.3.74****supplementary reinforcement**

reinforcement, in addition to the structural and component reinforcement which is provided to resist actions induced during manufacture, handling, transport, construction and erection and in-service and ultimate conditions

**1.3.75****temporary fixing**

fixing that is designed to transfer temporary loads during construction

Note 1 to entry: Temporary fixings are not required to transfer loads in the permanent structure.

**1.3.76****tilt-up**

method of lifting a prefabricated concrete element from a horizontal to a vertical position by rotation about one edge

**1.3.77****tilt-up element**

prefabricated concrete elements lifted or erected by the tilt-up method

**1.3.78****unprepared, uneven surface**

rough ground or similar surface which has not been graded, compacted or otherwise prepared for the travel of vehicles

**1.3.79****working load class**

descriptor of the class or size of a system of components indicating the maximum WLL of the system derived from the minimum characteristic strength of the component materials

Note 1 to entry: The WLL may be less than the Working load class of an insert in concrete where the WLL is limited by concrete failure to less than the failure of the insert material e.g. steel failure.

**1.3.80****working load limit****WLL**

maximum load that may be applied to an item, component or system

Note 1 to entry: For design purposes, this is an unfactored load in terms of AS/NZS 1170.0 and not the design load.

**1.4 Symbols**

|                  |   |                                                                                                                                                                                                                         |
|------------------|---|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $A_{c,N}$        | = | actual projected area for concrete cone failure of single insert idealized as a rectilinear pyramid of height $h_{ef}$                                                                                                  |
| $A_{c,Nb}$       | = | idealized projected area for concrete blow-out                                                                                                                                                                          |
| $A_{c,V}$        | = | idealized area of concrete cone at the lateral concrete surface for shear failure                                                                                                                                       |
| $A_h$            | = | loadbearing area of the head of the insert                                                                                                                                                                              |
| $A_{c,N}^0$      | = | projected concrete failure area of a single insert idealized as a rectilinear pyramid of height $h_{ef}$ and base length $S_{i,cr,N} = 3 h_{ef}$ where the distance to an edge is equal to or greater than $1.5 h_{ef}$ |
| $A_{c,Nb}^0$     | = | reference projected area for concrete blow-out                                                                                                                                                                          |
| $A_{c,V}^0$      | = | idealized area of concrete cone of an individual insert at the lateral concrete surface not affected by edges, element thickness or adjacent inserts                                                                    |
| $A_s$            | = | stress cross-sectional area of brace insert bolt                                                                                                                                                                        |
| $A_{s,re}$       | = | cross-section area of the splitting reinforcement                                                                                                                                                                       |
| $a$              | = | spacing of stirrups or wire mesh                                                                                                                                                                                        |
| $COV$            | = | Coefficient of variation                                                                                                                                                                                                |
| $c$              | = | edge distance                                                                                                                                                                                                           |
| $c_i$            | = | edge distance measured from the centre of an insert shaft to the edge of the concrete                                                                                                                                   |
| $c_{i,cr,N}$     | = | minimum edge distance required to achieve the characteristic tension load resistance                                                                                                                                    |
| $c_{i,cr,N,mod}$ | = | modified minimum value for edge distance to achieve characteristic resistance to tension load                                                                                                                           |
| $c_{i,cr,sp}$    | = | minimum value for edge distance to achieve characteristic resistance to splitting                                                                                                                                       |

