

AS 3850.2:2024



STANDARDS
Australia



Prefabricated concrete elements

Part 2: Building construction



AS 3850.2:2024

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Part 2: Building construction

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Preface

This Standard was prepared by the Standards Australia Committee BD-066, Prefabricated Concrete Elements, and supersedes AS 3850.2:2015.

The objective of this document is to provide requirements for safety in the planning, manufacturing, construction, design, casting, transportation, erection and incorporation of these factors into the final structure of prefabricated concrete elements in building construction.

This document complements AS 3850.1 and AS 3850.3.

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

The terms “normative” and “informative” are used in Standards to define the application of the appendices or annexes to which they apply. A “normative” appendix or annex is an integral part of a Standard, whereas an “informative” appendix or annex is only for information and guidance.

This Standard includes a commentary on some of the clauses. 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 document.

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Australian Standard®

Prefabricated concrete elements

Part 2: Building construction

1 Scope and general

1.1 Scope

This Standard sets out requirements which impact on safety for planning, construction, design, casting, transportation, erection and incorporation into the final structure of prefabricated concrete elements in building construction. It applies to all prefabricated concrete elements e.g. wall elements, columns, beams, flooring and facade elements.

This document does not cover the in-service design of these elements.

Additional requirements for some products are covered in other Standards.

This document does not cover the following elements:

- (a) Prefabricated concrete elements for civil construction. Refer to AS 3850.3.
- (b) Small individual concrete elements that can be handled manually (e.g. bricks, blocks and pavers).

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 1379, *Specification and supply of concrete*

AS 1657, *Fixed platforms, walkways, stairways and ladders — Design, construction and installation*

AS 2159, *Piling — Design and installation*

AS 2550 (all parts), *Cranes, hoists and winches — Safe use*

AS 3600, *Concrete structures*

AS 3610.1, *Formwork for concrete, Part 1: Specifications*

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

AS 3850.1, *Prefabricated concrete elements, Part 1: General requirements*

AS 4100, *Steel structures*

AS 4991, *Lifting devices*

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

AS(/NZS) 1100 (series), *Technical drawing*

AS/NZS 1170.0, *Structural design actions, Part 0: General principles*

AS/NZS 1170.1, *Structural design actions, Part 1: Permanent, imposed and other actions*

AS/NZS 1170.2, *Structural design actions, Part 2: Wind actions*

AS/NZS 1554 (series), *Structural steel welding*

AS/NZS 2425, *Bar chairs in reinforced concrete — Product requirements and test methods*

AS/NZS 4671, *Steel for the reinforcement of concrete*

1.3 Terms and definitions

For the purposes of this document, the following terms and definitions given in AS 3850.1 and AS 3600 and the following apply.

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

may

indicates the existence of an option

1.3.2

shall

indicates that a statement is mandatory

1.3.3

should

indicates a recommendation

2 Design and documentation

2.1 General

This clause specifies requirements for the construction design and documentation of prefabricated concrete elements.

NOTE 1 Other relevant standards for specific elements should be reviewed for additional requirements.

NOTE 2 For further reading, see Bibliography.

2.2 Design stages

The following two separate design stages shall be taken into account:

- (a) *In-service* — The in-service design provides for the performance of the element as part of the permanent structure. In-service design shall be conducted in accordance with the relevant Standard.

NOTE 1 For examples of in-service design, refer to AS 3600 and the AS 2159 series.

NOTE 2 The practicality of the construction process should be taken into account in the in-service design.

- (b) *Erection design* provides for the element to resist all construction loads, temporary surcharge loads as applicable, handling forces, including impact, arising from stripping, storage, transport, lifting, temporary bracing and propping.

While in the braced condition, the element shall be regarded as a temporary structure.

It shall be carried out by a competent person in erection design (see [Clause B.2](#)) who is a professional engineer (refer to AS 3850.1 Clause 1.3).

NOTE 3 For buried structures such as pipes and culverts loads applied during installation should be taken into account to prevent damage to the precast element.

NOTE 4 The stability of the structure during all phases of the construction process, including loads applied due to staged construction, should be taken into account in the erection design.

NOTE 5 Fire performance should be taken into account during construction.

C2.2 *The NCC Volume 1 includes requirements for the design for fire requirements.*

The design of prefabricated concrete buildings for fire is a complex matter and the design should take into consideration the behaviour of the building under fire conditions. Reference should be made to the NCC and its commentary, with particular attention to the structural adequacy provisions in the event of fire.

2.3 Erection design

The design shall make provision for the interrelation of the various stages of manufacture, construction, transport and erection.

The post-tensioning drawings shall document the erection procedure and sequence assumed in design for elements that rely on sequenced post-tensioning for stability during construction.

C2.3 *The full benefit and economies inherent in prefabricated methods of construction are only possible with preplanning.*

The complete construction and erection sequences should be planned prior to manufacture of Project Specific elements. The prefabricated concrete elements and the following factors should be taken into account:

- (a) *Site limitations.*
- (b) *Site access.*
- (c) *Element sizes, shapes and masses.*
- (d) *Crane size, type, mobility and access.*
- (e) *Casting sequence.*
- (f) *Overhead obstructions (e.g. to crane and temporary work platforms), especially overhead power lines.*
- (g) *Lifting, handling and erection sequence.*
- (h) *Construction sequence.*
- (i) *Imposed loads during erection and installation.*

Handling requirements and transport limitations should be taken into account during the planning and design of elements.

Some elements may require the use of special vehicles for transport.

2.4 Building stability during erection and construction

At each stage during erection, the stability of the complete structure shall be maintained. Design and construction shall include the potential risk of progressive collapse during construction.

C2.4 During construction, prefabricated concrete structures are susceptible to progressive collapse. The failure of a single bracing or propping member should not lead to the disproportionate collapse of a structure. Due consideration should be given to the situations during construction where the failure of a single element could lead to disproportionate or progressive (domino-type) collapse.

To avoid disproportionate or progressive collapse, erection designers should consider—

- (a) adequate strength and continuity of the structure and its parts; and
- (b) alternative load paths, whereby applied forces can be transmitted safely through the structure.

Structural continuity might rely upon, among other things, moment, shear or tensile connection, depending on the kind of structural system employed.

2.5 Design considerations for manufacture, handling and erection

2.5.1 Size and shape

When determining the size and shape of concrete elements, the following shall be taken into account:

- (a) Size, capacity and arrangement of crane(s) that will undertake lifting and erection.
- (b) Manufacturing restrictions.
- (c) Location and proximity of overhead power supplies.
- (d) Access to, and around, the workplace.
- (e) Bracing, propping and grouting requirements.
- (f) Transport restrictions.

2.5.2 Determination of design loads

When determining the design load or load combination, provision shall be made for construction sequences, installation and construction procedures, and transport.

NOTE 1 Guidance to the design process for lifting and handling is provided in [Appendix C](#).

The design for manufacture, handling and erection shall not compromise the integrity of the in-service design.

NOTE 2 Loads imposed during handling and erection may impact on the in-service performance.

In the design for handling, transport, and erection, the weight of the element and superimposed loads shall be regarded as a dead load (permanent action) in accordance with AS/NZS 1170.0 and AS/NZS 1170.1.