|               |   |                                                                                                                                |
|---------------|---|--------------------------------------------------------------------------------------------------------------------------------|
| $c_{i,max}$   | = | maximum distance from centre of an insert to the edge of concrete element                                                      |
| $c_{i,min}$   | = | minimum value for edge distance to achieve characteristic resistance                                                           |
| $c_{i,1}$     | = | edge distance to first edge                                                                                                    |
| $c_{i,1,mod}$ | = | modified edge distance to first edge                                                                                           |
| $c_{i,2}$     | = | edge distance to second edge                                                                                                   |
| $c_{i,2,max}$ | = | largest of two edge distances parallel to the direction of loading                                                             |
| $d_{cut,m}$   | = | medium cutting diameter of drill bit                                                                                           |
| $d_f$         | = | diameter of clearance hole in the shear test sleeve                                                                            |
| $d_i$         | = | diameter of the shank of insert                                                                                                |
| $d_{i,h}$     | = | diameter of the head of insert                                                                                                 |
| $d_{i,nom}$   | = | nominal outside diameter of the insert                                                                                         |
| $f_{bd}$      | = | design bond strength                                                                                                           |
| $f_{cm}$      | = | mean value of the <i>in situ</i> compressive strength of concrete at the relevant age                                          |
| $f_{lift}$    | = | compressive strength of concrete at the time of lifting                                                                        |
| $FoS$         | = | “Factor of Safety” — working load limit factor                                                                                 |
| $f_{sy}$      | = | nominal yield strength of the reinforcing steel                                                                                |
| $f_{su}$      | = | characteristic ultimate strength of insert                                                                                     |
| $f'_c$        | = | characteristic compressive (cylinder) strength of concrete at 28 days assessed in accordance with AS 1379 Clauses 5 and 6      |
| $f'_{ct}$     | = | characteristic uniaxial tensile strength of concrete                                                                           |
| $f'_{c,age}$  | = | characteristic compressive strength of concrete at an age other than 28 days, assessed in accordance with AS 1379 Clause 5.3.2 |
| $H$           | = | concrete element depth                                                                                                         |
| $H_{min}$     | = | minimum concrete element thickness required to avoid splitting failure                                                         |
| $h_{ef}$      | = | effective embedment depth of the insert                                                                                        |
| $h_{ef,mod}$  | = | modified effective depth of embedment for narrow elements                                                                      |
| $k_{cr}$      | = | factor relating to condition of concrete (cracked/non-cracked)                                                                 |
| $k_s$         | = | sampling factor                                                                                                                |
| $l_f$         | = | loadbearing length of the insert in shear = $h_{ef}$ in case of a uniform diameter of the shank of the headed insert           |
| $N_d$         | = | design tensile strength of brace insert                                                                                        |
| $N_{m,bas}$   | = | mean tensile strength of the brace insert determined from basic tension tests                                                  |

|                 |   |                                                                                                               |
|-----------------|---|---------------------------------------------------------------------------------------------------------------|
| $N_{m,c,bas}$   | = | mean ultimate load of concrete cone failure based on basic tension tests                                      |
| $N_{m,p,bas}$   | = | mean ultimate load of pull-out failure mode based on basic tension tests                                      |
| $N_{m,pcyc}$    | = | mean ultimate tensile strength of the insert determined from post-cyclic slip tension tests                   |
| $N_{m,s,bas}$   | = | mean ultimate load of steel based on basic tension tests                                                      |
| $N_s$           | = | tension component of the applied load                                                                         |
| $N_{s,lim}$     | = | tensile strength of the brace insert determined in accordance with AS 4100                                    |
| $N_u$           | = | characteristic tensile resistance of insert                                                                   |
| $N_{ult}$       | = | ultimate load of a given test                                                                                 |
| $N_{uslip}$     | = | load at uncontrolled slip of the brace insert                                                                 |
| $N_{u,bas}$     | = | characteristic ultimate tensile strength of the brace insert determined from basic tension tests              |
| $N_{u,c}$       | = | characteristic tensile resistance of an insert in the case of concrete cone failure                           |
| $N_{u,c,bas}$   | = | characteristic ultimate load of concrete cone failure based on basic tension tests                            |
| $N_{u,c,Inn}$   | = | characteristic tensile resistance of an innovative insert to concrete cone failure                            |
| $N_{u,c,Ref}$   | = | characteristic tensile resistance of a reference insert to concrete cone failure                              |
| $N_{u,c,\beta}$ | = | basic concrete breakout strength of an insert loaded in tension, accounting for the shape modification factor |
| $N_{u,cb}$      | = | characteristic resistance of an insert in the case of blow-out failure                                        |
| $N_{u,cb,Inn}$  | = | characteristic tensile resistance of an innovative insert in the case of blow-out failure                     |
| $N_{u,cb,Ref}$  | = | characteristic tensile resistance of a reference insert in the case of blow-out failure                       |
| $N_{u,p}$       | = | characteristic resistance of an insert in the case of pull-out failure                                        |
| $N_{u,pcyc}$    | = | characteristic tensile strength of the brace insert determined from post-cyclic slip tension tests            |
| $N_{u,p,bas}$   | = | characteristic ultimate load of pull-out failure mode based on basic tension tests                            |
| $N_{u,p,Inn}$   | = | characteristic tensile resistance of an innovative insert in the case of pull-out failure                     |
| $N_{u,p,Ref}$   | = | characteristic tensile resistance of a reference insert in the case of pull-out failure                       |
| $N_{u,ref}$     | = | characteristic resistance of an insert having predefined reference geometry                                   |
| $N_{u,s,bas}$   | = | characteristic ultimate load of steel based on basic tension tests                                            |
| $N_{u,sp}$      | = | characteristic resistance of an insert in the case of splitting failure                                       |
| $N_{u,sp,Inn}$  | = | characteristic tensile resistance of an innovative insert in the case of concrete splitting failure           |
| $N_{u,sp,Ref}$  | = | characteristic tensile resistance of a reference insert in the case of concrete splitting failure             |