When locating lifting points and supports for transport, provision shall be made for the effects of prestress in elements.

EXAMPLE Steel assemblies, temporary fall prevention equipment, and formwork are superimposed loads.

The design forces in the rigging, lifting points and elements shall be determined by applying the factors in [Table 2.5.2\(A\)](#) to the dead load.

NOTE 3 The sling angle factors in [Table 2.5.2\(B\)](#) are applicable for lifting points located symmetrically about the centre of gravity of the concrete element. When inserts are in other positions, the angles may not be symmetric and the tension forces in the slings and rigging components are not equal.

The design forces shall be used for the determination of the required Working Load Limit (WLL) of the lifting insert and lifting device e.g. hook, clutch.

The WLL of the rigging shall be not less than the WLL of the insert.

Crane capacity shall be in accordance with AS 2550.1.

The selection of crane capacity shall take into account the load factors given in [Table 2.5.2\(A\)](#).

Table 2.5.2(A) — Required load factors

Case	Mould suction	Sling angle	Dynamic	Service life
Release from the mould	Table 2.5.2(C) or 2.5.2(D)	Table 2.5.2(B)		
Lifting, handling, storage, transport and installation into the final location ^a		Table 2.5.2(B)	Table 2.5.2(E)	1.0 ^a
Repetitive lifting ^b		Table 2.5.2(B)	Table 2.5.2(E)	1.8 ^b
^a All lifting and handling of prefabricated concrete elements during manufacture, delivery and installation prior to the completion of construction. ^b Where the application of the element requires it to be lifted repetitively throughout its service life (e.g. temporary concrete barriers that are regularly repositioned). NOTE 1 The application of the 1.8 service life factor is equivalent to increasing the WLL factor from 2.25 to 4.0 as given in AS 3850.1. NOTE 2 Where the application involves a severe consequence of failure, e.g. a precast element to be lifted over existing critical infrastructure where the consequences of failure have significant ramifications, the application of the factor 1.8 should be taken into account in the lifting insert design.				

The increase in load due to suction shall be calculated using the most appropriate method from the following:

- (a) The application of a load factor to the self-weight of the element (typically used for thin flat elements), see [Table 2.5.2\(C\)](#).
- (b) The increase in load by taking into account the influence of the contact surface area, mould geometry, surface roughness, state of prestress and any other applicable factors, see [Table 2.5.2\(D\)](#).

C2.5.2 Loads imposed during transport, e.g. use of A-frames or flatbed trailers, and other specialized equipment should be taken into account. Care should be taken when using mobile lifting equipment for movement or installation of elements. The load factor for transport over very rough ground may be higher in certain circumstances, see [Table 2.5.2\(E\)](#).

Special consideration should be given to the following:

- (a) Construction loads.
- (b) Handling and transport loads, e.g. long girders, supported on dollies and jinkers.
- (c) Erection loads.
- (d) Wind loads.
- (e) Snow and seismic loads.
- (f) Pre-tensioned elements.
- (g) Thin or asymmetrical elements.
- (h) Circular and other unstable elements.

(continued)

The element design should consider variations in impact load and load distribution during lifting, rotation, and element placement.

The suction factors in [Table 2.5.2\(C\)](#) and suction loads in [Table 2.5.2\(D\)](#) assume the use of effective bond-breakers and release agents. Suction loads may vary according to the finish and the type of mould. Where the mould has a profiled or textured surface, the suction load factor may exceed 2 and should be taken into account in the design.

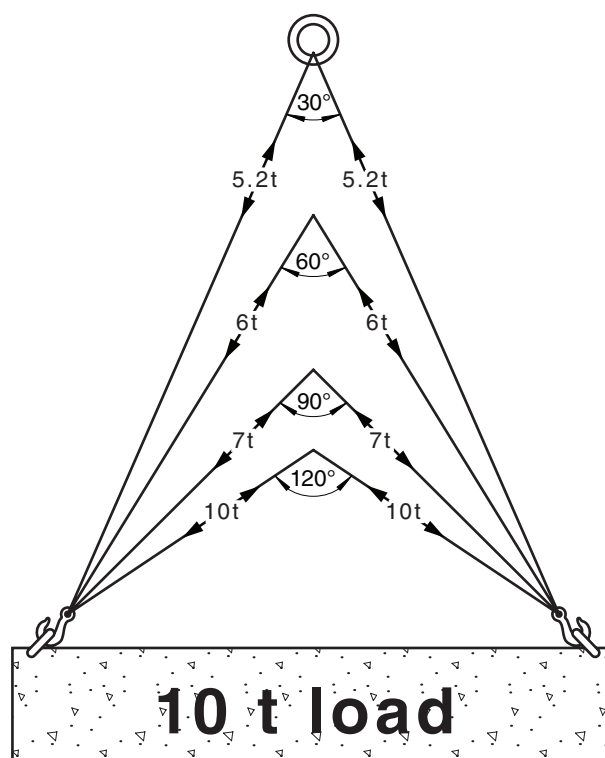
NOTE 1 Consideration should be given to the mould profile to ensure that any fixed edges have adequate draw (slope) to enable the element to be released without striking the mould edges.

NOTE 2 For formliners, or other special surface finishes, manufacturers may provide appropriate form friction factors.

Dynamic loads generated during handling and transport may be significant and should be taken into account in the design of the prefabricated concrete element, the lifting inserts and the rigging system.

Table 2.5.2(B) — Sling angle factors applied to the element and lifting points

Angle in degrees	Sling angle factor
0	1.00
30	1.04
60	1.16
90	1.42
NOTE 1 Internal forces in the lifted element may increase with increasing sling angle.	
NOTE 2 For an example of the effects of the sling angle on the lifting inserts with a 10t element, see Figure 2.5.2 .	
NOTE 3 Where possible the sling angle should be limited to 60° but never exceed 90°.	
NOTE 4 The factors could vary at different stages of manufacture, handling and erection.	



NOTE The 120° angle should not be used.

Figure 2.5.2 — Sling angle factor

When calculating insert loads and internal forces in the precast element at the time of lift, suction factors given in [Table 2.5.2\(C\)](#) shall be applied to the element weight in the design of the element and lifting points.

Table 2.5.2(C) — Suction factors for thin flat elements

Suction condition	Suction factor
Flat, concrete casting bed with an effective bond-breaker for thin flat elements	≥ 1.4
Smooth, flat, oiled, steel casting bed for thin flat elements	≥ 1.2
Other mould surfaces to account for the effects of suction and adhesion e.g. form liners	As appropriate

Suction loads calculated from the contact surface area in [Table 2.5.2\(D\)](#) shall be taken into account in the design of the element and lifting points.

Table 2.5.2(D) — Suction loads

Formwork and condition	Form friction (kPa) ^a
Elements with asymmetric prestressing about the horizontal axis	0 to 0.5
Oiled steel mould	1
Smooth and clean resin treated timber forms	2
Rough timber mould treated with release agent	3
^a The surface area used is the total contact area between the concrete and the formwork. NOTE The values in this table provide guidance for form friction and should be minimum values.	

[Table 2.5.2\(E\)](#) lists dynamic factors for element and lifting points by transportation type. The following requirements apply to [Table 2.5.2\(E\)](#):

- (a) A prepared, even surface shall be created in accordance with the surface preparation requirements of AS 2550.5.

NOTE Surfaces not meeting the surface preparation requirements of AS 2550.5 should be classified as unprepared, uneven surfaces.

- (b) All lifting operations using mobile lifting equipment shall be in accordance with AS 2550.5.

Table 2.5.2(E) — Minimum dynamic factors applied to the element and lifting points, by crane and transportation type

Means of transportation	Dynamic factor
A stationary crane, including an overhead gantry crane; a tracked mobile crane, a crane standing on outriggers; or a tower crane	≥ 1.2
Transport by truck on a prepared, even surface (for element design, not applicable to lifting inserts)	≥ 1.4
Rubber tyred mobile gantries or straddle carriers travelling with a suspended load (lifting hook within the wheels) on a prepared, even surface	≥ 1.5
Tracked mobile lifting equipment travelling with the suspended load on a prepared, even surface	≥ 1.7
Non-tracked mobile lifting equipment (including rubber-tyred) travelling with the suspended load on a prepared, even surface	≥ 2.0
All mobile equipment travelling with the load suspended on unprepared, uneven surfaces	≥ 5.0
NOTE 1 Mobile lifting equipment travelling with a suspended load should be operated according to the manufacturer's instructions, paying attention to the travelling speed and surface condition.	
NOTE 2 For a maximum travelling speed with a suspended load, refer to AS 2550.1.	
NOTE 3 The factors could vary at different stages of manufacture, handling and erection.	
NOTE 4 The transport of prestressed elements or heavy elements on rough ground while suspended is not recommended.	
NOTE 5 The dynamic factor of ≥ 5.0 is associated with a non-standard transportation situation. It should not be expected that a precast concrete product has been designed for this magnitude dynamic factor, unless specifically stated in documentation from the product manufacturer. Advice from the product manufacturer should be sought if a transport situation associated with a dynamic factor of ≥ 5.0 is expected.	
NOTE 6 Site specific testing may be carried out to determine appropriate dynamic factors.	

2.5.3 Typical rigging configurations

Typical rigging configurations include but are not limited to the following:

- (a) Flat lifting of elements.
- (b) Edge lifting of elements.
- (c) Face lifting of elements.
- (d) Mid-air rotation of elements.

Common rigging configurations are shown in [Appendix D](#). The rigging system shall be designed and documented in conformance with the requirements set out in [Appendix A](#) to suit the spacing and layout of the lifting inserts and to meet the requirements of the handling methods, erection plan and procedures. The design of the rigging system shall take into account the types and capacities of cranes required for all handling and erection operations. Load-equalizing lifting beams shall be of adequate length and capacity in accordance with the relevant Australian Standard (e.g. AS 2550 and AS 4991) to suit the specified rigging system.

When using multi-leg (three or more), fixed-length slings connected to a common point (e.g. a hook or ring), any two legs of the system shall be capable of supporting the full load, see rigging configurations in [Figures 2.5.3](#) and [Appendix D Figure D.1](#).

The included angle between the legs of a multi-leg sling shall not exceed 90°, see [Figure 2.5.2](#).

The layout of the lifting points and the rigging configurations during all lifting and handling operations shall ensure stability of the element without manual assistance by personnel in the drop zone.

NOTE 1 This is not intended to exclude the use of guide ropes that may be used to control an element with the operative standing outside the drop zone.

For pre-tensioned elements, the layout of the lifting points and the location of supports are critical to the structural integrity of the element.

NOTE 2 Lifting inserts should be symmetrically located about the centre of gravity of the element to enable load equalization. Load equalising devices may be used for all elements to be lifted on more than three points.

NOTE 3 Common rigging configurations are shown using fixed length slings and load equalising devices in [Figures 2.5.3](#) and [D.1](#) to [D.5](#).

C2.5.3 *Thin, wide elements may become unstable if lifted from only two inserts placed on the face or the side of the element (e.g. large pit-lids). Therefore, it is recommended that three or four lifting inserts (see [Figure 2.5.3](#)) be used as follows:*

- (a) *For three inserts — inserts for lifting an element should be located so that a line drawn between any two inserts does not pass through, or close to, the centre of gravity of the element.*

Rationale: The element could rotate uncontrollably about the two inserts in line with the centre of gravity. If the sling attached to the third insert was subject to a compression load, being flexible, it would collapse and become non-loadbearing.

- (b) *For four inserts — inserts for lifting an element should be located so that a line drawn between any two adjacent inserts does not pass through, or close to, the centre of gravity of the element.*

Lifts should be planned so that rotation of snatch-block swivels under load is not required. Where the snatch block is required to rotate, it should have thrust races or separate swivel bearings.

Rigging should be inspected prior to lifting and swivels inspected before each use by a person competent in rigging (see [Clause B.6](#)) to ensure that the collar pin is intact and the collar has not become loose.

Where sheave blocks with lockable clamp bolts are not available, the cheek-plate clamp bolt should be fully tightened to ensure that rubbing and abrasion under load does not occur.

Although the loads in the slings of running rigging attached to each insert are equal, the components of the sling load in the plane and perpendicular to the prefabricated elements may not be equal for each lifting insert due to the differing inclination of the slings to the elements. The sling loads, including their in-plane and perpendicular components, will also vary during rotation of the element.

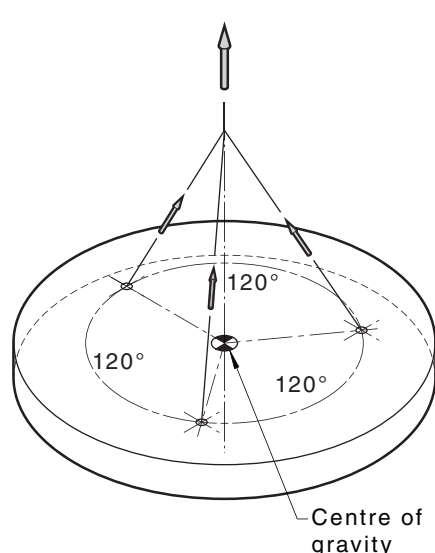
NOTE Running rigging refers to rigging where slings pass through a sheave or snatch block.

For elements that are to be rotated, the use of lifting systems comprising three, six, nine or 12 lifting points should be avoided wherever possible due to the complex rigging required.

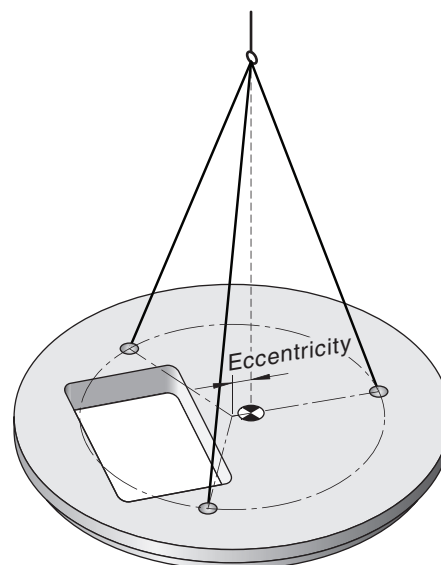
When facelifting using running rigging, sling lengths should be documented in the erection design and should be not less than the minimums shown in [Appendix D Figure D.3](#). During mid-air rotation (see [Figures D.4](#) to [D.5](#), the loads applied to the lifting inserts vary depending on the relative position of the

(continued)

lifting inserts and crane lines. Therefore, the load transferred to a single insert may exceed 75 % of the total load.