|                  |   |                                                                                                                                                                                                                                                                                           |
|------------------|---|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $N_{u,c}^0$      | = | characteristic resistance of a single insert placed in cracked concrete and not influenced by adjacent inserts or edges of the concrete element for concrete cone failure/characteristic tensile pull-out strength of an insert when tested in accordance with <a href="#">Clause A.7</a> |
| $N_{u,cb,2}^0$   | = | characteristic resistance of an insert to blow-out failure, not influenced by adjacent inserts or free structural component edges placed in cracked concrete including the shape modification factor                                                                                      |
| $N_1$            | = | load corresponding to limit for uncontrolled slip                                                                                                                                                                                                                                         |
| $N^*$            | = | design tension load applied to insert                                                                                                                                                                                                                                                     |
| $N_s^*$          | = | design tension component of the applied load                                                                                                                                                                                                                                              |
| $n$              | = | accumulated sample size or total number of components tested to destruction                                                                                                                                                                                                               |
| $R_u$            | = | critical characteristic strength of an element or assemblage (limiting case of $N_k$ , $V_k$ or a combination of these)                                                                                                                                                                   |
| $R_{u,N}$        | = | critical characteristic ultimate normalized tensile strength of the insert considering the effects of slip due to cyclic loading                                                                                                                                                          |
| $R_{u,Ncp}$      | = | characteristic ultimate tensile strength of post-installed brace insert normalized to a concrete strength equal to 20 MPa for concrete cone failure or pull-out failure                                                                                                                   |
| $R_{u,Ns}$       | = | characteristic ultimate tensile strength of post-installed brace insert for steel failure                                                                                                                                                                                                 |
| $R_{u,V}$        | = | critical characteristic ultimate normalized shear strength of the insert                                                                                                                                                                                                                  |
| $R_{u,Vc}$       | = | characteristic ultimate shear strength of post-installed brace insert normalized to a concrete strength equal to 20 MPa for concrete failure                                                                                                                                              |
| $R_{u,Vs}$       | = | characteristic ultimate shear strength of post-installed brace insert for steel failure                                                                                                                                                                                                   |
| $s$              | = | standard deviation of a finite population of components tested to destruction                                                                                                                                                                                                             |
| $s_i$            | = | spacing of inserts                                                                                                                                                                                                                                                                        |
| $s_{i,cr,N}$     | = | critical spacing to ensure adjacent inserts do not influence characteristic tensile resistance of insert                                                                                                                                                                                  |
| $s_{i,cr,N,mod}$ | = | modified critical spacing to ensure characteristic tensile resistance of insert in a narrow element                                                                                                                                                                                       |
| $s_{i,cr,sp}$    | = | critical spacing to ensure adjacent inserts do not influence characteristic splitting resistance of insert                                                                                                                                                                                |
| $s_{i,max}$      | = | maximum centre to centre spacing of inserts in a group                                                                                                                                                                                                                                    |
| $s_{i,min}$      | = | minimum spacing required to avoid splitting failure                                                                                                                                                                                                                                       |
| $s_{i,1}$        | = | spacing of inserts in direction 1                                                                                                                                                                                                                                                         |
| $s_{i,2}$        | = | spacing of inserts in direction 2                                                                                                                                                                                                                                                         |
| $S_t$            | = | test load                                                                                                                                                                                                                                                                                 |
| $T$              | = | torque                                                                                                                                                                                                                                                                                    |
| $T_{inst}$       | = | installation torque                                                                                                                                                                                                                                                                       |