(a) Loading on three legs governed by geometry



(b) Element lifted with three legs

NOTE 1 Although the load is theoretically equally distributed over three legs, when the lifting inserts are positioned equally around the centre of gravity and the legs are of equal length, the design should only consider two legs, see [Figures 2.5.3\(a\)](#)

NOTE 2 When flat lifting with three lifting points in a single plane with equal length slings, the centre of lift for the lifting points should be located in line with the centroid of the element, otherwise the sling and insert loads will be unequal and potentially unstable, with the load shared by only two slings.

NOTE 3 When lifting a non-symmetrical element on three points where the geometric centre of the lifting points is eccentric to the centre of gravity [see [Figure 2.5.3\(b\)](#)], the rigging should be designed to ensure that centre of lift is in line with the centre of gravity of the element and take into account the desired erection orientation and stability. In this case, the sling and insert loads would be unequal.

NOTE 4 An element lifted with three legs cannot be assumed to be equally loaded, see [Figure 2.5.3\(b\)](#).

Figure 2.5.3 — Flat lifting unequal loading — Three point, fixed-leg chains joined by rings

2.5.3.1 Special considerations for rigging for mid-air rotation of elements

The rigging design shall take into account the orientations of the prefabricated element, the delivery vehicle and erection crane/s.

The rigging shall be designed to ensure that during rotation, the fall of the main winch and auxiliary winch ropes are in the same plane as the crane jib.

If the delivery vehicle is positioned such that the lifting points are not in line with the plane of the crane jib [see [Figure D.4 \(a\)](#)], the element shall be provided with two tail lifting points configured to lie equidistant from the centre of gravity of the element, which shall be used to lift the element clear of the delivery vehicle with one of the hoists. The element shall then be turned to lie in the same plane as the crane jib prior to the connection of the second hoist to the erection inserts prior to mid-air rotation. The typical rigging configuration is shown in [Figure D.4\(b\) – \(d\)](#).

Dual hoist lifting or rotation of elements is not permissible if a fleet angle could develop between the main and auxiliary hoist ropes [see [Figure D.5\(a\)](#)]

If the delivery vehicle is positioned such that all lifting points are in line with the plane of the crane jib [see [Figure D.5\(a\)](#)], the element may be lifted from the vehicle and rotated directly using a combination of the main and auxiliary crane winches, provided that the crane is designed for this operation and that both winches have suitable capacity. In this case the element may be rotated using a single “tail” lifting point, however the preferred rigging configuration uses two sheaved “tail” lifting points and two sheaved erection insert points [see rigging [Figure D.5\(b\) – \(c\)](#)].

2.5.4 Lifting inserts

2.5.4.1 General

Lifting inserts conforming to AS 3850.1 shall be incorporated into prefabricated elements to enable them to be lifted.

Other inserts may be used provided they have been designed and validated by testing to provide performance equivalent with the requirements of AS 3850.1.

Lifting inserts are designed and manufactured with a controlled strength and ductility. They shall be specified and installed in accordance with the manufacturer specifications. Where manufacturer specifications require the use of component reinforcement, it shall be in accordance with AS 3850.1. The design of lifting inserts and component reinforcements shall take into account the direction of the applied load.

The locations of the lifting inserts shall be determined according to —

- (a) the number of lifting inserts, their spacing and edge distances;
- (b) the centre of gravity;
- (c) the method of lifting (face or edge);
- (d) the mass, size and shape of the prefabricated concrete element and presence of openings and cuts;
- (e) the structural capacity of the prefabricated concrete element;
- (f) the strength of the prefabricated concrete element at the time of lifting;
- (g) the capacity of the lifting inserts;
- (h) the pre-tensioning forces (if applicable); and
- (i) the direction of load (shear, tension or combined shear/tension).

To avoid instability, the centre of lift shall not be placed below the centre of gravity of the concrete element. Where this is not practicable, alternative measures to ensure stability shall be provided.

Face-lifted prefabricated concrete elements shall be designed to hang not more than 10° from the vertical. If this is not possible, an alternative method of lifting using edge-lifting or a combination of face- and edge-lifting shall be used.

Where specified for a lifting system, component reinforcement shall be installed and checked prior to casting by a competent person in pre-casting inspection (see [Clause B.4](#)) in accordance with the manufacturer specification for the lifting system.

Welding of reinforcement to lifting inserts, brace inserts or ferrules is not recommended, see [Clause 3.8](#).

NOTE 1 See Appendix D [Figures D.1](#) to [D.6](#) for examples of rigging configurations for prefabricated concrete elements.

NOTE 2 For an example of shear and tension loads, see [Figure 2.5.4\(A\)](#).

NOTE 3 [Figure 2.5.4\(B\)](#) provides examples of component reinforcement which have little or no effect on the lifting insert capacity. It also shows an insert with a tension bar which may increase the lifting insert capacity.