|                      |   |                                                                                                                                                                                                      |
|----------------------|---|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $t_{\text{fix}}$     | = | thickness of shear test sleeve                                                                                                                                                                       |
| $V_s$                | = | shear component of the applied load                                                                                                                                                                  |
| $V_{s,\text{lim}}$   | = | shear strength of the brace insert determined in accordance with AS 4100                                                                                                                             |
| $V_{u,\text{bas}}$   | = | basic characteristic shear strength of the brace insert for concrete mode of failure                                                                                                                 |
| $V_{u,c}$            | = | characteristic shear resistance of an insert                                                                                                                                                         |
| $V_{u,c,\text{Inn}}$ | = | characteristic shear resistance of an innovative insert in the case of concrete edge failure                                                                                                         |
| $V_{u,c,\text{Ref}}$ | = | characteristic shear resistance of a reference insert in the case of concrete edge failure                                                                                                           |
| $V_{u,c}^0$          | = | characteristic shear strength of a reference insert ( $R$ ), being a round body, cast-in headed insert with a minimum net bearing area of 4 times the cross-sectional area of the body of the insert |
| $V_{u,c,2}^0$        | = | initial value of the characteristic resistance of an insert loaded perpendicular to the edge in cracked concrete, including provision for a shape modification factor                                |
| $V^*$                | = | design shear load applied to insert                                                                                                                                                                  |
| $V_s^*$              | = | design shear component of the applied load                                                                                                                                                           |
| $w_k$                | = | width of crack                                                                                                                                                                                       |
| $\bar{x}$            | = | mean value of the test results of the accumulated sample of components                                                                                                                               |
| $x_i$                | = | test result of each individual component of the sample                                                                                                                                               |
| $X_k$                | = | characteristic value of the test values                                                                                                                                                              |
| $z$                  | = | internal lever arm of the concrete element                                                                                                                                                           |
| $\alpha$             | = | influencing factor based on the shape of the supplementary reinforcement                                                                                                                             |
| $\alpha_0$           | = | parameter used to reduce characteristic strength based on ratio of post-cyclic tensile strength to basic tensile strength                                                                            |
| $\alpha_1$           | = | parameter used to reduce characteristic strength based on basic tension tests                                                                                                                        |
| $\alpha_2$           | = | parameter used to reduce characteristic strength based on post-cyclic slip tension tests                                                                                                             |
| $\alpha_3$           | = | reduction factor for uncontrolled slip for basic tension tests                                                                                                                                       |
| $\alpha_4$           | = | reduction factor for uncontrolled slip for post-cyclic slip tension tests                                                                                                                            |
| $\beta_{c,N}$        | = | tension shape modification factor for concrete cone failure                                                                                                                                          |
| $\beta_{c,V}$        | = | tension shape modification factor for concrete blow-out failure                                                                                                                                      |
| $\beta_{p,N}$        | = | tension shape modification factor for pull-out failure                                                                                                                                               |
| $\beta_{sp,N}$       | = | tension shape modification factor for concrete splitting failure                                                                                                                                     |
| $\emptyset$          | = | capacity reduction factor                                                                                                                                                                            |
| $\emptyset_c$        | = | capacity reduction factor for fixings to concrete                                                                                                                                                    |
| $\emptyset_s$        | = | capacity reduction factor for bolted connections in shear                                                                                                                                            |

|                |   |                                                                                                                                                     |
|----------------|---|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| $\psi_c$       | = | factor to normalize brace insert strength according to concrete strength                                                                            |
| $\psi_{h,sp}$  | = | factor accounting for the effect of element thickness on splitting failure                                                                          |
| $\psi_{h,V}$   | = | factor accounting for the effect of element thickness on shear failure                                                                              |
| $\psi_{re,V}$  | = | a factor accounting for the effect of the state of the concrete and the type of reinforcement at the edge                                           |
| $\psi_{s,N}$   | = | factor accounting for the disturbance of stresses in the concrete due to edges of the concrete element for tension loading                          |
| $\psi_{s,Nb}$  | = | factor accounting for the disturbance of the distribution of stresses in the concrete due to a corner of the concrete element for break-out failure |
| $\psi_{s,V}$   | = | factor accounting for the disturbance of the distribution of stresses in the concrete due to a corner of the concrete element for shear failure     |
| $\psi_{ucr,N}$ | = | factor relating to the state of the concrete (cracked/non-cracked) for tension loading                                                              |
| $\sigma_{adm}$ | = | admissible tensile stress for the definition of non-cracked concrete                                                                                |
| $\sigma_L$     | = | stresses in the concrete induced by external loads including insert loads                                                                           |
| $\sigma_R$     | = | stresses in the concrete due to restraint of intrinsic imposed deformations or extrinsic imposed deformations                                       |

## 2 Materials, components and equipment

### 2.1 General

All components to be used on site within a system shall be compatible.

Components of proprietary systems shall not be substituted without verification of their compatibility (including WLL) and that the components when assembled together satisfy the design intent of the system of which they form a part.

Verification of compatibility of proprietary components shall be proven by design and testing in accordance with [Appendix A](#) and documented and certified by a professional engineer competent for component design (refer [Appendix C](#)).

Where proprietary components of a system are substituted with other products, the in-service designer and or the erection designer (as applicable) shall assess and certify that the component substitution is compatible and does not compromise the intent of the design for which the system has been specified for use.

The clutch, the insert and the insert void former of a lifting system shall be compatible.

The WLL of a lifting clutch shall not be less than the lifting insert with which it is designed to be compatible.

**C2.1** *Incompatibility of different types of inserts or sizes may lead to failure. This is particularly relevant to lifting inserts, lifting clutches, bolts and ferrules. It should be ensured that all components within a system are compatible.*

*Just because two components "fit" together does not mean that they are compatible, e.g. a nut which fits a Grade 4.6 bolt has the same dimensions and fits a Grade 8.8 structural bolt but is not compatible.*

(continued)

*Not all lifting components or systems function identically. Substitution of proprietary system components can lead to changes in function and behaviour of the specified system. On-site substitutions of proprietary clutches inserts and void formers have resulted in serious accidents arising from incompatibility of design, materials or function of the substituted components from the proprietary system specified by the in-service, lifting and or erection designer.*

*Adopting the lowest WLL of a combination of components may not be a safe practice. Any combination should be determined by testing in accordance with [Appendix A](#).*

## 2.2 Working load limit (WLL) calculation

The working load limit for the components (and component assembly if applicable) listed in [Table 2.1](#) shall be calculated as follows:

$$WLL = R_u / FoS$$

Each test result that relies on steel failure of a steel component shall be normalized as follows:

$$R_u = R_{\text{test}} \left( \frac{R_m}{R_{m,\text{test}}} \right)$$

where

$R_{\text{test}}$  = result of the element, insert and/or assembly established in the test

$R_m$  = characteristic ultimate tensile strength of the steel of a component as specified by the manufacturer

$R_{m,\text{test}}$  = measured ultimate tensile strength of the steel of the component used in the test

NOTE 1 Where a component consists of multiple parts, each part shall be normalized as above.

Where  $R_u$  is the critical characteristic strength, determined by investigating modes of failure for the components listed in [Table 2.1](#), 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 [Clause A.7](#), [Appendix A](#), and [Appendix B](#).

NOTE 2 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 3 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 |
| Cast-in lifting inserts            | 2.25 |
| Lifting clutches                   | 4.00 |

Table 2.1 (continued)

| Component type                                                                         | FoS  |
|----------------------------------------------------------------------------------------|------|
| Levelling pads and shims                                                               | 1.20 |
| 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 |

## 2.3 Concrete and reinforcement

Cementitious materials, aggregate, additives, reinforcement and tendons shall comply with the appropriate clauses and materials Standards, as specified in AS 3600 and AS 5100 as applicable.

Test cylinders used to determine  $f'_{c,age}$  shall be stored and cured in the same environmental conditions (same location and temperature) as the concrete being tested.

The method of testing to determine  $f'_{c,age}$  that shall be used to accurately predict the pullout capacity of the *in situ* concrete at the lifting insert or brace fixing locations. Where test cylinders are used, they shall be stored and cured in the same environmental conditions (same location and temperature) as the element being manufactured, the brace footing concrete, and be from the same concrete pour and at the same time as the pour of the element or brace footing.

**C2.3** Calcium chloride may corrode the reinforcement or cause increased shrinkage, and should not be used as an additive in its own right to increase the rate of strength gain of the prefabricated concrete element concrete, except as permitted in AS 1478.1.

## 2.4 Curing compounds and release agents

Curing compounds shall comply with AS 3799.

Where curing compounds, bondbreakers and release agents are used together, they shall not compromise the effectiveness of each to perform their respective functions.

**C2.4** The strength, permeability and durability of concrete are dependent on it being adequately cured. The 'suction' between the precast concrete element and the casting bed should be kept to a minimum to reduce the stresses on the prefabricated concrete element.