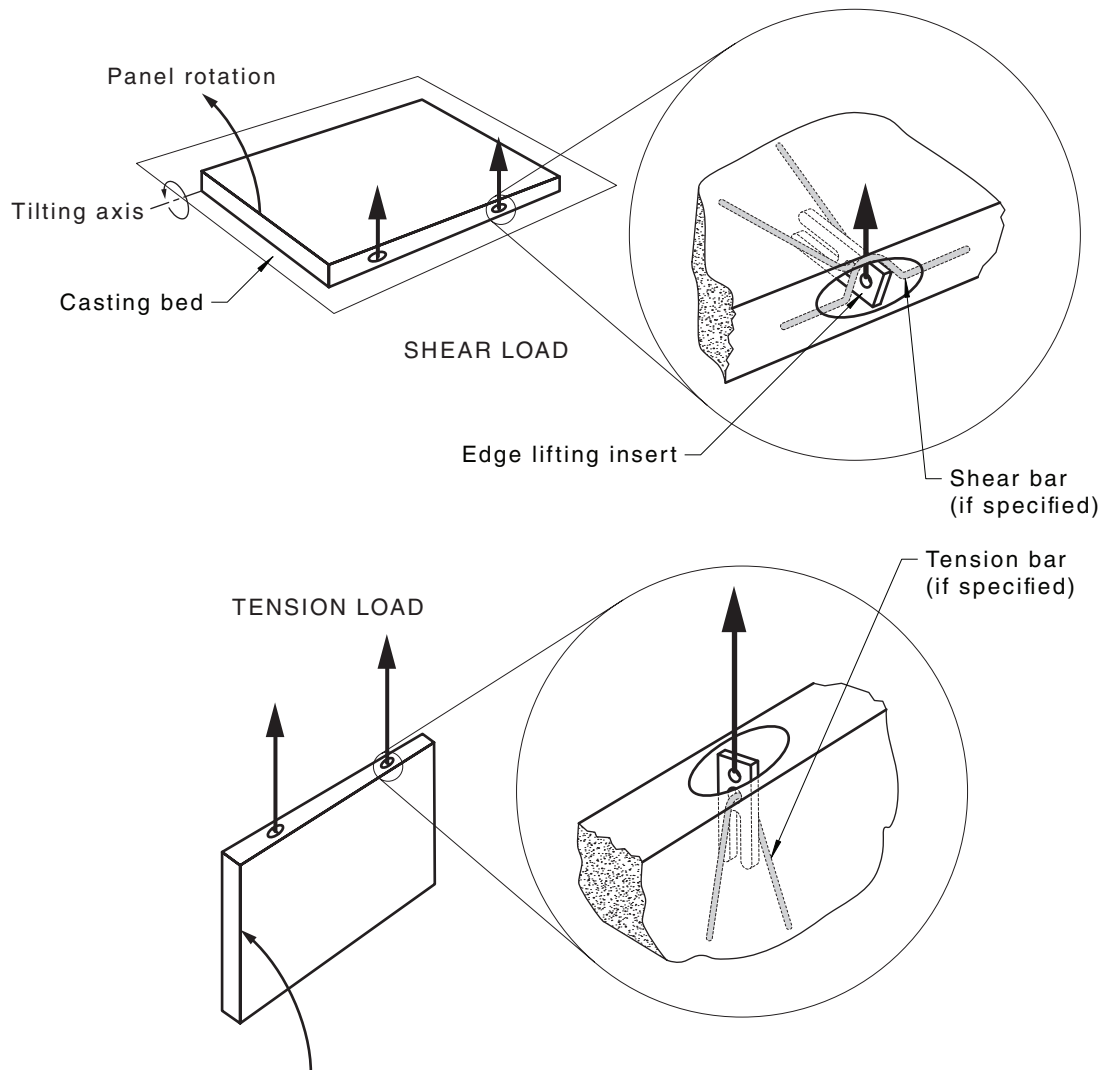
C2.5.4.1 When specifying the location of lifting inserts, slenderness of the concrete element, penetrations, element geometry and the need for strongbacks or bracing to resist the lifting forces should be taken into account.

An element's centre of gravity is essential to the lifting design and ensures the stability of the element during all stages of the lift.

The anchorage capacity of the lifting point is affected by —

- (a) method of installation;*
- (b) proximity to the edges;*
- (c) proximity to the holes, recesses or edge rebates;*
- (d) proximity to other loaded lifting devices;*
- (e) concrete thickness;*
- (f) concrete strength at lifting;*
- (g) embedment depth;*
- (h) presence of cracks;*
- (i) direction of load, for example shear and tension (see [Figure 2.5.4\(A\)](#));*
- (j) proximity of reinforcement or prestressing tendons; and*
- (k) additional reinforcement specified by the insert supplier.*

Any reinforcement not specified by the insert supplier cannot be assumed to increase capacity unless the competent person in component design (see [Clause B.1](#)) has verified the capacity by testing in accordance with AS 3850.1.



NOTE If shear load lifting is required in the opposite direction to the initial lift, then shear bars may be required on both faces.

Figure 2.5.4(A) — Shear and tension loads in edge-lifted elements

NOTE 4 Horizontal bars placed around the lifting insert generally provide little or no additional lifting capacity compared to inserts placed without bars and fail by the same mechanism (cone failure), see [Figure 2.5.4\(B\)](#).

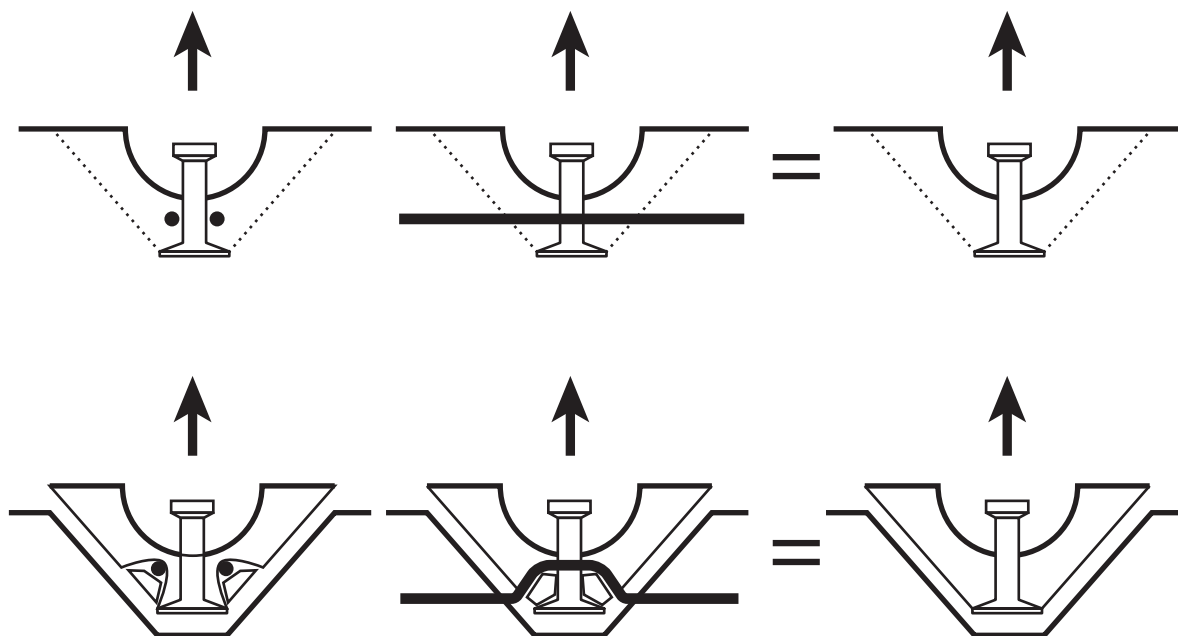


Figure 2.5.4(B) — Ineffective horizontal reinforcements

Bars placed around the foot of the lifting insert typically provide no additional lifting capacity, see [Figure 2.5.4\(B\)](#).

NOTE 5 An example of the correct connection of component reinforcement to an insert is given in [Figure 2.5.4\(C\)](#).

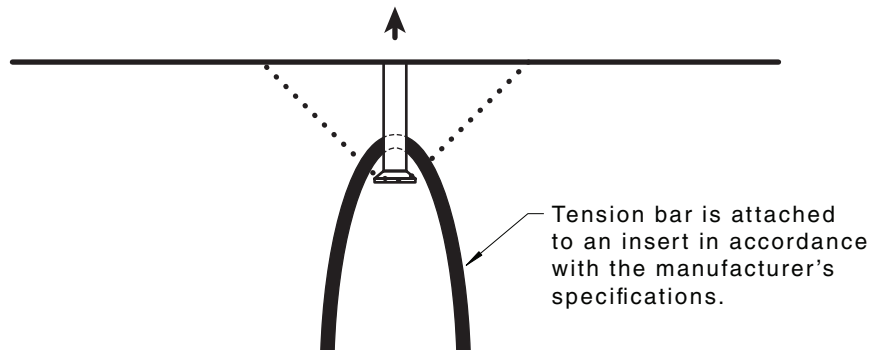


Figure 2.5.4(C) — Tension bar

NOTE 6 Lifting inserts, bracing inserts or ferrules should not be welded to reinforcement.

Lifting inserts within the prefabricated concrete element should preferably be specified as cast-in inserts. Where cast-in inserts are omitted or, after casting, are found to be unusable, replacement lifting devices which provide equivalent performance shall be designed and installed prior to lifting the element.

2.5.4.2 Re-use of lifting Inserts

The re-use of lifting inserts is permissible for lifting and handling of precast concrete elements during all stages of manufacture, delivery and installation prior to the completion of construction. Where re-used, a service life factor of 1 shall be used.

Where a prefabricated concrete element is required to be lifted repeatedly during its service life, a service life factor of 1.8 shall be used, see [Table 2.5.2\(A\)](#).

NOTE 1 An insert shall not be re-used if there is evidence that it has been overloaded beyond the WLL.

NOTE 2 A lifting insert should not be re-used without verification that it meets the design requirements where if upon inspection at the time of lift—

- (a) the concrete surrounding the insert is unsound; or
- (b) the insert shows signs of damage, corrosion, deformation or wear which could result in loss of strength.

C2.5.4.2 *Elements are typically lifted more than once between manufacture and final position. The principal factors that may limit the re-usability of lifting inserts in precast concrete elements are as follows:*

- (a) *Overloading of the insert past its WLL.*
- (b) *The condition of the concrete at time of lift.*
- (c) *Deformation and wear of the lifting insert.*
- (d) *Corrosion of the lifting insert.*
- (e) *Other actions that have a physical impact on the insert's material properties or the insert shape (i.e. welding to the insert).*

Special requirements detailed in [Clause 2.5.2](#) apply to concrete elements that are designed to be repetitively lifted during their design life (e.g. temporary road barriers).

2.5.5 Bracing inserts

2.5.5.1 General

Bracing inserts shall be installed in accordance with AS 3850.1 and designed to resist all loads transferred by the brace to the fixing, including loads dependent on the angle of bracing and prying forces dependent on the geometry of the brace foot.

NOTE [Figure 2.5.5](#) illustrates the effect of brace angle and brace foot geometry on the tension or compression forces into a brace fixing.

Where elements are lifted with braces attached, brace inserts in the elements shall be positioned so the crane rigging will not foul the brace during lifting.

Braces shall not obstruct the erection of subsequent construction. Where braces need to be removed to permit other construction processes, a removal procedure conforming to the erection design shall be conducted.

The permanent structural elements that will provide in-service stability to the element (such as subsequently constructed *in situ* concrete elements) shall be installed prior to removal of the braces in accordance with [Clause 6.3](#).

C2.5.5.1 *In general, brace inserts should not be placed closer than 300 mm to the edge of the element (to avoid edge reduction factors), footing or other bracing support, unless specifically designed otherwise. Where closer edge distances are required, they should be specified in the erection documentation.*

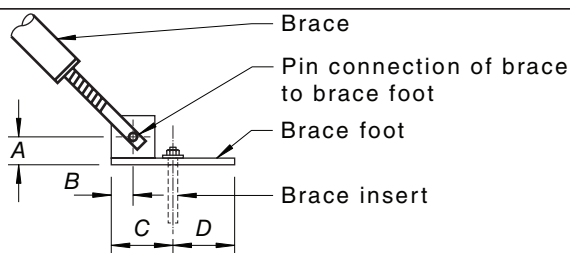
Where possible, for face-lifted wall elements, brace inserts should be on the same face of the element as the lifting inserts.

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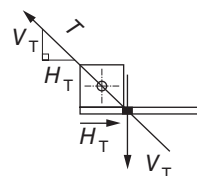
Brace insert capacities are sensitive to the same factors as lifting inserts given in C2.5.4.1 Items (a) to (k).

Brace inserts above the line of attachment of roof steelwork are an example of obstruction of subsequent construction.

The durability of brace inserts may be impaired by exposure to environmental elements and the design should also take this into account.



Dimensions of brace foot required to calculate brace insert load

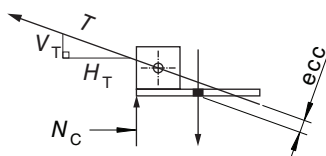


Ideal brace angle of inclination

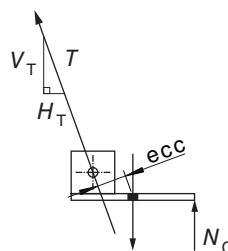
Brace's axis passes through fixing hole centre-line on underside of brace (Bolt tension = V_T)

$$N_C = \frac{T \times ecc}{C}$$

$$\text{Bolt tension:} \\ = V_T + N_C$$



Brace inclination below ideal angle



$$N_C = \frac{T \times ecc}{D}$$

$$\text{Bolt tension:} \\ = V_T + N_C$$

Brace inclination above ideal angle

Key

V_T	=	vertical component of the tension
N_C	=	reaction load
T	=	tension in the line of the brace
H_T	=	horizontal component of the tension
ecc	=	Eccentricity

NOTE 1 A rigid base plate is assumed.

NOTE 2 Dimensions A, B, C and D can be obtained from the brace supplier's product information.

NOTE 3 The bracing loads may be tension or compression.

Figure 2.5.5 — Effect of brace angle and brace foot geometry on tension in brace fixing

2.5.5.2 Cast-in fixing and brace inserts (ferrules)

2.5.5.2.1 General

Cast-in inserts, such as threaded inserts, weld plates or brackets, shall be designed to meet the performance requirements of the erection design or in-service design or both. Cast-in inserts shall be installed according to the documentation in [Appendix A](#). To minimize the chance of error, fixings shall be standardized for all prefabricated concrete elements on an individual project. Where permanent

fixings are also intended to be used for the attachment of temporary supports, all load cases shall be examined.

Any fixings or fixing method that compromise the strength of a prefabricated concrete element shall not be used.

NOTE Forces applied to fixing inserts are determined by a competent person in in-service design, see [Clause B.3](#). Therefore, their determination is outside the scope of this document; however, all fixings required for the permanent structure should be shown on the architectural or structural drawings, as appropriate. The required service life and corrosion protection for cast in fixings also need to be taken into account and detailed.

2.5.5.3 Specifying inserts

The in-service designer of inserts shall specify either —

- (a) the type and size of the permanent fixing inserts; or
- (b) the loads the inserts are required to resist.

2.5.5.4 Specifying loads

The specified loads shall be documented to show —

- (a) The direction in which they act; and
- (b) whether they are factored or unfactored.

2.5.5.5 Selection and location of inserts

When selecting inserts to take specified loads, the load capacity of the insert shall have been determined by testing in accordance with [Appendix A](#) with due allowance for the following possible areas of difference between the test and the proposed insert location:

- (a) Concrete strength.
- (b) Element thickness.
- (c) Fixing length.
- (d) Edge distance.
- (e) Proximity of fixings to one another.
- (f) Component reinforcement.
- (g) Ductile behaviour of the insert steel.
- (h) The effects of prestress or post-tensioning.
- (i) The effects of short-term or long term vibration.
- (j) The effects of corrosion on either temporary or permanent inserts exposed for the service life of the structure which is determined by the material properties and finish.
- (k) Performance in fire.