When selecting curing compounds, release agents and bondbreaker, considerations should include the following:

- (a) **Effectiveness of bondbreaker and release agents** — The effectiveness of the bondbreaker, release agents and the curing compound should not be compromised by either compound. In the absence of previous experience, testing is highly recommended.
- (b) **Tests** — Simple tests that check the effectiveness of the bondbreaker or release agent after application should be available to the applicator. The supplier should supply details of the test.
- (c) **Solubility** — Rain may affect the performance of release agents and bondbreakers. They should be retested after rain in accordance with the supplier's instruction.
- (d) **Discolouration** — Where a pigmented product is used, the pigmentation should weather off within a reasonable time.
- (e) **Temperature effects** — The product should be suitable for the climate at the project location, for example extreme temperatures may blister the product and cause it to lose its properties.

(f) **Effect on finishes** — *The adherence of applied finishes, including joint sealants, should not be affected.* (continued)

*Products should be used in accordance with the supplier's instructions.*

## 2.5 Lifting, brace and fixing inserts

### 2.5.1 General

All lifting inserts, brace inserts and ferrules shall be manufactured from ductile materials. Cast-in inserts shall not be welded without written permission dependent upon knowledge of the specified design, material properties of the cast-in insert, and the effects of welding on these properties. Permission shall specify the required weld design, process and procedure in accordance with the relevant part or parts of the AS/NZS 1554 series. Permission shall not reduce the strength or ductility of the cast-in insert.

NOTE Written permission should be provided by the insert manufacturer.

The washers used for all brace inserts and ferrules shall be of an appropriate size and strength to transfer the load. When used with braces, they shall also be of sufficient size to retain the attached fixing in the brace shoe.

Reinforcement and prestressing strands, bent to receive a hook or shackle and cast into the prefabricated concrete element, shall not be used for lifting unless conformance with [Clauses 2.5.1](#) and [2.5.2](#) can be demonstrated.

A lifting system shall comply with [Clause 2.5.2](#) unless it is not practicable for a particular prefabricate concrete element (e.g. some types of lattice girder elements or odd-shaped elements). In this case, an analysis of the lifting system and the materials shall be conducted. Such analysis shall be carried out and verified by a competent engineer.

All non-thread hot dip galvanized products shall conform with AS/NZS 4680. All threaded hot dip galvanized products shall conform with AS/NZS 1214.

**C2.5.1** *The strength of a given insert will be dependent on the embedded length and inserts will need to be installed in accordance with the supplier's requirements.*

*The slots in brace shoes are typically 22 mm to 24 mm wide and a suitable structural washer of adequate strength and width will be required to transfer the brace load to the insert.*

*Where an insert projects from the surface of a prefabricated element, there is increased risk of damage to the insert and the element. Provision should be made to protect the integrity of such inserts and elements.*

### 2.5.2 Lifting inserts

#### 2.5.2.1 General

The WLL for lifting inserts shall be determined in accordance with [Clause 2.2](#).

Lifting inserts shall not be made from cast metals or materials that do not have reliable homogenous mechanical properties.

Lifting inserts shall be manufactured from ductile materials, which exhibits plastic deformation prior to failure, at all service temperatures for which the inserts are designed to be used.

NOTE 1 The typical service temperature for inserts in Australia is -10°C to +80 °C.

NOTE 2 Materials and manufacturing processes should ensure that the condition of inserts, as supplied, are free from embrittlement, including temper, strain-age, hydrogen and liquid metal embrittlement.

During the design validation, when lifting inserts are loaded in tension to ultimate failure—

- (a) there shall be evidence of a ductile failure and plastic deformation of the material; and
- (b) the failure surface shall be fully fibrous, with no evidence of cleavage fracture, consistent with ductile failure.

The insert assembly, which includes the void former, shall be marked with the manufacturer's name or symbol and the working load class to ensure compatibility with other system components.

Lifting inserts may rely on component reinforcement to achieve their ultimate capacities. Where such is the case, the  $R_u$  of the anchor shall be determined by testing the anchor and component reinforcement together as a system in concrete.

**C2.5.2.1** *The requirements of [Clause 2.5.2.1](#) are not intended to prevent the use of other suitable metals that meet the performance requirements of this Standard. Some guidance may be obtained by referring to CEN/TR 15728:2016.*

#### **2.5.2.2 Additional requirements for tension testing of lifting systems that require component reinforcement**

Where a plate style edge lift insert is used, it shall have component reinforcement (tension bar) fitted and incorporate integral tension legs.