All cast-in inserts required for in-service and erection shall be specified and documented in accordance with [Appendix A](#) and where applicable in the structural drawings, conforming to the requirements of the in service and/or erection design.

NOTE Structural drawings may be referred to as certified drawings where they have been checked by the in-service and/or erection designer to ensure conformity to the relevant design.

C2.5.5.5 *As elevated temperatures may reduce the capacity of anchors, particularly chemical anchors, supplier's data should be consulted.*

2.5.5.6 Post-installed fixings and bracing inserts

The use of cast-in fixings is preferred if they can be reasonably held in position while casting. If post-installed inserts use cannot be avoided, then bracing inserts shall be designed and tested in accordance with Appendix B of AS 3850.1, and permanent fixings designed in accordance with AS 5216 or AS 3850.1 and installed by a competent person. For the installation of post-installed fixings, see [Clause B.10](#).

The WLL shall be calculated by dividing the characteristic strength derived from either AS 3850.1 or AS 5216 by the factor given in Table 2.1 of AS 3850.1:2015.

C2.5.5.6 *Deformation-controlled anchors should not be used because they —*

- (a) *have no additional expansion (and hence additional load capacity) after the initial setting process;*
- (b) *fail without warning; and*
- (c) *are highly sensitive to installation procedures.*

Torque-controlled anchors may be used because after their installation the application of load causes these anchors to behave elastically until a load is reached at which they first begin to slip. After first slip, the anchor exhibits “ductile” load behaviour.

Cyclic load conditions (e.g. wind loads) can result in failure of an expansion anchor that has been loaded in excess of its first slip load, even if subsequent load cycles do not exceed the first slip load.

NOTE *Screw type concrete anchors are not appropriate for dynamic actions and should not be used.*

2.5.6 Wind loads

Wind loads on temporarily braced elements shall be determined according to AS/NZS 1170.2 using the annual probability of exceedance based on AS/NZS 1170.0. When comparing wind loads with the WLL of temporary braces, the wind load shall be divided by 1.5 to convert to the working load.

Where the drop zone of the element is within the boundary of the construction site, a minimum importance level 2 shall be used in accordance with AS/NZS 1170.0. Where the drop zone of the element is beyond the construction site boundary, the importance level of the adjacent property shall be taken into account if it is greater than 2.

NOTE 1 Refer to AS/NZS 1170.0 for importance levels.

NOTE 2 The design terrain category, region and design wind speed should be included in the erection documentation.

NOTE 3 The scope of AS 5216 limits design to applications with static or quasi-static loads. Appendix B of AS 3850.1 includes provisions for cyclic tension load restrictions for wind brace fixings.

C2.5.6 *For elements with potential to cause progressive collapse, by falling on other elements or falling from height onto other structures, the design should consider a more conservative annual probability of exceedance.*

When significant delays in construction occur, the design of the temporary works may need to be reassessed to ensure the design assumptions are still valid. This may be of relevance for projects in

(continued)

locations where seasonal variations are possible (e.g. cyclonic areas) where the initial intention was to construct during non-cyclonic periods.

This document uses items of equipment that have their capacity stated as WLL. Therefore, for consistency, WLL has been adopted throughout this document. When AS/NZS 1170.2 changed the method of design from working loads to limit states, the load factor for conversion between the two was 1.5. That value has been retained in this document.

Site huts, amenities and evacuation/refuge areas should be located outside of the drop zone.

2.5.7 Strength specification of concrete

The concrete shall be specified in accordance with AS 1379.

The concrete shall be specified for the in-service conditions unless a higher strength concrete is required to satisfy temporary load conditions.

The specification of concrete for lifting inserts, brace fixings and temporary brace footings shall satisfy the following criteria:

- (a) The characteristic strength required to develop the WLL of an insert or the required strength for a brace footing at the time of applying load (e.g. of lifting or bracing).
- (b) The requirements for in-service loading, durability, and any construction requirements such as workability.
- (c) A method of testing 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 or of the brace footing concrete. It shall also be from the same concrete pour and at the same time as the pour of the element or brace footing. Design of elements for manufacture, transport and erection

2.5.8 Design of elements for manufacture, transport, installation and erection

Precast concrete elements shall be designed to be safely handled throughout all stages of their life cycle; from manufacturing through to storage, transport and erection before incorporation into the final structure.

Additional reinforcement may be required in concrete elements where stresses imposed by the manufacturer's transport, installation and/or erection exceed the design stresses for in-service loads. Where additional reinforcement is required, it shall be designed in accordance with the requirements of the competent person in in-service design, see [Clause B.3](#).

Reinforcement bars cast into, and protruding from, precast elements shall be bent or re-bent in accordance with AS 3600.

Bending moments shall be determined from elastic analysis. Bending stresses in precast elements imposed by their self-weight (factored only as required by [Clause 2.5.2](#)) during handling, transportation and erection, and determined with the rigging configurations specified, shall be either —

- (a) resisted by the flexural tensile strength of the concrete at the time of the activity; or
- (b) in accordance with reinforced concrete elastic design methods, including prestressed design; or
- (c) a combination of Items (a) and (b).

NOTE Item (a) is usually applicable to thin, lightly reinforced elements where the tensile stress should be limited to $0.41\sqrt{f'_{\text{age}}}$ provided that the concrete has cured for not less than 48 h.

Crack-width calculations shall be based on the worst possible loading case occurring during erection, construction or handling.

C2.5.8 *Thin flat elements to be transported to site should include at least one continuous perimeter reinforcing bar, typically 12 mm or 16 mm diameter, lapped as required and coggled at the corners.*

Additional reinforcement may be required for the following conditions:

- (a) *Near the base of the concrete element to resist stresses arising from thermal and shrinkage movements while the concrete element is supported only on the levelling shims.*
- (b) *At the edges and around openings in the concrete element to resist thermal and shrinkage stresses, and to prevent cracking due to concrete element mishandling.*
- (c) *Where there is a possibility of load reversal due to mishandling that could occur during transport or erection.*

Additional reinforcement or strongbacks should be provided where the maximum flexural tensile stress in concrete elements exceeds the limits recommended in AS 3600 as applicable or, whichever is the lesser. Additional stresses from the release of prestressing strand should be assessed and reinforced accordingly.

2.5.9 Temporary bracing

2.5.9.1 General

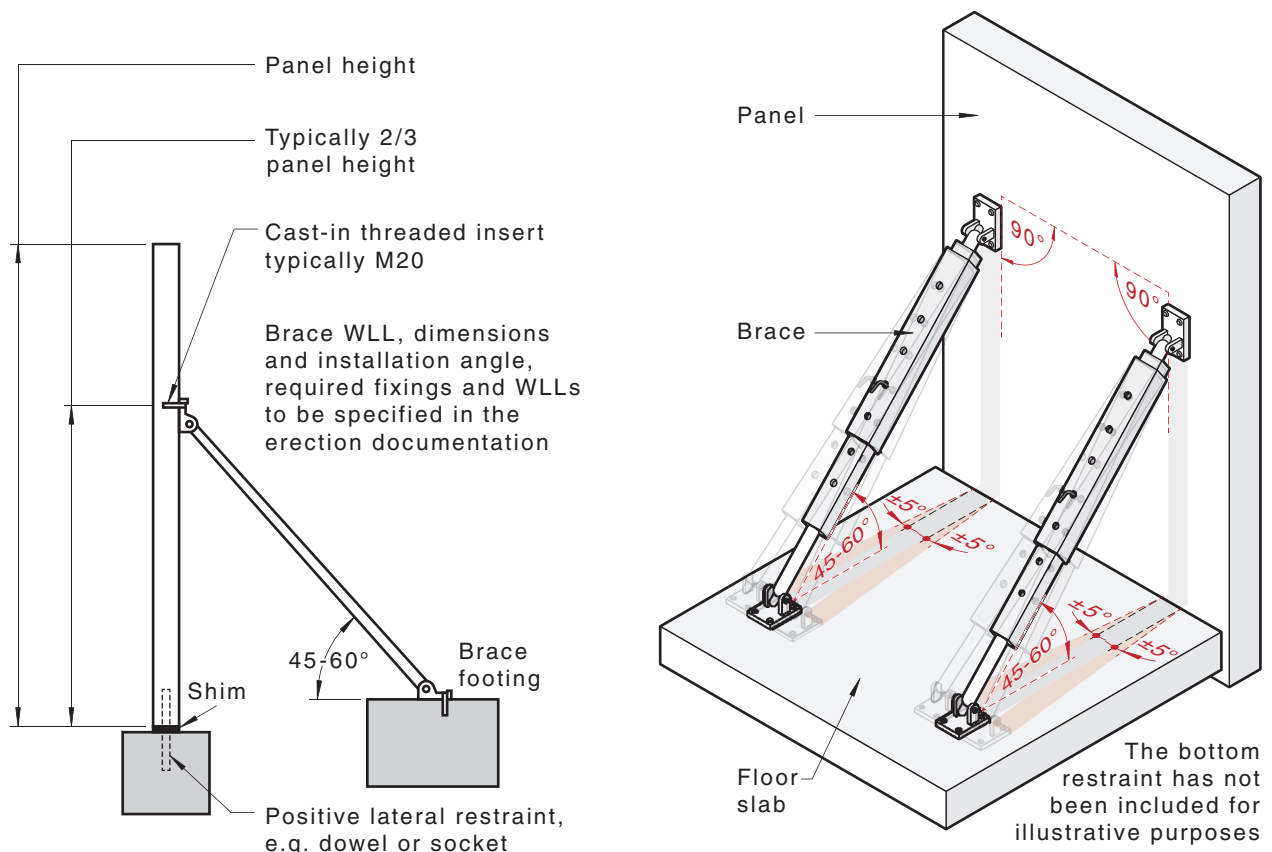
All bracing systems shall be designed to meet the requirements of the erection design. Proprietary bracing systems shall conform to AS 3850.1.

Element geometry may result in additional loads. Additional loads shall be factored into the design for temporary bracing.

2.5.9.2 Design of temporary bracing for vertical elements

Where prefabricated elements are erected without sufficient horizontal stability at the point of installation, additional supports shall be incorporated in the design to ensure the required restraint is provided prior to the completion of the structure. The temporary restraint system may be designed as either primary bracing or a combination of primary and secondary bracing components.

NOTE For an illustration of primary and secondary bracing elements, see [Figures 2.5.9.2 \(A\) and \(B\)](#).



[SOURCE: SAFE WORK AUSTRALIA. *Guide to managing risk in construction: Prefabricated Concrete*. © Commonwealth of Australia 2020. <https://creativecommons.org/licenses/by/4.0/legalcode>]

2.5.9.2(A)(a) Side elevation

2.5.9.2(A)(b) Isometric view

Figure 2.5.9.2(A) — Braces for vertical elements

The design of temporary support for vertical or near-vertical elements shall meet the following requirements:

- (a) The brace shall be designed according to AS 3850.1.
- (b) Wind forces in temporary braces shall be determined in accordance with [Clause 2.5.6](#)
- (c) Additional superimposed lateral load shall be factored into the bracing design for vertical concrete elements, e.g. earth pressure and compaction of back fill.

NOTE For requirements for superimposed loads, see [Clause 2.6](#).

- (d) Lateral pressure from the *in situ* pour shall be factored into the bracing and base connection design for vertical elements acting as formwork for the adjacent *in situ* construction, e.g. an *in situ* deep beam abutting a concrete panel.
- (e) The overall stability and sequence of element erection shall be checked by a competent person in erection design (see [Clause B.2](#)) to minimize the potential risk of a mechanism leading to progressive collapse of the elements at any stage of construction.

- (f) Except as provided for in Item (g), each element shall be supported by a minimum of two braces of the required capacity.
- (g) Narrow elements shall be braced in two orthogonal directions; see Figure.2.10
- (h) Where the use of proprietary bracing systems is not practicable, alternative means of bracing shall be specified in the erection documentation. Methods of achieving required bracing are —
 - (i) equivalent supports, such as corner supports, main structure and box structures;
 - (ii) a single fixed-length brace purposely designed for the specific application. Such a brace shall have a maximum slenderness ratio of 90.
- (i) Fixings at each end of the brace shall be capable of transmitting the force into the element and support. The type of fixing or the required capacity of the fixing shall be nominated on the approved shop drawings.
- (j) The support shall be designed to resist the brace force.
- (k) The effective length of a main brace may be reduced by the inclusion of secondary bracing components to afford lateral restraint at a location along its length, provided any such secondary bracing shall restrain the main brace in all directions from possible buckling. Calculation of loads applicable to components that provide buckling restraint shall conform to the requirements for parallel-braced compression members given in AS 4100 regardless of the materials used in the secondary bracing.
- (l) The capacity and performance of any component or system of components and their required connections to act as a buckling restraint (as secondary bracing) shall meet the requirements for additional testing for braces given in AS 3850.1. A test report shall be provided by the component supplier and checked by a competent person in erection design (see [Clause B.2](#)) to ensure conformity to AS 3850.1.
- (m) The brace structure shall be capable of supporting the prefabricated elements.
- (n) The bracing requirements shall be fully documented in the erection documentation.
- (o) Where elements are braced to other temporarily braced elements, the system shall be designed to provide adequate temporary support to avoid the potential for progressive collapse or disproportionate collapse or both.
- (p) The design of the brace layout and erection sequence, particularly where elements are designed to abut at corners, shall ensure that during erection of the second corner panel the braces are placed without fouling the braces of the first erected panel. The angle and location of the brace of the second element shall be factored into the design.
- (q) Where bracing is required to be progressively removed during construction, the stability of the structure shall be ensured at all times. The staging of the removal of bracing shall be detailed in the erection documentation.
- (r) The shop drawings and the erection documentation shall be complementary.

C2.5.9.2 *A bracing system is an arrangement of temporary supports which provide stability to prevent a prefabricated concrete element from overturning. Common types of bracing systems include the following:*

- (a) *Primary bracing only — individual, clear-spanning main braces.*
- (b) *Primary and secondary bracing — main braces with dual secondary knee braces.*