Edge lift inserts shall be tested in accordance with [Appendix A](#), both with and without a tension bar.

The WLL of an edge lift insert shall be determined from tests, with the tension bar fitted, in accordance with [Clause 2.2\(a\)](#).

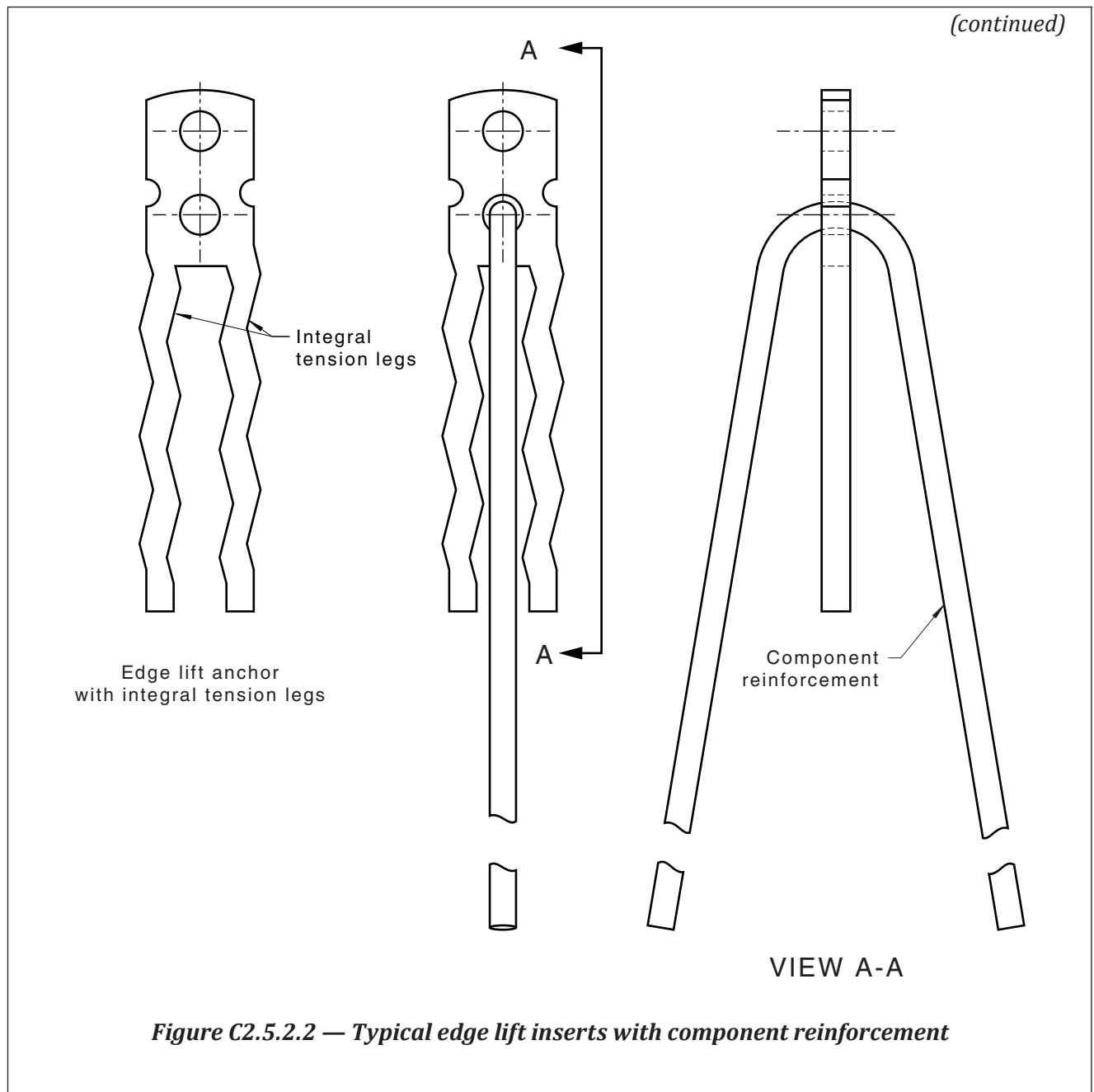
All plate style edge lift inserts, and some other inserts, require component reinforcement. The details of the required component reinforcement shall be obtained from the suppliers of these items.

When tested without a tension bar or component reinforcement, the characteristic strength  $R_u$  of an edge lift insert shall be not less than WLL of the insert with a tension bar.

If lifting inserts rely on component reinforcement, the size, shape, material properties, orientation and installation tolerances of the bar(s) shall be specified in the manufacturer's documentation.

Where component reinforcement is required, it shall be in accordance with AS/NZS 4671. The bending of reinforcing shall be in accordance with AS 3600 and AS 5100 as applicable.

**C2.5.2.2** *While the tension bar is part of the overall lifting system, the additional anchorage provided by it into the element can act as an integral anchorage to the lifting insert in circumstances where manufacturing error may not have properly anchored the lifting insert into the element (see [Figure C2.5.2.2](#)).*



### 2.5.2.3 Marking of lifting inserts

Lifting inserts shall be permanently marked to enable identification and conformance with the erection documentation and the determination of the compatible lifting clutch.

The markings shall be visible when the insert is installed in concrete in accordance with the manufacturer's documented instructions.

Inserts where the design characteristic strength and WLL are determined by concrete interlock and breakout capacity only (i.e. inserts without tension bars) shall be marked as follows:

- (a) The manufacturer's name, symbol and or item code.
- (b) The maximum WLL of the insert.
- (c) The nominal length from which the embedment depth can be determined from the manufacturer's documentation.

### 2.5.2.4 Additional requirements for flexible wire rope loop lifting inserts

A wire rope loop lifting insert shall be a proprietary product and meet the requirements set out in this clause.

These inserts are used in prefabricated concrete elements designed in accordance with AS 3850.3.

It shall be manufactured as a closed loop (swaged ferrule connection) as shown in [Figure 2.5.2.3.1](#).

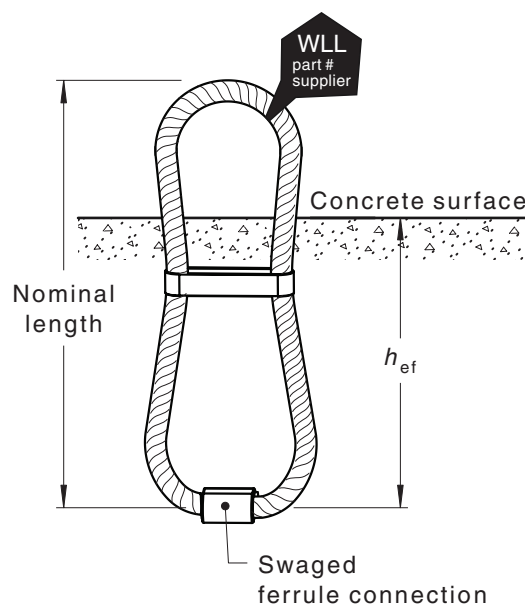


**Figure 2.5.2.3.1 — Wire rope loop lifting insert**

The wire rope shall conform with AS 2759 and be manufactured from galvanised wires of grade 1770 MPa-1960 MPa. The preferred wire grade is 1770 MPa. Where wire grades higher than 1770 MPa are used and the mechanism of failure is breakage of the wire rope clear of the swaged ferrule, when tested in accordance with [Appendix A](#), the characteristic loop strength shall be normalized to a loop made of Grade 1770 MPa wires

The loop shall be fitted with a durable identification tag showing the WLL and the manufacturer's name or symbol.

The wire ropes shall have a multi-strand flexible construction with a minimum number of wires depending upon the rope diameter as shown in [Table 2.2](#).

**Table 2.2 — Wire rope loop construction details**

| <i>T</i> diameter      | Minimum number of wires | Typical rope construction   |
|------------------------|-------------------------|-----------------------------|
| $d \leq 14 \text{ mm}$ | 114                     | (steel wire $6 \times 19$ ) |
| $d > 14 \text{ mm}$    | 186                     | (steel wire $6 \times 31$ ) |

The loop shall not be made from a single strand or a multiple of single strands.

The manufacturers documentation shall clearly indicate the required embedment depth of the wire rope loop.

NOTE 1 Wire rope loop lifting inserts typically require component reinforcement (designed by the Lifting Designer) to provide confinement and anchorage of the lifting system.

The loop shall be lifted with a shackle or purpose-built device with a minimum  $D/d$  ratio of 3.5 between the rope diameter  $d$  and the diameter  $D$  of the lifting device as follows: