

NATIONAL CODE OF PRACTICE FOR PRECAST, TILT-UP AND CONCRETE ELEMENTS IN BUILDING CONSTRUCTION



FEBRUARY 2008



Australian Government
**Australian Safety and
Compensation Council**



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FOREWORD

The Australian Safety and Compensation Council (ASCC) leads and coordinates national efforts to prevent workplace deaths, injury and disease in Australia. Through the quality and relevance of the information it provides, the ASCC seeks to influence the awareness and activities of every person and organisation with a role in improving Australia's occupational health and safety (OHS) performance.

More specifically, the ASCC aims to:

- > support and enhance the efforts of the Australian, state and territory governments to improve the prevention of workplace deaths, injury and disease;
- > work in alliance with others to facilitate the development and implementation of better preventative approaches; and
- > ensure the needs of small business are integrated into these approaches.

The *National OHS Strategy 2002-2012* (National Strategy), released by the Workplace Relations Ministers' Council (WRMC) on 24 May 2002, records a commitment by all Australian, state and territory governments, the Australian Chamber of Commerce and Industry and the Australian Council of Trade Unions to share the responsibility of ensuring that Australia's performance in work-related health and safety is continuously improved.

The National Strategy sets out five national priorities to achieve short-term and long-term improvements. Its priorities are to:

- > reduce high incidence and high severity risks
- > improve the capacity of business operators and workers to manage OHS effectively
- > prevent occupational disease more effectively
- > eliminate hazards at the design stage, and
- > strengthen the capacity of Government to influence OHS outcomes.

National standards and codes of practice are declared by the ASCC under Section 4 of the *Australian Workplace Safety Standards Act 2005* (Commonwealth), and describe preventative action to avert occupational deaths, injuries and diseases. Most national standards deal with the elimination, reduction or management of specific workplace hazards.

The expectation of the Australian Government and the ASCC is that national standards and codes will be suitable for adoption by the Australian, state and territory governments. Such action will increase uniformity in the regulation of OHS throughout Australia and contribute to the enhanced efficiency of the Australian economy.

ASCC documents are instruments of an advisory nature, except where a law other than the *Australian Workplace Safety Standards Act 2005*, or an instrument made under such a law, makes them mandatory. The application of any ASCC document in any particular state or territory is the prerogative of that state or territory.



The ASCC acknowledges those who have assisted in the development of this *National Code of Practice for Precast, Tilt-up and Concrete Elements in Building Construction*, including representatives from Australian, State and Territory Governments as well as union and industry members.



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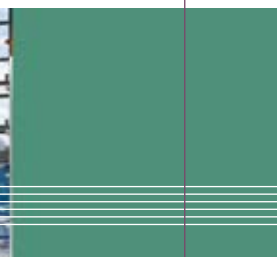
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1. INTRODUCTION

The *National Code of Practice for Precast, Tilt-up and Concrete Elements in Building Construction* (referred to in this document as this National Code) provides practical guidance on ways to eliminate hazards and/or minimise risks in the safe handling of concrete elements in building construction.

In October 2002, the ASCC's predecessor, the National Occupational Health and Safety Commission (NOHSC), recognised that the construction industry warranted a high priority in Australia's efforts to reduce workplace death and injury.

In March 2003, the Final Report of the Royal Commission into the Building and Construction Industry recommended that uniform national OHS construction standards be developed under the National Strategy.

In November 2003, the WRMC agreed that national material for the construction industry should be developed. The *National Standard for Construction Work* [NOHSC: 1016 (2005)] (referred to in this document as the National Standard) was declared by NOHSC in accordance with Section 38 of the *National Occupational Health and Safety Commission Act 1985* (Commonwealth) on 27 April 2005.

The National Standard's objective is to protect persons from the hazards associated with construction work. High-risk construction work as defined in the National Standard includes tilt-up and precast concrete construction work. The National Standard sets out the requirements for both OHS Management Plans and Safe Work Method Statements referred to in this National Code.

During 2004, the NOHSC commenced development of this National Code in consultation with the NOHSC Construction Reference Group (CRG) and the NOHSC Tilt-up and Precast Construction Working Group (TUWG). The TUWG's role was to provide technical expertise and guidance to the NOHSC.

In April 2006, the ASCC established the Construction (Concrete Elements) Technical Group with representatives from Australian, state and territory governments as well as industry and union representatives. The technical group's role was to provide technical expertise to the ASCC on the continued development of this National Code.

In August 2006, the ASCC agreed to release a draft version of this National Code for public comment.

This National Code draws together best practice from Australian, state and territory OHS authorities into a framework that will promote a nationally uniform approach to the management of the hazards and related risks in the safe handling of concrete elements in construction work.

The *National Code of Practice for Precast, Tilt-up and Concrete Elements in Building Construction* was declared by the ASCC, in accordance with Section 4 of the Australian Workplace Safety Standards Act 2005 on 27 February 2008.

Compliance with the recommendations of this National Code will not necessarily mean that a person has fulfilled their obligations under all relevant OHS Acts and Regulations. Persons should contact their Australian, state or territory government OHS authority for information on their obligations.



1.1 Purpose

This National Code provides guidance to persons working in the general construction industry on the safe handling of concrete elements in building construction.

1.2 Scope

This National Code is concerned with the prevention of injury to persons who work with or around concrete elements in construction work and provides practical guidance on the safe handling of concrete elements. A concrete element means a concrete panel or other precast concrete element, made in either an on-site or off-site casting yard that is cast and then lifted into position to form part of a building.

Concrete elements not included in the scope of this National Code include concrete pipes, bridge beams and culverts. This National Code does not cover any other form of construction work other than building construction.

Although the illustrations and guidance in this document are related to wall panels, some of the guidance in this National Code may be appropriate for precast concrete beams, columns and slabs as indicated in the scope of this National Code.

Precast service cores such as lift shafts and stair cores are also included in the scope of this National Code. The re-use of wall panels is allowed, provided relevant industry building standards requirements are met. Further guidance on the re-use of panels is provided in **Appendix B**. Guidance on the demolition of concrete elements is provided in **Appendix C**.

This National Code sets out industry-wide guidelines for establishing and maintaining a safe working environment wherever concrete elements are used in construction work, in order to meet the requirements of the National Standard.

This National Code covers:

- > safe design
- > handling, storage, transportation
- > on-site prefabrication
- > erection, and
- > demolition.

Further information on the general design, erection and prefabrication of concrete elements, including tilt-up wall panels, can be found in Australian Standards and other documentation referenced in this National Code.

Users of this National Code should be aware that it is based on current knowledge and construction methods within the industry and is not intended to exclude other methods or processes that can also meet the required safety standards.



1.3 Definitions

The definitions used in this National Code are provided at **Appendix A**.

It should be noted that this National Code refers to “an engineer” throughout the document unless otherwise stated. Where the term engineer is specified in the document, the type of engineer is dependent on the type of work being undertaken. All work related to erection should be handled by the erection design engineer and the overall building design by the project design engineer.

1.4 Referenced documents and further reading

A list of documents referenced in this National Code as well as further reading is provided at **Appendix D**.



2. DUTY HOLDER RESPONSIBILITIES

This section provides information on the responsibilities of clients, designers, persons with control of construction projects, persons with control of construction work, and persons undertaking construction work.

2.1 Australian, state and territory laws and regulations and how they apply

The National Standard describes the health and safety responsibilities of persons involved in construction work.

It is important to note that persons engaged in construction work should comply with all other health and safety obligations set out in Australian, state or territory government regulations. The agency responsible for OHS in your state or territory will be able to provide you with further information about your health and safety obligations (see **Appendix E** for contact details).

2.2 Clients

Clients have a responsibility to consult with designers and builders to ensure that safety matters are considered in all aspects of the design work for all concrete element construction work.

2.3 Designers

To the extent that they have control over the design, designers have a responsibility to ensure that any risks to the health and safety of any person that result from the design are identified and eliminated, or where this is not possible, minimised.

Where there have been several stages of design undertaken by individual designers, each designer has responsibility for the stage over which they have control. In these circumstances, the designers must consult on the health and safety implications of the design.

In general, designers are expected to eliminate known hazards, or where this is not possible:

- > minimise the risk of the known hazards, and additionally
- > provide to the client or person with control written information relating to the design including:
 - hazards identified
 - the proprietary documentation that sets out the safe use of a component or component system
 - structural design drawings showing the in-service use of the concrete element, and
 - the documentation relating to the prefabrication and erection of the concrete elements.

Designers are responsible for two separate phases of design in concrete element construction:

- > structural design, and
- > design for erection.



Some of the issues that need to be taken into consideration to ensure design obligations are met include that:

- > the structural design should take into account the particular requirements of precast concrete structures to ensure that the concrete elements can be erected
- > special care is taken during design and construction to guard against progressive collapse
- > the slenderness and stability of precast and tilt-up concrete elements is taken into account
- > the specification of the strength of concrete takes into account the strength required at lifting, as well as the requirements for in-service loading, durability and ease of construction
- > the concrete strength required at lifting is in accordance with the lifting insert manufacturer's specifications, and
- > concrete specifications are clearly shown on the drawings and include any special requirements, for example cement content and water-cement ratio.

Further guidance on designer obligations is provided at **Section 4**.

2.4 Person with control of the construction project or construction work

The person with control of a construction project or control of construction work has a responsibility to protect the health and safety of any persons who may be affected by the construction work:

- to the extent that the person has control over the construction work
- to the extent that the health and safety of the affected person is affected by the construction work.

The person with control has a duty to ensure that all hazards are identified and that information relating to the hazard identification, risk assessment and risk control process is compiled and recorded.

2.4.1 Risk Management

Risk management is the process of identifying hazards and situations which have the potential to cause harm to those persons undertaking or affected by concrete element construction work. This includes implementing, monitoring and reviewing controls to prevent harm to those persons.

Information on performing a risk assessment for concrete element construction work is provided in **Section 3**.

2.4.2 Person with control to provide Safe Work Method Statement(s)

Concrete element construction work is defined in the National Standard as high-risk construction work. As a consequence, where concrete element construction work is to be undertaken on a construction site, the person with control of a project should ensure that each person with control of construction work involving concrete elements prepares a Safe Work Method Statement (SWMS) for each task. Where no other person can be identified as responsible, the person with control of the construction project should prepare the SWMS. A SWMS template is provided at **Appendix F**.



While there are generic aspects of concrete element work tasks, the SWMS should be specific to the construction project. The SWMS should address site and environment-specific variations to work tasks and set out the safe working procedures. The SWMS must be signed off by the person with control of construction work and by the erector.

The minimum requirements for a SWMS include:

- > identification of work activities and hazards
- > identification of the risks to safety posed by the hazards
- > description/s of the control measures that will be applied to the work activities
- > description/s of how the safety measures will be implemented to allow the work to be undertaken safely, and
- > description/s of the equipment used in the work, the qualifications of the personnel doing the work, and the training required to do the work safely.

2.4.3 Person with control to ensure compliance with Safe Work Method Statement/s

The person with control of the construction project has a responsibility to ensure that those persons undertaking concrete element construction work comply with the SWMS.

2.4.4 Person with control to provide work plan and/or OHS Management Plan

Where five or more persons are working (or are likely to be working) simultaneously on a construction site, the person with control must ensure that a site-specific OHS Management Plan (OHSMP) is developed before construction work commences. The OHSMP includes a SWMS for all high-risk construction work. Alternatively, arrangements that exist in each state or territory may be used as a guide.

For concrete element construction work where an OHSMP is not required (i.e. less than five persons are working or are likely to be working simultaneously on a construction project), it is desirable that the person with control should develop a work plan that sets out the details of the construction work and how this can be undertaken safely.

A work plan should contain the following information:

- > design documentation (see **Section 4.1**) including:
 - proprietary documentation
 - prefabricator's inspection and statement
 - structural design drawings
 - element documentation including marking plans, shop drawings and erection documentation
- > the proposed sequence of work and SWMS (see **Section 2.4.2**). The complete construction and erection sequences should be planned before the concrete elements are prefabricated (see **Section 7.1**)
- > a traffic management plan (see **Section 6.7.1**)



- > details of the stabilisation methods (temporary and permanent) to be used while concrete elements are being erected in order to guard against the collapse of a concrete element, panel or structure. The methods used need to be sufficient to ensure adequate structural strength and continuity of the structure and its parts, both during the erection phase and in the finished structure. The methods used need to safely transmit applied loads through the structure
- > crane requirements (see **Section 6.3**)
- > signed copies of any changes made to specifications and/or signed instructions, advice or diagrams made or issued by an engineer
- > a copy of any notification to a relevant authority responsible for the regulation of concrete element construction work
- > a copy of any exemption from the requirements of regulation granted by any authority, in relation to the work
- > a copy of any inspection report on the formwork set-up referred to in AS 3850 or the most recent equivalent, for each concrete element
- > a copy of the engineers' approval for any temporary storage facilities
- > a copy of any report, licence or authority required to carry out concrete element construction work.

Note: A copy of the work plan may also be required to be lodged with a relevant local government authority.

In addition to the requirements of the National Standard, the person with control should develop or obtain documentation in relation to concrete element construction work (see **Section 4**).

2.4.5 Person with control to provide OHS training

A person with control of a construction project must ensure that any information, instruction and training relating to any hazards, risks and control measures identified is provided to those engaged to undertake the construction work.

Appropriate OHS training should include:

- > OHS induction training
- > induction on this National Code and AS 3850 or the most recent equivalent
- > identification of hazards associated with the use of plant and equipment and the manufacture, transport, storage, erection and demolition of concrete elements
- > the selection, fitting, care, use and storage of required protective clothing and equipment
- > emergency procedures, and
- > familiarisation with the OHSMP and the SWMS for the concrete element construction work.

Note: OHS induction should be in accordance with the requirements of the National Standard. The training provided must meet the requirements of the state or territory in which the construction work is undertaken.



2.4.6 Person with control to ensure consultation

The person with control should ensure that all persons engaged in concrete element construction work are consulted and involved in the hazard identification, assessment of risk and methods used to control those risks.

Consultation

Before commencing work on a project, and while work is proceeding, relevant subcontractors, self-employed persons and employees should be informed of the following matters:

- > the methods used to control the workplace hazards including the content of the OHSMP and SWMS
- > how to minimise the likelihood of hazards becoming a source of harm to themselves and others
- > the location and correct use of safety equipment
- > emergency procedures, and
- > the results of any health and safety monitoring undertaken in the workplace.

Note: Legislation in each state and territory governs specific consultation arrangements that must be implemented at workplaces.

2.4.7 Persons engaged to carry out construction work

Any person or persons undertaking construction work have a duty to protect their own health and safety while at work, as well as to take reasonable care to ensure that their actions do not harm or place others at risk. All persons engaged to carry out high-risk construction work should plan construction work to ensure that their work is consistent with the SWMS.

A range of people may be engaged to carry out construction work. These people include employees, self-employed persons, contractors, apprentices or subcontractors.

Any work that has been identified as not being able to be carried out safely should be discussed with their supervisor or a health and safety representative. Work should not be carried out until a safe method for conducting that work has been provided.

2.4.8 Planning and layout

The parties involved in the design, prefabrication, transport and erection process should plan the complete construction and erection sequences before manufacturing the concrete elements.

The casting and erection sequences of the concrete elements should be agreed between the builder, the project design engineer, the erector, the prefabricator and the erection design engineer. The builder, in association with the erector, the prefabricator and the erection design engineer, should prepare plans for the erection sequence and bracing layout in accordance with the requirements of this National Code (see **Section 7.5**).



3. RISK MANAGEMENT

The risk management process for concrete element construction work should be a systematic process that is used to:

- > identify the hazards associated with concrete element construction work
- > eliminate the hazards
- > where the hazards cannot be eliminated, assess the risks posed by those hazards to develop ways to control the residual risks
- > monitor and maintain the implemented controls.

3.1 Hazard identification

Due to their size and mass, concrete elements may be hazardous and pose a significant risk to those undertaking their prefabrication, transport, handling, erection and fixing. Persons working on other activities on the construction site are also at risk.

Hazard identification should be considered at each stage of the concrete element construction work, including:

- > design
- > prefabrication
- > handling, storage and transport
- > erection and temporary bracing
- > fixing into final structure
- > brace removal
- > modification and/or demolition.

A systematic hazard identification process should be used to identify all hazards associated with concrete element construction work. Hazard identification should also consider the presence of other hazards on the construction site and the impact of these contributing hazards on the concrete element construction work.

Contributing hazards

Contributing hazards may include:

- > the features of the site such as sloping ground, rough surfaces, holes and other obstructions
- > overhead power lines and/or underground utilities
- > weather conditions, particularly locations that are prone to gusty wind conditions
- > working at height
- > sites with many activities being undertaken at the same time



- > manual handling tasks
- > hazardous substances including curing compounds and release agents, and
- > the movement of traffic and mobile plant on and adjacent to the site.

3.2 Risk assessment

Once a hazard has been identified, an assessment of the risk posed by that hazard is required. The person with control should undertake this risk assessment together with others involved in the work. It is important that the persons undertaking the risk assessment have the necessary information, knowledge and experience of concrete element construction work.

A risk assessment is an estimate of harm that may result from the hazard, based on all the available information. It is used to consider the likelihood and the severity of an injury as a result of working with concrete elements in construction work. The greater the likelihood of an incident occurring, and the greater the potential severity of injuries, the higher the priority for controlling the hazard.

The most significant hazard posed by concrete elements is that of severe crush injuries resulting from:

- > the uncontrolled collapse of concrete elements during handling and erection, including while temporarily braced or when elements are being modified or removed
- > a person being caught between concrete elements, between elements and mobile plant or between elements and other structural components.

In concrete element construction work, other factors can also contribute to the likelihood of an uncontrolled collapse and subsequent injury.

3.2.1 Factors contributing to risk

Factors that may contribute to the likelihood of an uncontrolled collapse and injury include:

- > faulty design, including the use of incorrect components or inadequate concrete strength
- > faulty lifting inserts or connectors
- > poorly secured loads or incorrect methods used for loading or unloading elements for transport
- > weakness in concrete elements due to inappropriate modifications
- > incorrect lifting and erection practices, including the unsafe use of rigging
- > lifting before the concrete element has reached its design strength
- > weakness resulting from errors while prefabricating the concrete elements
- > inadequate lifting equipment for the task, i.e. the unsafe use of cranes
- > inappropriate or unstable work area for the cranes
- > inadequate structural capacity of footings
- > damage to concrete elements and/or weakness of subsequent repairs; and
- > inadequate temporary storage facilities, including racking systems, suspended floors or beams.



3.2.2 Environmental factors

Environmental factors may also increase the likelihood of an injury for persons undertaking concrete element construction work. For example:

- > the wind speed may exceed specifications for the safe erection of the concrete elements
- > wet weather may cause instability in the crane standing area or erection area
- > extremes in temperature may make it unsafe for those persons erecting the concrete elements, for example warm clothing or weather conditions may muffle instructions and/or block the line of sight for hand signals.

3.3 Hierarchy of control

Once all of the hazards have been identified, the person with control should eliminate the hazards. Where elimination is not reasonably practicable, the person with control should minimise the risk in the following order of preference:

1. change the proposed method of work to lessen the risk posed by the hazard
2. isolate the hazard from persons at risk
3. minimise the risk posed by the hazard by engineering means
4. applying administrative control
5. the use of personal protective equipment (PPE).

3.4 Monitoring and maintaining controls and recording in a SWMS

The person with control should regularly monitor the control measure/s to ensure that the controls are used properly and remain effective. Details on the procedures for monitoring and maintaining controls should be recorded in the SWMS (**Appendix F**). For all high-risk construction work, the SWMS should form part of the OHSMP (see **Section 2.4.4**).

It is a requirement of the National Standard that concrete element construction work be recorded in a SWMS.



4. DESIGN CONSIDERATIONS

Concrete element construction work generally involves two separate phases of design: the structural design, which is for the in-service performance of a concrete element as part of the complete structure; and the design for the handling, storage, transport and erection of a concrete element.

Where multiple designers undertake these phases of design, the designers should consult on the health and safety implications of the design.

In addition to the requirements of the National Standard, the person with control should develop and collect a range of documentation in relation to concrete element construction work including:

- > a copy of any notification to a relevant authority responsible for the regulation of concrete element construction work
- > a copy of any exemption from the requirements of a regulation granted by any authority in relation to the work
- > a copy of the structural and concrete element documentation (see **Section 4.1.2**)
- > a current work plan setting out details of the proposed execution of the work (see **Section 2.4.4**) together with a copy of any related information, instructions or diagrams received from the design engineer
- > a copy of any inspection reports of the formwork set-up referred to in AS 3850 or the most recent equivalent, and
- > a copy of any report, licence or authority required to carry out concrete element construction work.

4.1 Design documentation

The National Standard recognises that the provision of information on safety issues is a key component of ensuring proper, adequate and suitable design. Where hazards can not be eliminated from the design and risks remain, information and instructions for the work should be included with the design to alert others to the risks.

Documentation relating to the design and residual hazards and risks should be provided to the person with control of the construction project for incorporation in the construction work plan (see **Section 2.4.4**).

Concrete element documentation includes a marking plan, shop drawings and erection documentation. All of the documentation should be available at the construction site whenever work is being carried out.

4.1.1 Proprietary documentation

Where applicable, the following proprietary documentation should be included:

- > drawings that clearly identify the component or system to which it refers
- > adequate information which fully describes its intended use
- > instructions for use, storage and maintenance including all precautions to be observed in its use



- > criteria for rejection and reworking of the component or system
- > detailed information including, where appropriate, the:
 - part number
 - dimensions
 - section properties
 - self-weight
 - details of any special attachments such as coupling sleeves
 - locations for attachment points and bracing points
- > the strength and serviceability limit state capacities referred to in AS 3850 or the most recent equivalent
- > the Working Load Limit (WLL); and
- > a statement that the component or system depicted in the documentation complies with AS 3850, or the most recent equivalent.

All components used on site, within a particular system, should be compatible. Different proprietary components should not be mixed without confirmation of compatibility from the supplier and the designer. The proprietary documentation should set out the information required for the correct use of the component or system.

Incompatibility of different types of inserts and variations in sizing may lead to failure. This is particularly relevant to lifting inserts, bolts, ferrules and lifting clutches. All materials, components and equipment should comply with the relevant Australian Standards, in particular the requirements of AS 3850, or the most recent equivalent.

4.1.2 Structural design drawings

The structural design drawings are prepared by an engineer and should include the:

- > date and issue number of the drawing
- > plans and elevations clearly indicating the structural framing and concrete element layout
- > structurally critical dimensions
- > reinforcement, strands and concrete cover required for in-service loads and conditions
- > framing connection locations and required type (e.g. cast-in) and where appropriate the capacity of the fixing inserts
- > levelling pad details for erection
- > structural design criteria affecting construction, e.g. wind design loads and tolerances
- > concrete specification including all special requirements to meet in-service loadings and conditions and a note that, at the time of lifting, all concrete must meet the strength requirements nominated on the shop drawings
- > base connection details, including grouting sequence of dowel connections, and



- > location of services such as plumbing, electrical and cabling conduits where they impact on the structural integrity of the concrete element.

The structural design drawings, including the approval of any proposed proprietary or manufactured inserts and fixings, should be signed off by an engineer.

4.1.3 Marking plan

A marking plan (layout plan) prepared by the shop detailer should show the location of each concrete element in the final structure.

4.1.4 Planning

Prior to the preparation of the shop drawings, the parties involved in the design, manufacture, transport and erection process should liaise to plan the complete construction and erection sequences. Consideration should be given to details such as site limitations, local street access, delivery sequence, transport requirements, and overhead obstructions. These aspects can have a significant effect on the size of precast concrete elements and on the erection process.

4.1.5 Shop drawings

Shop drawings are prepared by the shop detailer and should include the:

- > date and issue number of the drawing
- > project location
- > concrete element numbers
- > mass of each concrete element
- > concrete element dimensions and centre of gravity
- > reinforcement, strands and concrete cover
- > size, configuration and concrete cover of any additional reinforcement required for the transport and lifting of the concrete element
- > size and grade of bolts to be used for any temporary erection fixings, in accordance with AS 1111 and AS 1252 or most recent equivalents
- > location, orientation and depth of all inserts and the size, configuration and concrete cover of any component reinforcement that is required. All edge-lift inserts and some other inserts require component reinforcement and details should be obtained from the suppliers of these items
- > location of any conduits for plumbing, electrical or cabling
- > location of grouting ducts and, where required, lateral restraint details
- > erection sequence
- > as applicable the type, make, capacity and technical specifications of the:
 - rigging system (thumb nail sketches of system to be shown)



- lifting inserts
 - bracing inserts and fixings including type and capacity
 - fixing inserts; and, if required
 - strongbacks, strongback fixing inserts and locations;
- > class and strength grade designation of the concrete as defined in AS 3600, or the most recent equivalent
 - > required concrete compressive strength of the concrete element as applicable at the time of lifting and erecting. It may be necessary to manufacture concrete elements with concrete strength grades higher than that specified on the structural drawings to achieve the concrete strengths required at the time of lifting
 - > brace and prop details for each concrete element. Where applicable, this should include requirements and details for knee bracing and any other secondary bracing that may be required and the
 - > standardised symbols used on the shop drawings in accordance with those used in AS 3850 or the most recent equivalent.

Note: A copy of the shop drawings may need to be lodged with a relevant local government Building Licensing Authority. Information contained in the shop drawings will assist in the consideration of any future modification work and the safety of any future demolition of the building.

Shop drawings are prepared by the shop detailer. The drawings should provide all the information and details required to manufacture the concrete element.

Shop drawings should be subject to review by a project design engineer and then approval by an erection design engineer. The drawings should be checked for consistency with the dimensions of the structural drawings and any necessary amendments marked up on the structural drawings. These amendments should be reviewed (signed and dated) by the engineer, and then returned to the shop detailer for incorporation into the shop drawings. The amended shop drawings should then be approved, signed and dated by the engineer. The approved shop drawings should be marked 'for construction' and retained on site by the person with control of the construction project.

An example of an engineer's certification letter for lifting and in-situ loads is at **Attachment G**.

4.1.6 Erection documentation

The erection documentation prepared by the engineer should cover every aspect of the erection process, including the:

- > erection sequence
- > orientation (position relative to each other) of the concrete elements
- > configuration and size of erection braces and, where applicable, knee braces and cross-bracing provided by the engineer
- > bracing details including type and angle (designed and certified by an engineer)



- > requirements for erection brace footings (and prop footings if required), brace fixings and concrete strength of the brace footings (including slabs) at the time of erection by an engineer
- > levelling shims details for erection, and the
- > requirements for grouting specified by an engineer.

Note: Erection documentation in the form of a SWMS should be provided by the erector/builder and signed by an engineer.

4.2 Structural design

The structural design of the concrete elements should be carried out in accordance with the requirements of AS 3850 (if applicable) and AS 3600 or their most recent equivalents as appropriate, as well as the provisions of this National Code.

The structural design for in-service performance must give consideration to the:

- > manufacturing details including element size and reinforcement
- > erection method of concrete elements which can produce higher loading conditions than the final in-service loads (lifting, rotation and impact can cause variations to load distributions)
- > requirements of the floor slabs to cater for additional construction loads from operating plant and material storage, and for additional loads that can be encountered from topping concrete on some floor slabs and beams that act as formwork, and the
- > stability of the structure prior to tying into the permanent structure.

Note: See Section 4.3.5.

4.2.1 Joints

Unless otherwise specified, joint widths between adjacent concrete elements should not be less than:

- > 15mm for joints with flexible sealant
- > 20mm for mortar or grouted joints, and
- > 150mm for in-situ concrete in-fills.

When selecting joint filling materials, consideration needs to be given to the:

- > thermal and shrinkage movement of the concrete element
- > fire resistance level
- > weather resistance
- > structural movements to be accommodated
- > dimensional tolerances of elements, and the
- > element location tolerance.

Joints between adjacent concrete elements should be sufficient to maintain designed position and alignment during erection and accommodate tolerances and expected movements.



4.2.2 Fixing inserts

The design of fixing inserts should provide for the:

- > number, location and placement of fixing inserts, adequate to resist the tension and shear forces (static and cyclic) imposed on the connections
- > reduction of insert capacity when placed near an edge or an opening
- > component reinforcement
- > adequate cover to all inserts, and the
- > ductile behaviour and robustness of the insert.

The type and characteristics of fixing inserts should be specified on the shop drawings and should not be changed without prior approval from an engineer.

The design of fixing inserts for connecting concrete elements to roof framing, and other structural members, should comply with AS 3850 or the most recent equivalent, and the Building Code of Australia (BCA).

4.3 Design for handling, storage and transport

The design for handling concrete elements should consider:

- > the size and shape of the concrete element
- > whether the concrete element is to be lifted by the edge or the face
- > whether the concrete element is to be rotated during erection
- > cast-in fittings
- > handling and storage loads including:
 - the effect of suction and adhesion at separation from the formwork or casting bed (lift off)
 - dynamic and impact loading during transportation, where applicable
 - erection and bracing loads
 - wind load on the braced panels in accordance with AS/NZS 1170.2 or the most recent equivalent
 - construction loads including any backfill and surcharge loads
 - permanent, imposed and other loads in accordance with AS/NZS 1170 or the most recent equivalent
 - seismic load in accordance with AS/NZS 1170.4 or the most recent equivalent (the increase in design loads due to wind load and seismic load is not cumulative).
- > additional reinforcement, and
- > the brace footings.



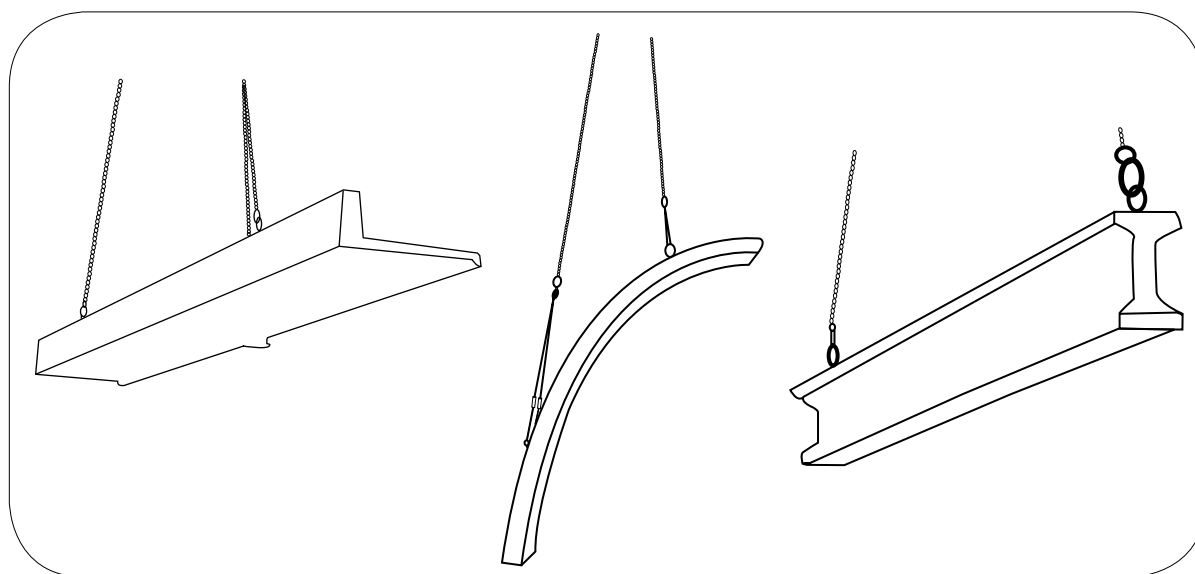
4.3.1 Size and shape of concrete elements

Slenderness and stability are major considerations in the design of concrete elements. While an engineer needs to address these issues for the in-service condition, they should also be considered for the prefabrication, handling, storage and erection phases of the construction work.

When determining the size and shape of concrete elements, consideration should be given to the:

- > size, capacity and configuration of crane(s) available to undertake lifting and erection
- > manufacturing restrictions
- > location and proximity of overhead power supplies
- > access to and around the site
- > bracing, propping and grouting requirements, and the
- > transport restrictions.

Figure 1. Various precast concrete elements



Concrete element slenderness ratio

The slenderness ratios for concrete elements are specified in AS 3600 or the most recent equivalent. These ratios may be exceeded provided a detailed analysis is carried out, taking into account the following factors:

- > loading on the concrete element
- > movements due to the eccentricity of vertical loads
- > movements due to deflection of the concrete element and its supports, and
- > long term effects, if any.



Dual lift slenderness design

Buckling and instability can occur during lifting and erection of long slender concrete elements.

Lifting inserts should be located to ensure that compression flange buckling (as in a long slender beam) can not occur, particularly during rotation of concrete elements.

4.3.2 Lifting inserts

The load capacity of lifting inserts is dependent on several factors including:

- > the strength of the concrete element at the time of lifting
- > embedment depth and placement of the insert, and
- > direction of load, shear or tension (see **Figure 2**).

When fixed length multi-legged slings are to be used for lifting concrete elements, any two of the lifting inserts should be capable of supporting the total load.

All lifting inserts require adequate embedment or anchorage to function effectively.

Anchorage is affected by the:

- > proximity to edges
- > proximity to holes, recesses or edge rebates
- > proximity to other loaded lifting devices
- > concrete thickness
- > concrete strength at lifting
- > embedment depth
- > presence of cracks, and
- > proximity of reinforcement.

Lifting inserts should be configured in accordance with the manufacturer's recommendations, including component reinforcement for the direction of the applied load.

When selecting lifting inserts, consideration should be given to the suitability of the component for the task to be undertaken. This information should be included in the shop drawings (see **Section 4.1.5**).

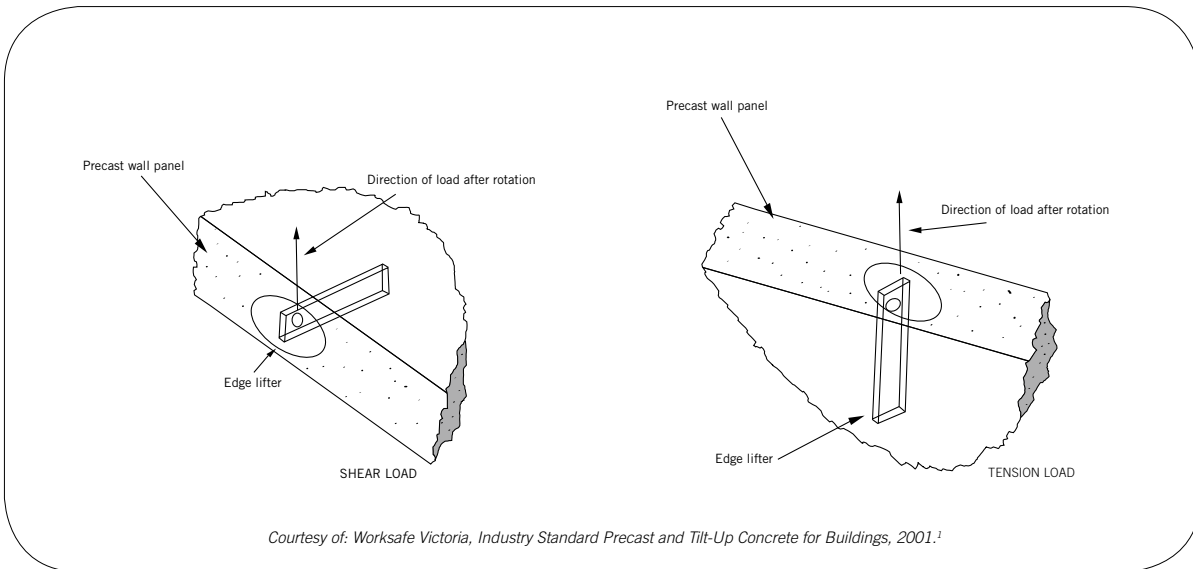
The number of lifting inserts required is dependent on several factors including the concrete element size and shape, insert capacity and insert location. The location of lifting inserts is interrelated to the reinforcement design and the proposed erection procedures.

When locating lifting inserts, consideration needs to be given to the need for strongbacks if the concrete element has large or awkwardly located openings.

Rated capacities of edge lifters should be checked to ascertain if the rating is for shear or tension loads.



Figure 2. Shear loads and tension loads in edge-lifted concrete elements



Multiples of three rows or columns of lifting points where equal loading is required should be avoided because of the complex rigging configurations required. For example, lifting arrangements comprising three, six, nine or 12 lifting points should be avoided.

Preferred lifting insert configurations for concrete wall panels are shown in **Section 7.5.6, Figure 9**. In the case of concrete panels, lifting inserts may be positioned in the face or edges of the panel.

4.3.3 Location of lifting inserts

The actual locations of the lifting inserts are determined according to the:

- > method of lifting (face or edge)
- > mass, size and shape of the concrete element and presence of openings and cut-outs
- > structural capacity of the concrete element
- > concrete strength at the time of lifting, and
- > capacity of the lifting inserts and direction of lift.

When it is intended that concrete elements be tilted about an edge using anchors placed in the panel face, the geometric centre of the face-lift inserts must be above the panel's centre of gravity.

Face-lifted concrete elements should be designed to hang no more than 10 degrees from the vertical. If this is not possible, consideration should be given to using edge-lifting or a combination of face-lifting and edge-lifting.

¹ For further information and future updates, please access www.worksafe.vic.gov.au



4.3.4 Cast-in fixings

Cast-in fixings such as threaded inserts, weld plates or brackets must be designed and specified by an engineer and should be installed as per the manufacturer's recommendations for proprietary items.

Where possible, to minimise the chance of error, fixings should be standardised for all concrete elements on an individual project. Where permanent fixings or connections are also intended for temporary use during construction, the builder or the erector should verify that such use will not compromise their long-term performance.

Impact driven fixings, including explosive charge driven fixings, should not be used.

4.3.5 Structural connections and temporary supports

In the design for erection, an engineer should consider the connection required to fix the concrete element together and into the final structure. During the erection sequence, the concrete element must be able to be connected into the final structure in such a manner as to eliminate the risk of collapse.

Connections between concrete elements, or between concrete elements and structural members, need to be designed to resist the lateral and vertical forces imposed on the connections in accordance with the requirements of AS 3850 and AS 3600, or their most recent equivalents as appropriate.

The design of the connections needs to take into account the capacity of both the fixing and the concrete. The ultimate capacity of the connection required should be the lesser of fixing failure (either in tension or in shear), and the cone failure.

All connections should be designed to fail in a ductile manner.

The details of the connections should be provided on the structural drawings.

Where permanent structural connections are being used for temporary connections, the connections should be checked for additional constructional loadings and the element checked for structural adequacy. In floor systems which utilise precast beams and slabs, sometimes these elements are not precast to their full size and are followed by a topping after erection to ensure monolithic action of the system. Such systems may require temporary supports until built up to their full size. If these temporary supports are not provided by the supplier, then the temporary supports should be designed by an engineer. Examples of these supports include props, form frames and brackets. They should be installed and removed as specified by the engineer. AS 3610, or most recent equivalent, provides guidance for designing supports.

4.3.6 Handling and storage loads

As well as the structural (in-service) design, concrete elements should be designed for the loads and conditions likely to be experienced during the prefabrication, handling, storage and erection phases of construction.

4.3.7 Suction loads

When concrete panels are lifted off the casting bed or panel stacks, suction loads can occur. These add direct loading to the crane and lifting gear. In some situations the suction loads can cause lifting gear



failure, structural crane damage or crane instability in the case of mobile cranes. Suction loads can also damage concrete panels.

If adequate precautions are not taken, suction loads can account for in excess of an additional 100% of the load (i.e. at least double the load). Some of the factors that increase concrete panel suction are:

- > failing to use an effective release agent (bond breaker)
- > failing to apply the release agent effectively by missing some parts of the concrete panel or by applying inadequate amounts of release agent, and
- > failing to design or cast the concrete panel with a profiled or textured surface.

An effective system should be implemented to reduce suction loads as far as is reasonably practicable. However, even when this is done the rated capacity of the crane and lifting gear should be at least 20% greater than the total calculated dead load of the crane lift.

When lifting a panel off the bed or stack, the force required to overcome concrete panel suction is not to exceed the rated capacity of the crane and lifting gear. If the concrete panel does not come free when the crane's load indicator registers the rated capacity of the crane, lifting is to be stopped.

One or more of the following alternatives should then be selected, provided they are supported by written direction from an engineer:

- > use of a larger capacity crane that can lift the load without the rated capacity of the crane being exceeded
- > manipulation of the panel (i.e. by wedging or jacking) to overcome the suction load, so that the rated capacity of the crane will not be exceeded. This alternative can only be used if the concrete panel is not damaged by the procedure.

4.3.8 Impact loads

Impact loads generated during handling and transport around the site can be significant and need to be considered in the design of the lifting inserts and rigging systems. These increases to loads may range from 20% during handling by a crane to up to 100% during transportation.

Impact loading should only be considered after release (lift-off) of the concrete element from the casting bed. The increase in design loads due to suction and impact is not cumulative.

4.3.9 Erection loads

Concrete elements need to be designed for the loads and conditions likely to be experienced during the erection and bracing phases in accordance with AS 3850 and AS 3600 or their most recent equivalents.

In determining the structural requirements for a concrete element, an engineer should consider the additional implications that the erection process places on the design. The design should provide for variations to the load-distribution on the concrete elements during lifting, rotation and impact during temporary and final placement.

The design for erection should address the:

- > size and shape of the concrete elements



- > erection loads
- > design of the supporting members to cater for the erection loads
- > cast-in fittings
- > lifting inserts
- > cast-in connectors
- > fixing requirements
- > grouting requirements
- > requirements for additional reinforcement, and
- > footings to brace any vertical concrete elements during construction.

4.3.10 Wind loads

Wind loading on concrete elements will vary depending on the size of the elements, wind speed and wind direction. In built-up areas, the wind effect may be less than in open areas although ‘funnelling’ effects can increase wind loading. Wind loads should be calculated in accordance with AS/NZS 1170.2 or most recent equivalent.

In cyclone-prone areas of Australia the potential wind loading applied to concrete elements will be greater. Sudden and severe wind gusts frequently occur throughout Australia, particularly in coastal areas.

4.3.11 Additional reinforcement

Additional reinforcement may be required in concrete elements to accommodate forces during handling, transportation and erection. Additional reinforcement may be used:

- > near the base of the concrete element to resist stresses arising from thermal and shrinkage movements whilst the concrete element is supported only on the levelling shims;
- > 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, and
- > where there is a possibility of load reversal due to mishandling during transport or erection.

Note: Additional reinforcement or strongbacks should be provided where the maximum flexural tensile stress in concrete elements exceeds the limits recommended in AS 3850 or the most recent equivalent.

4.3.12 Strongbacks

Strongbacks may be used to strengthen the concrete elements or to locate additional lifting points to prevent out-of-plane rotation of odd-shaped concrete elements. When strongbacks are required, they should be designed to ensure the strongback is sufficiently stiff to prevent cracking of the concrete element due to differential deflection.

The location of the strongbacks should not interfere with the rigging at any angle of the concrete element rotation. See **Figure 3** for examples of strongback applications using steel channel sections.

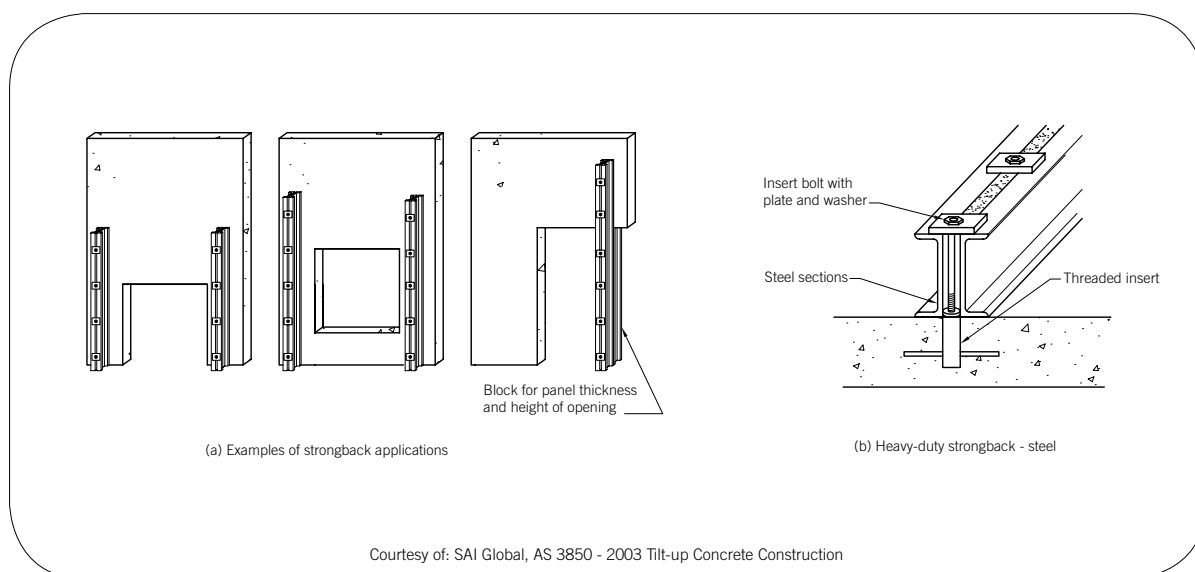


An engineer should approve any changes to the specified strongback system before the changes are carried out and the shop drawings should then be amended accordingly.

Where strongbacks are used, their weight needs to be included in the calculation to determine the weight of the concrete element and its centre of gravity for lifting purposes.

Strongback fixing inserts should be either cast-in ferrules or load controlled expansion inserts.

Figure 3. Example of wall panel strongbacks



4.3.13 Brace footings

The ends of the braces should be fixed to a solid, flat concrete surface or other surface that is capable of resisting the applied loads.

Brace footings need to be designed to resist all expected loads, including:

- > construction loads, and
- > wind loads for temporary structures in accordance with AS/NZS 1170.2 or the most recent equivalent.

Structural requirements for and details of brace footings for each type of concrete element should be clearly specified on the shop drawings (see **Section 4.1.5**). This should include the required concrete strength of the footing at the time of installation of the bracing. An engineer should provide a signed plan of the brace footing to the erector before erection commences.

4.3.14 Bracing inserts

Drilled through fixing inserts, undercut inserts or load controlled expansion inserts are acceptable alternatives where cast-in bracing inserts are not used to brace a footing. Where these inserts are used, the WLL should be limited to 0.65 of the first slip load determined in accordance with AS 3850 or the most recent equivalent.



For fixings to brace footings, the capacity of inserts may be less than the capacity of the brace itself, therefore requiring additional braces to support the concrete element. The use of inserts with higher capacities may avoid this. There is difficulty in ensuring an even load distribution where more than two braces are used (see **Section 7.7.1**).

Compliance with an engineer or their nominated agent's written instruction is required prior to brace removal.

4.3.15 Floor slabs

Floor slabs are frequently sufficient for brace footings. However, it is unlikely that floor slabs less than 100mm thick will provide adequate fixing for braces. At the same time, it should not be assumed that a slab greater than 100mm thickness will always be adequate.

Braces should not be fixed closer than 600mm from a joint in the slab.

4.3.16 Cast-in ground concrete anchorages

Where floor slabs are not capable of resisting the bracing forces, or are not in place, it may be necessary to use buried concrete blocks (deadmen) as brace footings. These are commonly cylindrical blocks of concrete that have been cast into the ground after an auger has been used to drill a hole in the ground.

The use of concrete mass blocks sitting on top of the ground, as anchorages for installing brace footings, is strongly discouraged as they are ineffective unless they are designed for the applied loads.

A deadman cast in the ground relies both on its mass and cohesion with the ground to resist wind loads tending to pull it out of the ground (i.e. wind blowing on to the concrete panel face on which the braces are attached). Wind blowing onto the face of the concrete panel opposite where the braces are attached will result in a compressive force in the brace which will tend to push the deadman further into the ground. Of the two different loading cases, the case where the wind tends to pull the deadman out of the ground is the more critical with respect to the design of the deadman.

In some situations soil that is stiffer will provide greater degrees of cohesion, and hence higher pull out loads than sandy soils. Therefore, stiff clay will have better cohesive properties than gravel. Sand will provide very little cohesion. An increase in water content in the ground will also reduce effectiveness of the deadmen.

Deadmen should be designed to comply with AS 3600, or the most recent equivalent. They are usually provided with a cast-in reinforcement bar that runs for the complete depth of the concrete to connect the brace foot to the concrete block. The bar will often be bent at right angles in the deadman which assists the pull out strength of the bar.

Expansion anchors and chemical anchors should not be used in deadmen due to the risk of the deadman breaking (i.e. inadequate edge distance and/or low concrete strength).

Deadmen are typically cast using low strength concrete (e.g. 20 - 25 Mpa) and there will usually be a need to leave them for a substantial amount of time to ensure the cast-in anchors do not pull out.



The following information should be available on site:

- > drawings that show deadman dimensions, concrete strength, steel content and location (if applicable), terrain category (for wind), and soil type
- > documentation that verifies each of the deadmen have been constructed in accordance with the drawings and the concrete has obtained its minimum required strength prior to installation of the braces, and
- > verification that the deadmen are able to resist wind loadings on the concrete panels in accordance with AS 1170 or the most recent equivalent, giving due consideration to the water content of the soil.

The verification should be in the form of an engineer's written certification for that particular site and signed off by a competent person to show the engineer's conditions have been complied with.

4.3.17 Other footings

Other types of footings may be used providing they are designed to ensure sufficient capacity to resist the forces from the braces. For example, concrete piles or metal screw piles may be used as footings.



5. PREFABRICATION AND CASTING

5.1 Materials and components

5.1.1 Concrete and reinforcement specifications

Testing of concrete and verification of concrete strength, in accordance with the requirements of AS 3600 and AS 1012 or the most recent equivalent, should be carried out prior to initial lifting.

The strength of the concrete at initial lifting, and in-service, should not be less than the values specified on the shop drawings.

5.1.2 Curing compounds and release agents

If any hazardous substances, including curing compounds, are used on site, then a Material Safety Data Sheet (MSDS) must be obtained and made available to all persons who may be exposed to the substance. The person with control must consult with all persons who might be exposed to the substance about the intention to use the substance and the safest method of use. Persons likely to be exposed must receive training on health risks, control measures and correct use. They must also be informed about the need for, and details of, health surveillance where appropriate.

The strength, watertightness and durability of concrete depends on the concrete being adequately cured. Curing compounds and release agents should comply with AS 3799 or the most recent equivalent.

Before a release agent is chosen for use in the concrete element, it should be checked for compatibility with the curing compound and other applied finishes and joint sealants. A proven proprietary combination curing compound/release agent can be used. Specialist advice may be necessary from the manufacturer or supplier of the products used.

The person with control should consult their state or territory OHS authority with regard to specific requirements for the manufacture or supply and use of hazardous substances.

The *National Code of Practice for the Control of Workplace Hazardous Substances* [NOHSC: 2007(1994)] can provide further information on the management of hazardous substances.

5.1.3 Lifting, bracing and fixing inserts

All lifting, bracing and fixing inserts should comply with the requirements of AS 3850 or the most recent equivalent and be manufactured from ductile materials. Site welding of reinforcement to inserts, other than weld plates, should not be carried out.

Product documentation, including full technical specifications, make, type and WLL for proprietary inserts, should be provided by the supplier (see **Section 4.1.1**) and be available on site.

If non-proprietary inserts are used they should be designed by an engineer in accordance with the appropriate Australian Standard and be compatible with the other parts of the system in which they are to be used.



The type and capacity of lifting, bracing and fixing inserts should be specified on the shop drawings. They should not be changed without prior written approval by an engineer.

Variations should not be made to the specified insert locations on the approved shop drawings without the prior written approval of an engineer. If changes are made, the shop drawings should be amended accordingly.

All cast-in inserts and any component reinforcement should be accurately positioned and securely fastened in accordance with the supplier's recommendations and as detailed in the shop drawings to prevent dislodgement during concrete placement.

5.1.4 Lifting inserts

Lifting inserts within a concrete element should be specified as cast-in products. Where cast-in inserts are found to be unusable after casting, approval to use an alternative rigging or fixing method should be obtained from an engineer before lifting.

Lifting inserts should be designed, manufactured and installed to provide a WLL complying with AS 3850 or the most recent equivalent, with a limit state factor of at least 2.5 against concrete failure. For this purpose, the applied load needs to include the mass of the concrete element as well as the suction and impact loads.

Steel reinforcement bars are also not suitable as lifting loops and must not be used for that purpose. Certain high tensile strength steel bars have properties that make it suitable only to resist tensile forces and they should not be used in any part of an insert anchorage. Prestressing strand should not be used, for the same reasons.

5.1.5 Bracing inserts

Bracing inserts provide the connection between the brace and the braced concrete element or brace footing. Bracing inserts must be designed to resist all expected loads, including:

- > construction loads, and
- > wind loads for temporary structures in accordance with AS 1170.2 or the most recent equivalent.

Cast-in bracing inserts should be used where possible. Where cast-in inserts are not used, acceptable alternative inserts are:

- > mechanical fixings, such as undercut inserts and drilled-through fixings, used in accordance with the manufacturer's or supplier's recommendations, and
- > load-controlled (torque-controlled) expansion inserts with a permissible load limited to 0.65 of the 'first slip load', established in accordance with AS 3850 or the most recent equivalent.

Chemical anchors relying solely on chemical adhesion shall not be used for bracing inserts unless each insert is individually proof tested to the WLL.

Deformation-controlled anchors, including self-drilling anchors and drop-in (setting) impact anchors must not be used as bracing inserts.



Bracing insert capacities are sensitive to the:

- > method of installation
- > strength of the concrete into which they are placed, and
- > distance from the insert to the edge of the concrete element.

Unless expressly designed and clearly specified, no bracing insert should be closer than 300mm to the edge of the concrete element or the bracing support. On larger concrete panels the distance to the edge may need to be increased to 500mm or more, based on the instructions of an engineer.

Substitution of anchor or insert types and manufacture must not be made without the written approval of the shop detailer or an engineer.

Bracing insert requirements and details for each type of concrete element must be shown on the shop drawings.

Bracing inserts should be located to allow the braces to hang vertically without interfering with the lifting rigging. A minimum horizontal displacement of 200mm for the bracing insert from the vertical line of the lifting inserts will normally be adequate.

When designing bracing inserts for footings, the strength of the concrete in the brace footing must be considered. The concrete strength required in the brace footing at the time of erection must be clearly specified on the shop drawings. Where conventional expansion anchor systems are used, the concrete must be at least three days old.

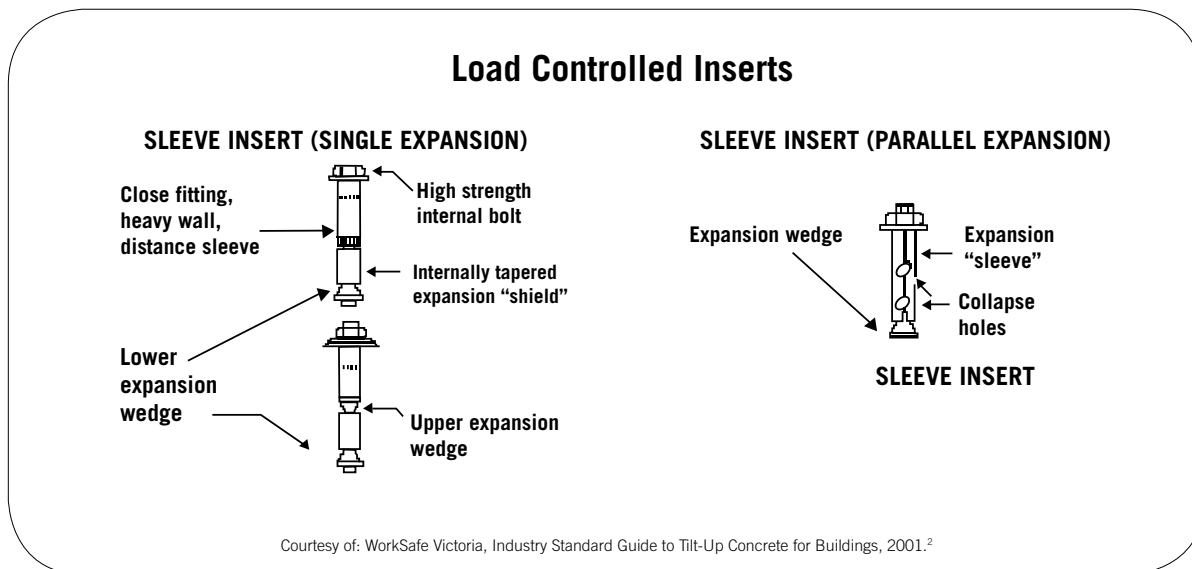
Only load controlled expansion inserts (see **Figure 4**) are permitted in concrete construction for fixing bracing. Where these inserts are used, the WLL should be limited to 0.65 of the first slip load determined in accordance with AS 3850 or the most recent equivalent.

Expansion inserts should be manufactured from ductile material.

Expansion inserts are more susceptible to installation errors than drilled-through fixings. A calibrated torque wrench should be used to ensure correct installation torque is achieved when installing expansion anchors and special attention needs to be given to the correct drilling of the holes. An adequate checking system should be in place to ensure expansion inserts are installed correctly.



Figure 4. Load controlled anchors



Note: Anchors used should be tested in accordance with Appendix A8.2 of AS 3850 or the most recent equivalent.

5.1.6 Fixing inserts

Fixing inserts for connecting the concrete element to roof framing and other structural members should be designed in accordance with the appropriate Australian Standard and the BCA to resist the forces imposed on the connections.

5.1.7 Strongbacks

Concrete elements that are odd shapes, elongated or have large or awkwardly positioned openings may require the addition of steel strongbacks to enable them to be successfully lifted and placed (see **Section 4.3.12**).

5.2 Casting bed

Before the casting bed on site is set out, consideration should be given to the:

- > orientation of the concrete elements on the casting bed
- > vehicular access around the site
- > location of overhead power lines, utility trenches and other services
- > concrete element storage locations, where required, and the
- > crane type, size and lifting position

² For further information and future updates, please access www.worksafe.vic.gov.au



- > erection sequence and bracing layout.

Provision needs to be made in the design for dimensional variation in accordance with AS 3600 and AS 3850, or their most recent equivalents.

Concrete elements should be prefabricated in accordance with the approved shop drawings (see **Section 4.1.5**).

Casting beds need to be capable of supporting formwork, concrete elements and other loads, particularly where the casting bed is used as the crane standing area. The builder should obtain verification from an engineer that the casting bed can carry the construction loads when precast or tilt-up elements are made on site.

Where there is insufficient room to cast all concrete elements on the casting bed, concrete elements may be cast one on top of another, in reverse order of erection. Care is needed with this casting method to limit the tolerances of a concrete element, especially flatness, as the deviation may be cumulative as successive concrete elements are cast one on top of another. Concrete elements are usually cast with their external face down to minimise the need for external patching after erection.

Additional casting beds may be constructed as required.

5.3 Formwork

Formwork should be designed and constructed in accordance with AS 3610 or the most recent equivalent. Each concrete element should be inspected in accordance with AS 3850 or most recent equivalent.

5.3.1 Stripping and repair

Formwork should be carefully stripped and stored to prevent damage.

If the concrete element suffers damage greater than minor spalling, an engineer should approve the proposed repair system in writing before work commences.

5.4 Placement and compaction of concrete

The concrete supplier should be advised of the:

- > specified characteristic concrete compressive strength
- > concrete compressive strength required at the time of lifting
- > required maximum aggregate size
- > required slump
- > special design requirements, if any (for example cement content and water-cement ratio), and the
- > details of the site access.

Before placing concrete, release agent effectiveness should be checked by sprinkling water over the casting bed. If the release agent is effective, the water should form into beads.



Concrete should be placed in a uniform manner and evenly spread over the area before commencing compaction. Vibrators should be used to compact the concrete unless self compacting concrete is used. Particular attention and care needs to be paid to vibrating the concrete around the inserts and adjacent to corners and edges.

5.5 Curing and release agents

If used, the curing compound and release agent should be applied in accordance with the manufacturer's specification and the requirements in **Section 5.1.2** of this National Code.

5.6 Element identification

All concrete elements should be permanently marked during or immediately after manufacture with a unique identification designation, commonly the concrete element number, and date of casting.

5.7 Prefabricator (pre-pour) inspection and statement

Before a concrete element is cast, the form arrangement and set up should be inspected by a competent person for compliance with the shop drawings (see **Section 4.1.5**).

The competent person needs to be familiar with the construction of the concrete elements and must be able to accurately read and understand the approved shop drawings for the concrete elements.

Where the competent person is not an engineer, this person can only verify that the shop drawings have been complied with. This person should not permit variations to the design unless written instructions which clearly detail the variations have been received from the engineer.

On some large projects, where there are regular variations to the shop drawings during the casting process, it may be preferable for the competent person carrying out the pre-pour inspections to be an engineer. However, the engineer must provide signed documentation that approves any variations to the construction of the concrete elements. The verification documentation should include the following information:

- > the identification number for the concrete element being cast – this number is marked on the concrete element following casting
- > the casting date of the concrete element
- > the minimum concrete specification to be achieved for lifting to take place
- > verification that the concrete element has been constructed in accordance with the drawing
- > the name of the competent person carrying out the pre-pour inspection
- > the competent person's signature, and
- > the date of the inspection.

One example of verification documentation that may be used is shown in **Appendix J** (Panel Casting Checklist).



Before the transportation or erection of concrete elements, the prefabricator should provide to the erector and/or builder documentation that demonstrates the prefabrication of the concrete elements was performed in accordance with the approved shop drawings. The verification documentation should be retained on site for the duration of the construction project.

No lifting should take place until the verification documentation covering the particular concrete element is available on site and has been sighted by the erector.

The inspection and verification process should include checks on the:

- > formwork dimensions
- > formwork stability
- > concrete element edge details and penetrations
- > connection details
- > insert locations, types and fixing to reinforcement
- > reinforcement size, location, concrete cover and fixing
- > release agent effectiveness
- > concrete quality and strength requirements, and
- > any necessary repairs.

5.8 Modification

Modifications to concrete elements and their associated supporting components and connections may be carried out only with the written and signed approval of an engineer.

The person with control of the construction project should incorporate the modification approval into the work plan (see **Section 2.4.4**), which is to be retained on-site during construction.

The person with control of the construction project should ensure that any local government authority building regulation requirement is met and, where required, that the authority is notified before proceeding with any variation from or alteration to approved plans, drawings and specifications. This requirement applies throughout the life of the building.



6. HANDLING, STORAGE AND TRANSPORT

Moving a concrete element may result in a risk to the safety of persons involved and a risk of damage to the concrete element. Careful planning and scheduling will minimise the need to relocate concrete elements. A concrete element should not be relocated without first discussing the relocation with the person with control of the construction project and ensuring that all criteria for lifting have been met. Methods for handling and storage of concrete elements will vary depending on the type of concrete element.

6.1 Handling

The rigging system to be used on site for each concrete element must be as set out in the erection documentation detailed in **Section 4.1.6**.

With proper preplanning, the handling of concrete elements can be minimised. The person in control should verify that the concrete element (and brace footing concrete) has attained the specified strength for lifting and that the nominated brace fixing bolts are available on site. If the concrete element does not achieve the specified strength for lifting in accordance with the structural drawings, the engineer should be notified immediately. Lifting must not be attempted until the engineer's approval has been received by the person in control of the project and the approval conveyed to the erector.

During handling, care should be taken to minimise the likelihood of impact between the concrete elements.

The transporter should be made aware of any site-specific hazards prior to the transporting of any concrete elements.

6.2 Storage

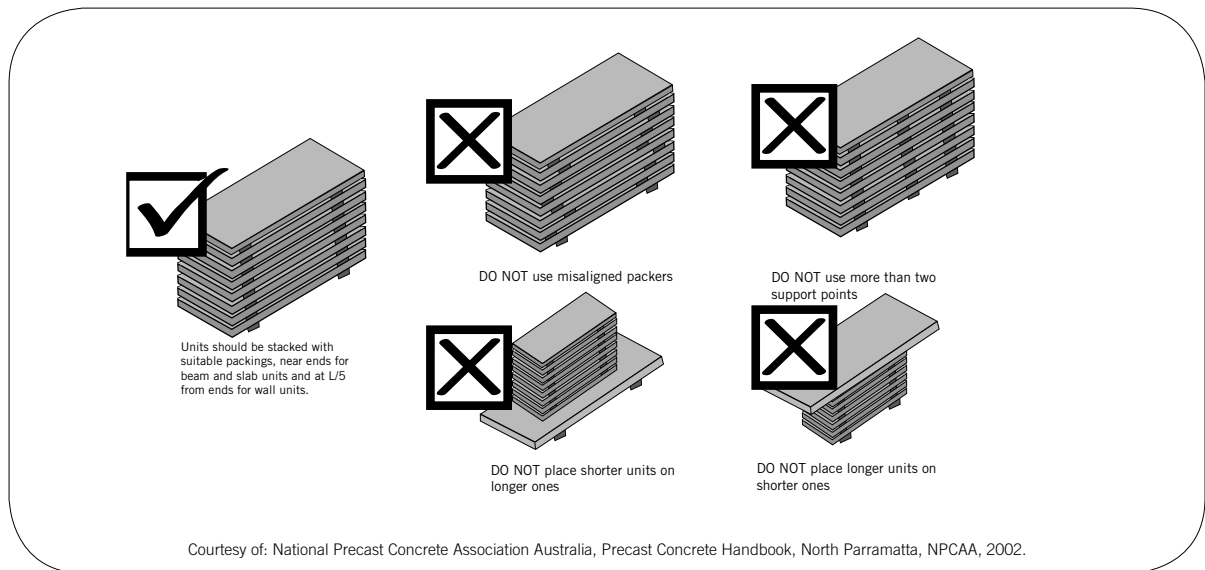
The general requirements for storage of concrete elements are that:

- > the concrete elements should only be stored in a position approved by an engineer
- > racking systems, frames and supports should be designed by an engineer for the shape, size and weight of the concrete element
- > approval and written instructions should be obtained from the engineer before a concrete element is stored horizontally
- > approval and written instructions should be obtained from the engineer before a concrete element is stored on a suspended floor slab or beams. This is particularly important in a situation where it becomes necessary to put a concrete element into unplanned temporary storage. For example, where the erection of a concrete element to the temporary braced condition cannot be finalised. If approval by an engineer cannot be obtained, the concrete element must be returned to ground level
- > during storage, care should be taken to minimise the likelihood of impact between the concrete elements. Where concrete elements are stored in areas of vehicular movement, protection by way of bollards or other physical barriers and appropriate warning signs should be provided, and that



- > prefabricated concrete elements should only be stored in a designated area and in such a manner as to minimise multiple handling.

Figure 5. Horizontal stacking of concrete wall or floor panels



6.3 Planning crane requirements

The planning process for the use of cranes should commence as early as possible in the development of the project. The person in control, the crane supplier, the erection engineer and the prefabricator should all take part in the consultation phase of the planning process. Considerations should include:

- > the crane selection, access and siting in accordance with AS 2550 or the most recent equivalent:
 - the crane should be located with consideration given to the erection sequence of the concrete elements to avoid any possibility of the rear of the crane slewing into braces supporting previously erected concrete elements, and
 - where two or more cranes are operating they should be sited so as to prevent them operating in each other's airspace. Where this is not possible, procedures must be established to prevent unplanned contact between them.
- > ground support conditions and the location of any excavations or underground services likely to be adversely effected by imposed crane loads
- > the proximity of overhead power lines (see **Section 7.5.3**)
- > written procedures (including a risk assessment of these procedures) for setting up and dismantling the crane and for the lifting method to be used
- > the make-up of the crane crew appropriate to the particular circumstances of the job
- > the communication system used between the crane operator and those assisting in the operation

Note: Audible and visual signals should comply with AS 2550.1 or the most recent equivalent



- > selection of lifting gear including, if rotation is to be carried out, the appropriate snatch block for rotation of concrete elements while suspended
- > means to disengage the rigging gear from the concrete panel once it has been temporarily fixed into position
- > PPE for the rigging crew
- > emergency procedures
- > protection of the general public, and
- > the rated capacity of the crane(s).

Documentation relating to the selection, erection and dismantling of a crane used during concrete construction work should be retained by the person with control of the construction project until completion of the construction project.

6.4 Crane selection and operation

The design of the cranes should comply with the requirements of AS 1418 or the most recent equivalent, and evidence of such compliance should be obtained prior to bringing a crane onto a construction site.

A tower crane or a mobile crane may be used for concrete element construction. If a mobile crane is to be used, the selection of the mobile crane, preparation of the site and correct location of the crane are crucial in ensuring the safe erection of concrete elements. The selection of the crane should be based on a number of criteria and lifting requirements. It should be noted that:

- > a crane's maximum capacity refers to its rated capacity at minimum radius
- > the rated capacity reduces as the working radius increases, and it is essential that the selection of crane size is made with consideration of the maximum working radius and maximum load involved in the lifting operation
- > for face-lifted concrete elements, assessment of the true working radius of the crane should be made by adding at least 1.5 metres to the final concrete element position radius to take account of flexing of the boom of the crane during lifting, and the hang of the concrete element from the lifting inserts and any lifting beams. This may need to be increased for tall elements. An assessment of the true working radius should be made according to individual concrete element details (see **Figure 6**)
- > the crane should be set up so that it does not need to slew greater than 180 degrees and the working radius is allowed for that area. The tail radius (the area covered by the counter weights) of the crane should not be overlooked in relation to any braces installed after crane set up to avoid damaging or displacing the braces, and
- > the casting sequence for concrete elements should reflect the erection sequence. To avoid multiple handling with stack-cast concrete elements, the top element should be erected first.

The correct selection of cranes requires that the configuration of each crane and its location in relation to the lift need to be considered as well as the actual gross load that is to be lifted. The gross load includes the weight of the lifted load, the weight of the lifting gear, fixed and non-fixed attachments, the crane block and rope, all strongbacks attached to the concrete panel and suction loads (see **Section 4.3.7**).



Mobile cranes used for this type of construction are often required to work close to their maximum capacity with high luffing angles due to the large size and mass of concrete elements. These factors increase the risk of the crane overturning, particularly if the operation requires pick-and-carry across uneven ground or is carried out in windy conditions. All cranes used for the lifting and erection of concrete elements must be fitted with load indicators and rated capacity limiters. The indicator provides lifted load information to the crane operator while the limiter prevents the crane from exceeding its rated capacity. It is critical to the safe operation of the crane and persons involved in the lifting operation or in its vicinity, that these devices are checked prior to the commencement of every work shift.

Safety devices, including indicators and limiters, must never be deactivated or bypassed in an attempt to enable a crane to exceed its rated capacity.

Crane load charts should be used to verify that the crane has the necessary rated capacity prior to carrying out a lift. A crane that does not have the necessary rated capacity appropriate for the particular lifting operation must never be used to lift a load.

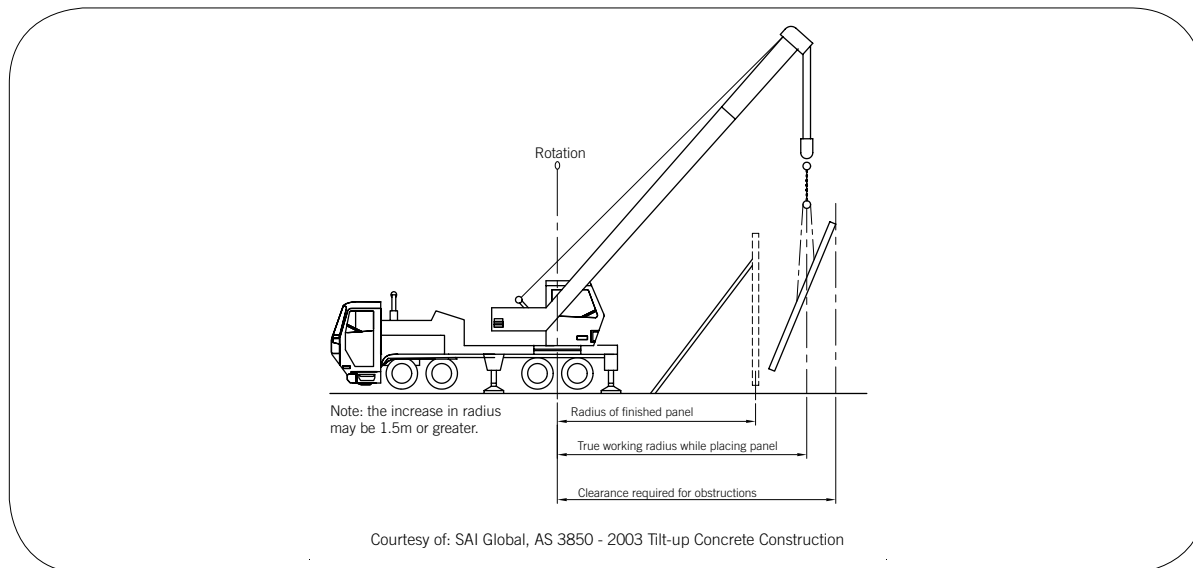
Cranes should never lift when wind speeds exceed those specified by the crane manufacturer. Particular care is required when lifting tilt-up panels as their large surface area means they are susceptible to wind, which combined with their heavy weight can cause excessive loading of the crane.

Selecting a larger crane than may be required has a number of advantages. In particular, it can reduce the number of site movements that would be otherwise required. A larger crane can reach a larger area of a site without the need for pick-and-carry operations or repositioning. This can result in a shorter construction period, and offset the extra cost of the larger crane. However, larger cranes are generally more difficult to manoeuvre around a site and require more operating space. Additional precautions are required to ensure they do not damage the structure or braces when operating, especially caused from the crane counterweight slewing.

In addition to their design characteristics, it is critical that cranes are properly operated and maintained to ensure the safety of persons involved in tilt-up operations. In this regard, cranes and mobile elevating work platforms should be operated, inspected and maintained in accordance with the written instructions of the designer or manufacturer of the equipment. If these instructions are not available, then appropriate written instructions must be developed by a competent person. Such instructions should be developed in accordance with AS 2550.4, AS 2550.5 and AS 2550.10 or their most recent equivalents.



Figure 6. Crane lifting radius



6.4.1 Crane type for pick and carry operation

In some situations mobile cranes are used in the pick-and-carry mode to lift concrete panels. In this situation, crawler type lattice boom mobile cranes with steel tracks should be selected. The use of rubber tyred mobile cranes is strongly discouraged for the following reasons:

- > the lifting capacity is generally too low for most panel jobs
- > these cranes are more prone to overturning than crawler cranes due to:
 - being articulated
 - being supported by rubber tyres that compress
 - having wheels that are more prone to enter ground depressions than tracks are, and
 - having hydraulic booms that are heavier than lattice booms.

6.5 Multiple crane operations and blind lifting

Where lifting is not possible with one crane and it is necessary to use two or more cranes for the operation, either each lift must be designed by a competent person or the rated capacity of each crane should be as follows:

two cranes	20% greater than their share of the load
three cranes	33% greater than their share of the load
four or more cranes	50% greater than their share of the load



On most sites, multiple lifting involves two cranes, which is known as 'dual lifting'. Multiple crane lifting is a potentially dangerous operation requiring a great deal of skill by operators. Multiple crane lifting should only be carried out where the physical dimensions and mass of the load prevent the load from being handled by a single crane available on the site.

The person with control of the construction project or construction work should ensure that the person directly supervising it, has the commensurate level of skill and knowledge of multiple crane lifting and is not otherwise involved in the operation.

As with all crane operations, multiple crane lifting should never be carried out where wind speeds exceed those specified by the crane manufacturer. The maximum operational wind speed may need to be reduced for such operations as the wind may affect each crane differently depending on its relative siting. For example, one may be in a more exposed area or be more susceptible to funnelling effects than another.

Self erecting tower cranes should not be used for multiple lifting operations.

More information on designed lifts and planning and carrying out multiple crane operations is given in AS 2550.1 or the most recent equivalent.

'Blind' lifting, where the rigging is on the side of the concrete element opposite to the crane, should be avoided because the crane operator and rigger will be unable to visually check the rigging during lifting. Very importantly, if failure should occur, the concrete element will fall towards the crane.

'Blind' lifting should be avoided and alternate methods used wherever possible. However, this practice may be required in some situations such as when placing a closure concrete element in a building.

6.6 Rotation of precast concrete panels

Where positioned on an A-frame, edge lifting inserts will be cast into the concrete panels, usually two lifters are cast into the top edge and two or four in the side edge. The concrete panel is lifted off the truck using the inserts on the side edge. In order to move the concrete panel into its vertical position, the concrete panel needs to be rotated through an arc of 90 degrees, and this can be achieved using one or two cranes. This procedure requires a great deal of skill on the part of the crane driver(s). Even though the concrete panel will be suspended by two hoist ropes, more than 50% of the concrete panel weight will be applied to one of the hoist ropes due to the cantilever.

An engineer can be approached to provide guidance on the minimum required capacity of the crane(s) used for rotating panels. However, the following rule, in general use by industry, may be used where such advice is not provided as long as the conditions are complied with.

Rule

Where one crane is used, the capacity of the auxiliary winch should have a minimum capacity of 75% of the concrete panel mass. Where two cranes are used, the crane handling the lesser load should also have a minimum capacity of at least 75% of the concrete panel mass. Conditions to be complied with are:

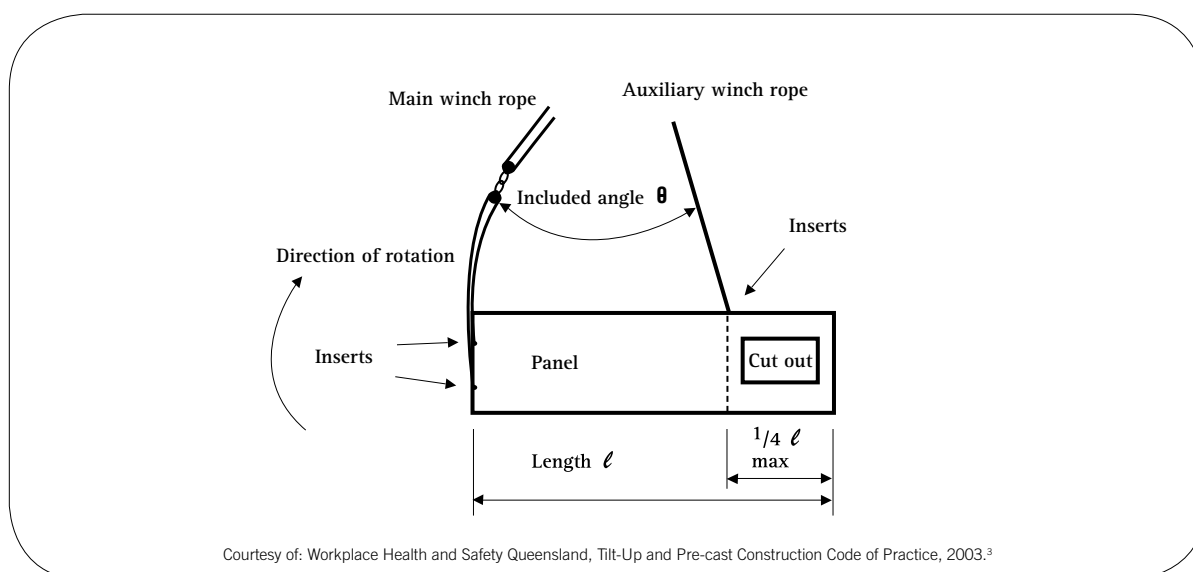
- > the distance from the auxiliary winch rope lifting point to the end of the concrete panel is not to exceed 1/4 of the panel length



- > the included angle between the main hoist rope and auxiliary hoist rope is not to exceed 45 degrees
- > concrete panels are to be rotated such that the concrete panel is suspended in its rotated position by the main winch (if one crane used), or the larger capacity crane (if two cranes used)
- > the combined weight of the auxiliary hook block and lifting gear is not to exceed 200 kg
- > where one crane is used, the main winch and auxiliary winch drives should be independent
- > there are to be no cut-outs in the half of the concrete panel closest to the main winch rope panel lifting point, and
- > the concrete panel is to be adequately reinforced to withstand the lifting stresses. When this occurs as in multi level panels, the system should be designed by an appropriately qualified engineer.

If the conditions above cannot be complied with, an engineer should verify the minimum required capacity of the hoist ropes. 'Rooster sheaves' is the name given to the short boom extension and sheave set-up attached to the boom head of the crane when concrete panels are rotated. Rooster sheaves and the associated rigging on the boom head should be designed and certified by an engineer.

Figure 7. Initial position of panel prior to rotation



6.7 Transport

The transporter needs to ensure that drivers have been adequately instructed in the safe transportation of concrete elements including panels, with particular attention given to:

- > power lines
- > other activities on the site at the time of transportation
- > recognised routes for over-dimensional loads
- > site limitations and local street access

³ For further information and future updates, please access www.deir.qld.gov.au



- > the site specific traffic management plan (see **Section 6.7.1**), and
- > differential road cambers as these may induce torsional loads in long concrete elements. Slender concrete elements may require temporary stiffening against lateral buckling.

Drivers should stop and check the load and the restraints shortly after commencing the journey. Restraints tend to loosen due to settling of the load and stretching of the restraints, particularly if webbing straps are used.

Delivery of concrete elements to the required location on the construction site requires planning and cooperation between the builder, the transporter and the erector.

To reduce hazards, the unnecessary transport of concrete elements, particularly where multiple loading and unloading is required, should be avoided wherever possible. Planning will reduce the need to transport concrete elements around the site.

Prior to entering the construction site, the transporter should inspect the traffic management plan and the relevant areas of the site to verify that there are no dangers such as uncompacted backfilled excavations or overhead services.

Note: Transportation of concrete panels must be undertaken according to Australian, state and territory requirements as well as relevant Australian Standards.

6.7.1 Traffic management plan

The traffic management plan should include:

- > the shape, size and mass of the concrete elements
- > specific design elements affecting transportation of the concrete element, including the stability of long or unusually shaped concrete elements during transportation and the concrete strength required for transportation (the builder needs to ensure the concrete element has reached the design concrete strength before transportation)
- > the activities of other trades on the construction site and their requirements at the time of transportation of the concrete elements around the site
- > provision for all-weather access for the delivery vehicle
- > information on the capacity of any permanent structures to carry transport loads, and
- > provision for temporary storage, where required.

The builder, as part of the work plan or OHSMP, should provide a documented site specific traffic management plan that includes provision, where necessary, for traffic control barricades and road closure permits to allow unimpeded access to the site for the transporter. The site specific traffic management plan should be available on site at all times when work is to be carried out.

6.7.2 Loading

Securely restrained loads on transport vehicles are vital in preventing accidents and injuries when handling concrete elements.



Concrete elements should be loaded in a sequence compatible with the required unloading sequence at their intended final destination. Each concrete element should be individually secured as the unloading sequence can lead to instability of loads.

Each concrete element should also be individually restrained from the sides and rear to prevent movement in any direction.

Concrete elements should be loaded so that identification marks are visible before and during unloading.

When unloading, individual concrete elements should not be released until the crane has taken the initial load of that element.

Equipment should be inspected before use to ensure it is serviceable.

The location of lifting inserts on the concrete elements should be checked to ensure they are compatible with the lifting system to be used. Lifting inserts should be clearly identified to assist in the loading and unloading stages.

Load restraints may be chains or webbing straps. The adequacy of a particular method of restraint will depend on the type and size of concrete element being transported and the type of vehicle being used. Special restraints may be required for long concrete elements, especially when transporting over long distances.

6.7.3 Support frames

Frames used to support concrete elements during transportation whether an integral part of the transport vehicle or an add-on, need to be designed to withstand loads and forces which may act on the system during loading, transportation and unloading.

A frame system that is not an integral part of the transport vehicle or trailer should be adequately secured and be capable of withstanding any forces applied during loading, transportation and unloading. The loading of vehicles must comply with the National Transport Commission's Load Restraint Guide. This includes the certification of support frames by a suitably qualified engineer.

Particular care needs to be taken during loading and unloading of concrete elements from frames to ensure the support frames remain stable at all stages.

6.7.4 Concrete element protection

The points of contact between concrete elements, supports, and restraints should be provided with protective material to prevent breakage and staining. Corner protectors should be used under all restraints to prevent movement and damage to the concrete element.

Low friction material should not be used as packing between concrete elements and supports.

Where concrete elements are transported horizontally, they should be stacked so that each element can support the loads from above. The support points should be directly above each other unless specifically designed otherwise.

The stacked height of concrete elements should be limited to ensure that the bearers and lowest concrete elements can support the loads from above and that the stack remains stable during transportation.



7. ERECTION PROCESS

The safe erection of concrete elements is dependent on good planning. All personnel should be aware that the erection of concrete elements is potentially hazardous. The purpose of the planning process is to identify hazards and control any risk in the erection process.

Due to their large surface area and mass, care needs to be taken when lifting, moving and securing concrete elements into position. The risk of fatalities if a concrete element falls is considerable. It is essential that both the concrete element erection crew and crane operator are highly skilled and experienced in the erection of concrete elements.

All persons involved in the erection process should be trained in this National Code and where required, hold a current and appropriate license for persons performing high risk work issued by the relevant Australian, state or territory OHS Authority.

Note: Special care needs to be taken in design and construction to guard against progressive collapse both during erection and in the completed structure.

7.1 Planning considerations

Before erecting concrete elements, the person with control of the construction project should, in association with the erector, plan the construction and erection sequences. The erection sequence of panels should be specified on the shop drawings and modified for each project.

The planning process should include consideration of:

- > the OHSMP (if applicable), work plans and SWMS
- > structural stability during erection, including temporary braces, props and fixings
- > site limitations and local street access
- > concrete element sizes
- > crane size, configuration, mobility and access
- > working radius of the crane shown on a crane layout drawing
- > height access equipment appropriate to the construction methods
- > compaction of site surface areas
- > casting and delivery sequence
- > overhead obstructions, particularly overhead power lines at or adjacent to the construction site
- > underground power lines and other utilities, and
- > underground tanks and soak wells.



7.2 Structural stability – Preventing unplanned collapse

Concrete element structures are susceptible to progressive collapse type failures. However, the failure or dislodgement of a single concrete element such as a bracing or prop should not lead to the complete collapse of the structure.

Progressive collapse may be prevented by providing either:

- > adequate structural strength and continuity of the structure and its parts, or
- > alternative load paths that cause applied forces to be safely transmitted through the structure.

Collapse may also occur when concrete elements are inappropriately stored on suspended floors or beams. Approval from an engineer is required before the temporary storage of concrete elements on suspended slabs or beams. Where this approval is not obtained, the concrete element must be returned to ground level.

Regular inspection of the braces and bracing inserts, fixings and connections should be undertaken. The torque of the brace bolts should be checked 24 hours after erection, unless otherwise instructed by the anchor manufacturer and again at appropriate intervals after installation as determined in the erection planning stage, especially if there have been high winds or the concrete panel has been struck by mobile plant. Always refer to the manufacturer's specifications, as some anchors may require re-torquing. Daily visual inspection is also recommended on all braced and bracing concrete elements.

It is the responsibility of the erector to ensure that the stability of the structure is monitored and maintained during the erection phase.

The stability of the whole structure should be checked at each stage of the erection process including under in-service load conditions. The stabilisation of the structure should take into account the requirements of AS 3828 or the most recent equivalent.

The order in which the various components and members are assembled should maintain the stability of the structure and allowance should be made for the effects of high winds on partially completed structures.

In the event of adverse weather conditions, it may be necessary to stabilise incomplete structures using measures considered as part of the initial design and forming part of the designed erection sequence. This should not be an ad-hoc means of stabilisation. Where a concrete element cannot be stabilised overnight it must be returned to temporary storage at ground level, unless the engineer approves an alternative storage method.

Structural continuity may rely upon, among other things, the connections (see **Section 4.3.5**) and the structural system employed.

7.3 SWMS for erection

Persons engaged to undertake the erection of the concrete elements should prepare a SWMS for erection. The SWMS needs to be specific to the project and be based on the documentation detailed in **Section 4**.



7.4 'No-Go' zones

Only persons directly involved (including supervisors and engineers) with the lifting of concrete elements should be allowed access to an area where lifting is taking place. For example, the driver making delivery of the concrete elements should move to the safe area away from the truck during the unloading process. Where possible, such persons should avoid being in a position where they can be struck in the event of a concrete element falling or a crane falling over, or being caught between a concrete element and any other hard surface.

Where reasonably practicable, loads should not be suspended over, or travel over, a person. If a load is suspended or travelling over a person, an effective back-up slinging system that is designed by an engineer should be used. The back-up system must be capable of containing all of the suspended concrete element in the event of a failure of the primary slinging system.

The establishment of a 'no-go' zone may necessitate the erection of appropriate signage and/or barriers depending on the ease of access and the likely presence of workers or members of the public. All members of the public and workers not involved in the lifting of concrete elements or related activities should be prevented from accessing a 'no-go' zone while lifting is taking place. The provision of perimeter fencing around the site will assist the operation of 'no-go' zones. Where a common boundary between two properties is located in a 'no-go' zone, an effective means of communication with occupiers is essential to keep members of the public away from the zone while lifting is taking place. This issue should be addressed in the planning stage.

Where a footpath, road or other access way is located in an exclusion zone, all members of the public and all traffic should be prevented from passing through the zone while concrete element construction work is being undertaken, until the concrete elements are fully secured with braces and other restraints.

7.5 Erection of elements

Before erection commences the builder and erector should:

- > ensure an engineer has provided a certification letter that certifies the temporary support system for the concrete element complies with AS 3850 and AS/NZS 1170.2 or their most recent equivalents. Examples of engineer certification letters that may be used are included in **Appendix H** and **Appendix I**
- > confirm that the erector's SWMS and risk assessment are appropriate and address all aspects of the erection procedure, including appropriate 'no-go' zones (see **Section 7.4**)
- > make sure that crane and truck access are inspected and safe
- > inspect the crane standing area and confirm that it is safe, and obtain verification from an engineer that the crane standing area can safely support the erection loads (see **Section 7.5.2**)
- > make sure the crane operating area has been cleared to provide adequate room for crane outriggers, counterweight tail swing, boom swing and under-hook and overhead obstructions, including overhead powerlines (see **Section 6.3 and 7.5.3**)
- > confirm that the erection crew members are properly licenced and trained and available in adequate numbers (see **Section 7.5.1**)



- > confirm that the concrete element has attained the minimum required concrete strength for lifting and erection as specified on the shop drawings
- > confirm that the brace footings have attained their required strength before the concrete elements are erected
- > consult with the rigger to confirm that:
 - the rigging system is designed to suit the spacing and layout of the lifting inserts (see **Figure 9**) for preferred rigging configurations
 - load distribution on lifting points is satisfactory
 - lifting will occur in the direction specified for the placement of the lifting inserts

Note: Concrete elements must be lifted in the direction of the load specified by an engineer. Lifting inserts may fail if the concrete elements are lifted incorrectly.

- the appropriate rigging equipment is available and is serviceable
- braces do not interfere with the rigging
- lifting inserts are compatible with lifting clutches and are in their correct location and recesses are cleaned out in preparation for lifting so that lifting clutches can correctly engage

Note: Where a lifting insert is found to be faulty, an engineer must be consulted for a suitable alternative rigging and fixing method.

- > in consultation with the rigger, determine an appropriate interval for checking the condition of braces and the torque on brace bolts, to ensure they have not become loose
- > ensure lifting gear and sheaves are in good condition and lifting clutches are fully engaged before the lift occurs
- > ensure lifting clutch release lines are fitted to enable clutches to be disengaged without the need for workers to climb on top of the concrete element
- > where possible, ensure all personnel are clear of the area where the concrete element may fall when it is lifted, tilted or rotated from horizontal to vertical. Where this is not possible, secondary systems i.e. back-up slings, should be used
- > ensure that provision has been made for safe working at heights (see Section 7.5.5);
- > check that strongbacks, if required, are available and are correctly installed
- > make sure that locating dowels or other horizontal restraints are fitted before concrete elements are lowered and that levelling shims are correctly located
- > confirm that the means of support, including falsework, are adequate for the intended purpose and are correctly located
- > check that sufficient clear space is available for the safe propping and bracing of concrete elements and ensure that nominated braces are fitted to the concrete elements, and
- > determine if weather conditions are adequate for erection.



During the erection sequence:

- > concrete elements should not be suspended, or travel, over a person
- > concrete elements should be lifted so that, while suspended, they lean away from the crane.

Note: Any situation where a concrete element being lifted tilts towards the crane is extremely dangerous. If part of the lifting system fails, the concrete element can fall against the crane and may cause the crane to overturn. The need to lift concrete elements in this manner can arise when concrete elements are cast on the outside of the building to be constructed.

- > no person should ever work on a concrete element that is leaning towards them or be placed between a concrete element being lifted and another wall or object, where movement of the concrete element could cause crushing
- > in all circumstances where a lift has been stopped, procedures such as wedging or jacking should be carried out as determined by the builder

Note: Such procedures need to be undertaken or directly supervised by the rigger in charge of the erection. Where used, wedges should be aligned with the line of lifting inserts unless written instructions state otherwise.

- > during the lifting process, the braces should not hang below the level of the base of the concrete element. This may be achieved by the use of adjustable length braces or taglines
- > where, in unusual circumstances, it is necessary to attach braces to the concrete element after it has been positioned, the concrete element should be held firmly, just past vertical, by the crane while the braces are attached, and
- > where bracing inserts are located on the opposite side of the concrete element to the lifting inserts, the concrete element should be tilted slightly back onto the rigging and the braces attached (bracing inserts are usually located on the same face as the lifting inserts).

Once erection to temporary braced condition has been achieved, the builder and erector should check braces, brace bolts and pins at regular intervals to ensure they maintain the required capacity.

The builder and erector should determine these intervals at the planning stage (see **Section 7.1**).

7.5.1 Erection crew

The erector should nominate one person in the erection crew to be responsible for the direction and coordination of the erection sequence. This person should hold a rigging licence in either Intermediate Rigging or Advanced Rigging and have experience in erecting concrete elements.

The crane operator should hold a license appropriate for the type and capacity of the crane in use, taking into account the maximum rated capacity of the crane.

When considering the size and make-up of the remainder of the erection crew, the person with control of the construction project should ensure compliance with any relevant Australian, state and territory Government regulations.



A qualification register for panel erection can be used to list those qualified persons in the erection crew (see **Appendix K**).

7.5.2 Crane standing area

Before erection commences, the builder should supply the erector with written certification from an engineer that any proposed crane standing area (i.e. floor slab, suspended slab or surrounding ground) can safely carry the construction and erection loads.

The engineer should provide this certification where the crane standing area forms part of the structure.

If the crane is to be set up on the ground, written certification of the ground bearing capacity should be obtained from an engineer with specific experience in soil engineering.

Backfilled excavations, trenches and soakwells should be identified and assessed. Additional measures, such as the provision of timber mats, may need to be taken to ensure that any backfilling can support the crane and erection loads.

7.5.3 Operating near overhead power lines

Safe plant operation near overhead powerlines

Where possible, and subject to Australian, state and territory government regulations, the following controls may be put in place in order of priority:

1. the power to the overhead powerlines should be isolated, and
2. where appropriate, limiting devices should be fitted to cranes to prevent the crane jib from contacting the power line or entering the danger zone (limiting devices are generally more suitable for tower cranes than mobile cranes).

If elimination (i.e. 'no go' zones) or engineering controls are not possible, then:

3. the normal cycle of operation should be slowed down to increase reaction time for assessing risks
4. visual aids such as tiger tails, attached by the power supplier and made of non-conductive material should be tied to aid visibility of the power lines, and
5. a dedicated spotter should be appointed to provide a warning to the crane operator should the crane or load approach the boundary of the danger zone.

Note: Check Australian, state and territory government regulations and codes of practice for further information on operating near overhead powerlines.

Wherever plant is required to work near overhead power lines, an additional hazard is created. In the case of concrete element construction, cranes often operate in close proximity to overhead power lines and the risk of injury can be very high.



Builders should plan ahead as far as possible to maximise safety. Electricity distribution authorities can isolate most overhead power lines when sufficient notice is given and every attempt should be made to achieve isolation.

Where overhead power lines have been isolated, the crane operator should retain the electricity authorities' isolation permit during operations. Where there is no isolation permit, all power lines must be treated as live.

When operating or travelling in an unfamiliar area, the crane operator should always check for the presence of overhead power lines.

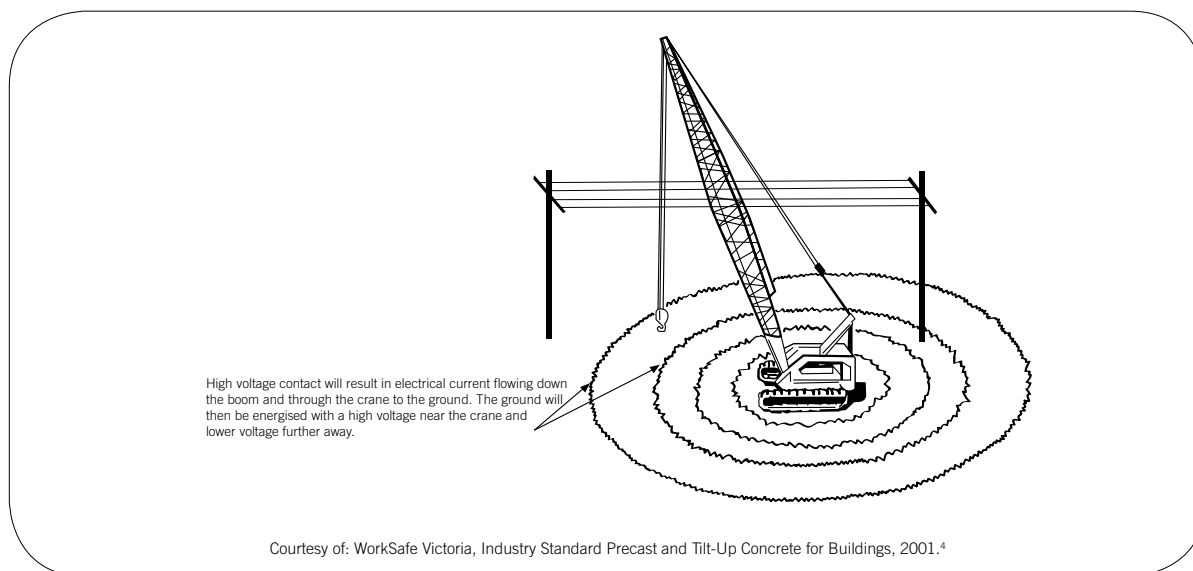
Persons not directly involved in the erection process should be excluded from the area where lifting is taking place (see **Section 7.4**).

In the event that the crane does contact live power lines, or arcing occurs, the crane operator should observe the following precautions:

- > remain inside the cabin
- > warn all other personnel to keep away from the crane and not to touch any part of the crane, rigging, tail ropes or load
- > try, unaided and without anyone approaching the machine, to move the crane until clear of the power line. If the machine cannot be moved away, remain inside the cab
- > if possible, by using a safe means of communication, get someone to inform the electricity distribution authority at once. Take no action until the distribution authority confirms that the conditions are safe
- > if it is essential to leave the cabin because electrical contact or arcing has caused a fire or other life-threatening emergency, jump clear as far away from the crane as possible. Do not touch the crane and the ground at the same time
- > when moving away from the crane it is extremely important that any person close enough to be affected moves away slowly taking small steps i.e. shuffle or hop slowly away from the affected area. Large steps should be avoided as one foot could be in a higher voltage area and the other in a lower voltage area. Under some circumstances, the voltage difference between the two areas could kill (see **Figure 8**), and
- > ensure someone remains at a safe distance from the crane to warn others of the dangers of approaching the crane.



Figure 8. High voltage contact



Note: Erection of steelwork in accordance with the requirements of AS 3828 or the most recent equivalent will minimise the risk of contact occurring.

7.5.4 Operating mobile plant near braces and concrete elements

Where it is necessary to operate mobile plant in close proximity to braces and concrete elements, control measures should be implemented, including the use of:

- > a spotter, to signal the plant operator to stop the plant in the event of any part of the plant approaching a brace or concrete element

Note: Such a system would need to ensure the communication method between the spotter and operator was effective and take into account factors such as noise on site and the spotter possibly being out of view of the operator.

- > barricades to ensure separation of plant and braces, and
- > temporary hazard warning indicators such as hazard tape, 'para-webbing' and/or signage to make the brace position obvious, particularly where braces are close to access areas.

The builder should be notified immediately of any instance where concrete elements or braces are struck by plant.

The use of mobile plant such as cranes, backhoes, excavators and elevating work platforms (EWP) close to concrete element braces can be extremely hazardous due to the risk of the elements and/or the brace being struck resulting in a subsequent collapse. Braces are designed to resist wind loads during the erection process and not the impact loading from moving plant.

⁴ For further information and future updates, please access www.worksafe.vic.gov.au



A damaged brace may collapse in a rapid uncontrolled fashion causing the concrete element to fall. A falling concrete element may strike other concrete elements and result in the further collapse of other elements or the progressive collapse of the whole structure.

When a crane is being used to erect structural steelwork, particular care needs to be taken to prevent parts of the crane and the suspended load from hitting braces and concrete elements.

The hazard can be minimised by giving careful consideration to the site of the crane (see **Sections 6.3 and 7.5.2**) and the erection sequence (see **Sections 4.1 and 7**) as discussed in this National Code.

Mobile plant should not be operated, or travel close to, erected concrete elements and braces unless there is a sound reason, such as the use of an EWP to assist in the installation or removal of braces.

Any excavation work carried out in the vicinity of brace footings should be approved by an engineer to ensure footings are not undermined.

7.5.5 Working at heights

To reduce the need for working at heights, as many sections of the structure as possible should be assembled on the ground before being lifted into their final position.

However, personnel are generally required to work at height to perform the following activities:

- > removal of braces from concrete elements
- > attaching the concrete elements to one another or to structural steelwork before removal of the braces, and
- > application of caulking to vertical joints between concrete elements.

Work at height should either be performed from platforms with guardrails such as EWP or mobile scaffolding. Portable ladders should only be used where other methods are impracticable.

Boom lift type EWPs are preferable to scissor lifts because they have superior reach to access more awkward areas and do not need to be driven next to an erected concrete element to gain access. In addition, 'rough terrain' type boom lifts are more suitable for poor ground conditions.

Note: All work at height should be carried out in accordance with Australian, State and Territory Government regulations for safe work at heights in construction.

7.5.6 Rigging

Before setting up a rigging system:

- > careful and thorough planning should be undertaken
- > the selection of the rigging system to connect the concrete element to the crane should be agreed between the erector and the rigger
- > in selecting the rigging gear to be used during lifting and erection of concrete elements, the rigger and erector should ensure that the system can take the forces to which it will be subjected



- > all rigging equipment should comply with the relevant Australian Standards and have a WLL adequate for its intended application and should be in a serviceable condition
- > the effect of any variations to the rigging of the concrete element being lifted should be approved by an engineer, and
- > spreader and lifting beams used in the rigging configuration are designed by an engineer in accordance with AS 4991 or the most recent equivalent.

Before lifting, an inspection and check of the rigging should be performed by the rigger in charge, especially where steel wire rope is being used in the rigging system. This inspection should include a visual check to ensure that the snatch block collar pin is intact and the collar has not become loose. The centre pin on all sheave blocks (with ball bearings or plain bearings) should be locked into position to stop rotation by the use of a retaining system, such as a bolt on lock plate.

All rigging below the hook should be inspected annually by a competent testing authority such as the National Association of Testing Authorities. Tags on the rigging system should be updated with the date of each inspection.

All components of the rigging system should be checked regularly for damage and excessive wear or corrosion to ensure they are appropriate for the loads being lifted.

The preferred configurations for concrete element lifting are shown in **Figure 9**. In general, the rigging system should be designed to distribute equal loads to all lifting points. In some circumstances the design may require unequal loading on lifting points causing an increased load to be applied to particular lifting inserts. This needs to be taken into account in selecting the capacity of these inserts. Where this is the case, such requirements should be clearly specified on the shop drawings (see **Section 4.1.5**).

Single, double and four leg slings are commonly used in the handling of concrete elements. In selecting the sling capacity, the increased force due to inclination of the sling and the change of direction at reeving points should be considered. The included angle between slings at reeving points should not exceed 120 degrees.

Lifts should be planned so that rotation of the snatch-block under load is not required. Snatch-blocks and other sheave blocks need to be equipped with thrust bearings or separate swivel bearings if rotation of sheave block swivels under load is unavoidable. Blocks with standard plain bearings are not intended to be rotated under load.

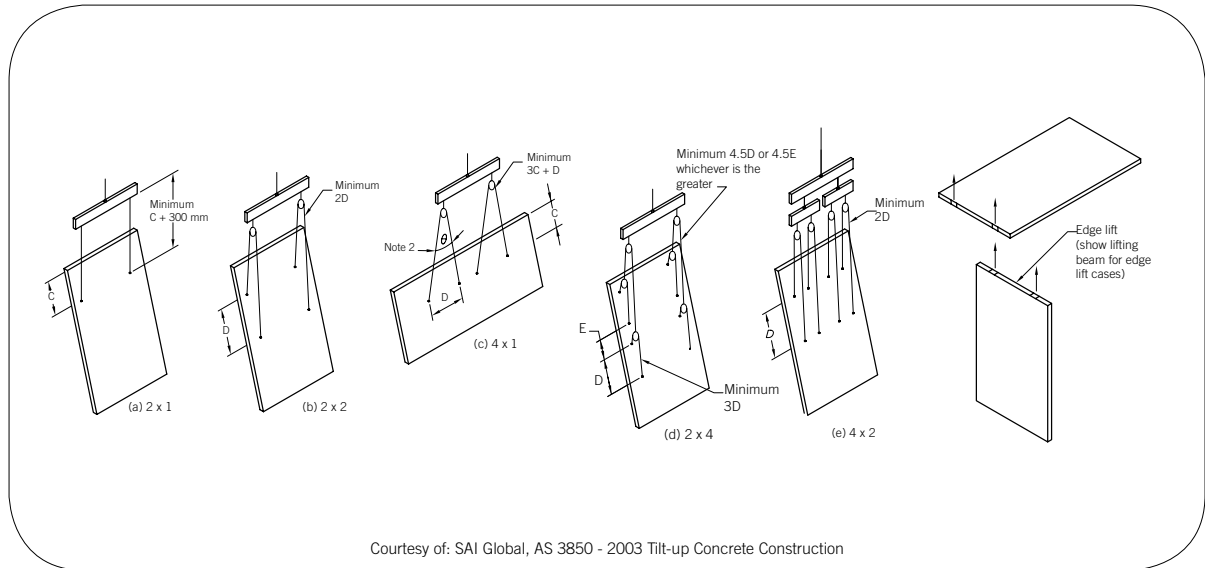
The rigging system should be arranged to allow the concrete element to lie in or near its correct attitude for erection into the structure.

Although loads in the slings attached to each insert in **Figure 9** are equal, the loads on the inserts may not be equal for face-lifted concrete elements because of the varying inclination of the slings to the concrete element, which also varies during rotation of the concrete element.

If it is identified that lifting inserts are incorrectly located, faulty or missing, or that concrete is poorly compacted or cracked close to lifting inserts, immediate contact should be made with an engineer to establish an appropriate solution.



Figure 9. Preferred concrete panel rigging configurations



Note: that dimensions on slings are total length through sheaves. The lifting insert supplier may specify a maximum value for this angle.

To prevent the concrete element slewing sideways during erection, lifting inserts should be located symmetrically about the centre of gravity across the width of the concrete element. In determining the centre of gravity, the effect of any additional equipment such as strongbacks need to be taken into account. When the concrete element is lifted, the bottom edge should be horizontal.

Bracing inserts should allow the braces to hang vertically without interfering with the lifting rigging. A horizontal displacement of 200mm for the bracing insert from the vertical line of the lifting inserts will normally be adequate.

Bracing inserts should not be located closer than 300mm to the edge of a concrete element, footing or other bracing support.

7.5.7 Lifting clutches

The lifting clutches should be designed in such a manner that they fully eliminate the possibility of inadvertent clutch release during operations such as panel rotations, particularly when clutches are fitted with remote-release lines. Many designers have adopted safety latches.

Lifting clutches should be designed with a limit state factor of five. Lifting clutches should be proof tested to a load of twice the WLL, certified and individually identified by permanent marking or attachment of a durable tag before use.

Lifting clutches should be inspected by the rigger for wear and deformation before each use. If any deterioration is seen or safety concerns are identified, a proof test should be conducted. A proof test using a load equal to 1.2 times the WLL should be conducted and recorded at least annually.



7.6 Bracing and propping

Temporary bracing and propping systems must be designed to resist all expected loads, including:

- > construction loads, and
- > wind loads for temporary structures in accordance with AS/NZS 1170.2 or the most recent equivalent.

Braces must have a permanently fixed identification plate displaying the following information:

- > the supplier or manufacturer, and
- > the model type or designation.

In addition, the load capacity of the braces must be marked as follows:

- > for fixed length braces, the WLL, in kilonewtons (kN), on the permanent identification plate
- > for adjustable length (telescopic) braces, the WLL, in kN, at maximum and minimum extension, on the permanent identification plate, and
- > for composite braces, the WLL, in kN, at maximum and minimum extension, suitably and clearly marked on the brace.

The WLL for braces at maximum and minimum extension must be determined in accordance with the requirements of AS 3850 or the most recent equivalent, taking into account the forces and non-alignment associated with the complete assembly of components that comprise the brace. Where this involves testing, such tests should be conducted by a registered National Association of Testing Authorities' laboratory or equivalent.

The WLL for props must be determined in accordance with the requirements of AS 3610 or the most recent equivalent.

Brace locking pins should be provided with retaining devices to prevent unintentional dislodgement of the locking pin. The retaining devices should require either a special tool or key to remove them to help prevent unauthorised persons handling the brace. Due to wind or construction load vibrations, brace locking pins should be checked on a regular basis while in use.

Brace and prop requirements and details for each type of concrete element must be clearly specified on the shop drawings. Where applicable, this includes requirements and details for knee bracing and lateral restraint bracing.

There should never be less than two temporary supports to each concrete element, unless specifically designed and detailed, and approved by an engineer. Such requirements and details must be clearly shown on the layout and shop drawings.



7.7 Installation, inspection and removal of temporary bracing

Bracing should be installed in accordance with AS 3850 or the most recent equivalent, and the approved shop drawings (see **Section 4.1.5**) unless prior written approval is obtained from an engineer. Any change to the vertical or horizontal position of a brace will alter the brace angle. Any increase in brace angle will increase the load transferred to the brace and requires the approval of an engineer.

7.7.1 Brace requirements

A minimum of two braces are usually required to support each concrete element. Three or more braces may be necessary on larger elements and in situations where load controlled expansion inserts are used in brace footings, since the capacity of these inserts may be less than the capacity of the brace itself.

However, where more than two braces are used there is difficulty in ensuring an even load distribution. Allowances should be made in the design for the potentially uneven loading where more than two braces are used on a concrete element.

One brace can be used where another part of the concrete element is securely fixed to an existing part of a structure. However, this configuration must be specified by an engineer. Elements supported by a single brace are very susceptible to failure by concrete element rotation about the brace.

Columns are usually braced with one brace in two orthogonal directions – that is, two braces in all. When wall panels are tall and narrow, they will need to be braced with two braces perpendicular to their flat face and restrained by bracing in the other orthogonal direction for stability.

A brace connected to one concrete element should not be connected to another braced concrete element for support unless this is clearly specified on the shop drawings.

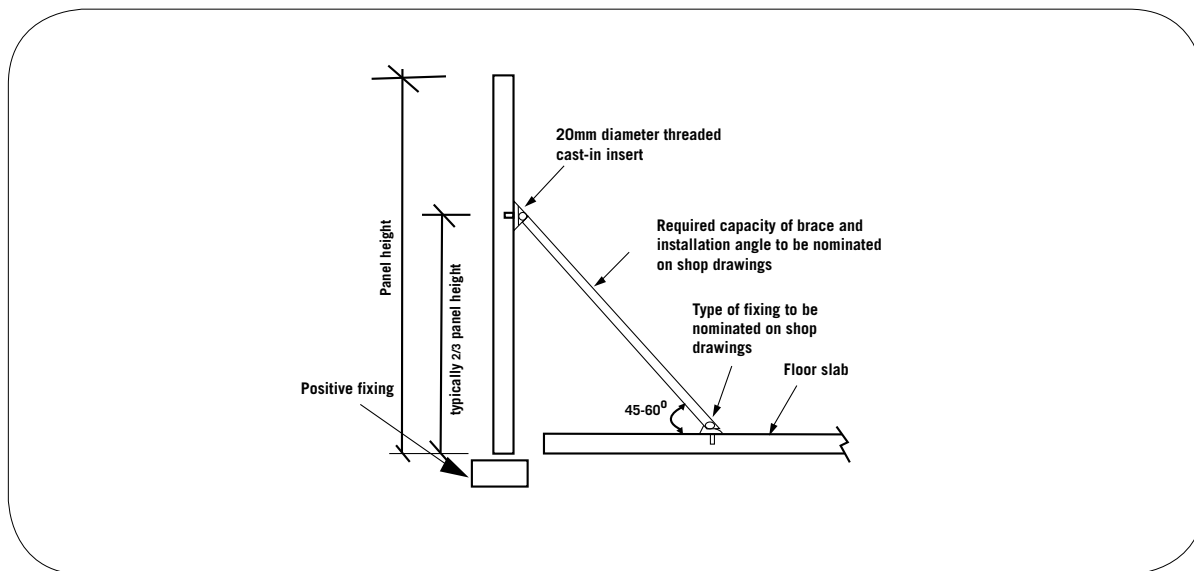
7.7.2 Installation

Before installation, written proof of the inspection after the last use of the brace is required.

The vertical angle of installation of braces should be shown on the shop drawings. Braces are usually installed at an angle of 45 degrees to 60 degrees to the horizontal and square to the line of the concrete element (see **Figure 10**), unless the engineer has considered another arrangement and it is shown on the shop drawings. If site conditions prevent the braces from being installed in the positions shown on the shop drawings, an engineer should be consulted and approval gained for an alternate location and any associated changes necessary such as larger braces and higher capacity base fixing.

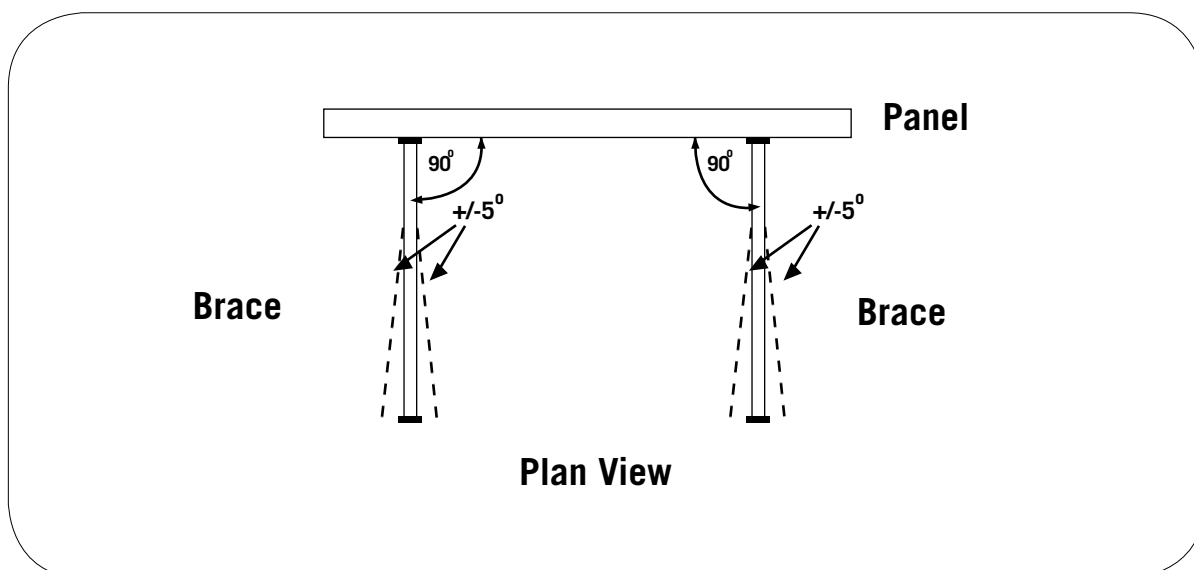


Figure 10. Concrete panel bracing, preferred arrangement



Bracing must be installed perpendicular to the concrete panel in the plan (**Figure 11**). Skewed braces greater than +/- 5 degrees to perpendicular will reduce concrete panel stability. The design and installation of skewed braces will need to be carefully reviewed to consider any induced lateral and torsional forces to the panel.

Figure 11. Concrete panel bracing



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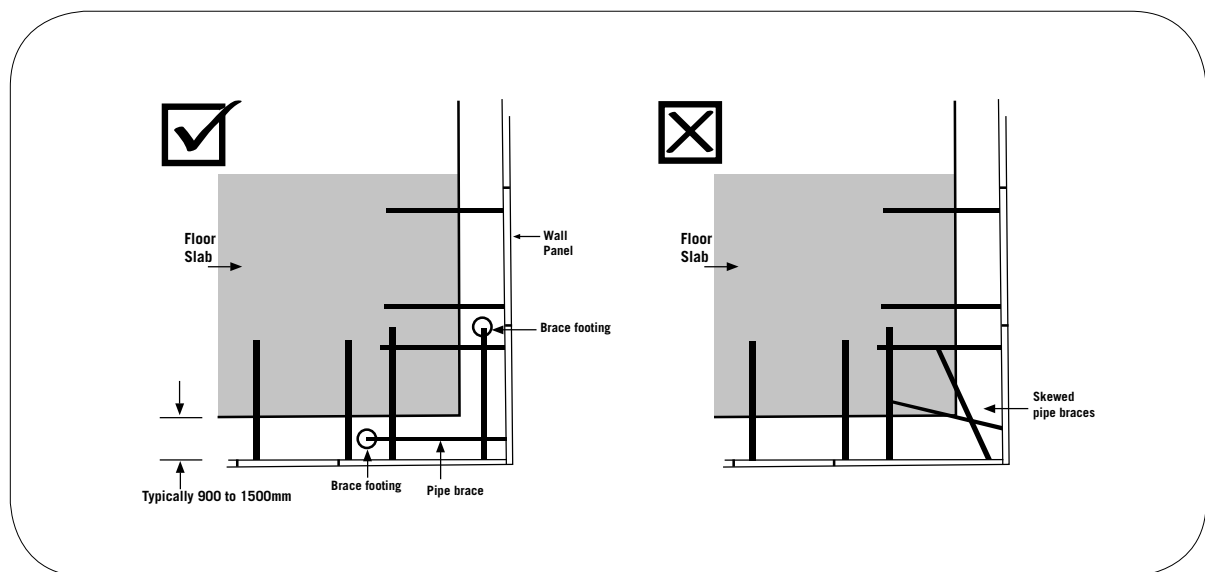
Figure 12 shows the proper method for bracing corner elements without having to skew the braces for attachment to the floor slab. Attachment of braces to concrete blocks (deadmen) in the leave-out area between the floor slab and the concrete elements allows the braces to be properly located without skew. Concrete element stability is reduced when braces are skewed.

The bracing feet (or shoes) that connect the brace to the concrete element or footing, need to be designed to prevent lateral displacement of the shoe from the fixing insert after installation.

The preferred location of bracing points is at two-thirds of the height, measured from the base of the concrete element and at least 600mm above the centre of gravity. Where it is necessary to locate bracing points below the concrete element's centre of gravity, the configuration needs to be specifically designed and detailed on the shop drawings.

Special provision should be made to prevent lateral displacement of the base of the concrete element in these situations.

Figure 12. Corner bracing



7.7.3 Inspection

Regular inspection of the braces and bracing inserts, fixings and connections should be undertaken (see **Section 7.2**).

7.7.4 Bearing capacity of brace anchors

Bolts or nuts used to secure the brace to the footing or concrete panel should be provided with washers of the correct grade and size.

The anchor bolt and washer combination on the foot of the brace should have adequate bearing capacity. Sometimes the bolt head and washer are too small for the slot size on the brace foot. This can cause the washer to collapse and cause the brace foot to become dislodged, which will in turn lead to panel collapse.



As a general principle, the slot width on the brace foot should not exceed the diameter of the largest diameter on the anchor bolt by more than 2mm, unless otherwise stated by the anchor supplier. In addition, the head of the anchor bolt should be large enough to be able to apply adequate load to the foot of the brace. If there is doubt about the ability of the bolt head to do this, the anchor supplier should be contacted and requested to supply guidance.

7.7.5 Safe removal of braces

When removing braces, the bottom bolts of the braces should be removed first. The weight of the brace must then be supported with a crane or other suitable means prior to the removal of the top bolts. The brace should then be lowered in a controlled manner.

As previously stated at **Section 4.3.14**, compliance with an engineer or their nominated agent's written instruction is required prior to brace removal.

7.8 Superimposed loads

Superimposed loads should not be applied to concrete elements in the temporary braced condition unless clearance is obtained from an engineer. Such loads should have been specifically allowed for in the design. These include loads from erection of steelwork and other attachments.

The erection of roof steelwork can exert significant outward loads onto braced concrete elements. In some cases, these forces may be sufficient to overload the temporary bracing and cause failure of the bracing inserts/bolts.

During release of the weight of a rafter from the crane, the braces adjacent to the rafter being erected should be monitored and adjusted accordingly.

The erection of roof steelwork may also impose substantial inward forces on braced concrete elements and fixings to steelwork as a result of temporarily unrestrained steel rafters rotating and moving sideways under self-weight and erection loads. The resulting forces may overload bracing and fixing inserts.

Clear instructions should be provided to the steel erector for the requirement of any temporary bracing for steelwork. Where such bracing is required, it should be detailed on the shop drawings so the steel erector can make provision for such bracing and riggers do not have to access an unstable structure.

To ensure safe work methods during the erection of steelwork, the engineer should consider the effect of the erection sequence on stability in accordance with AS 3828 or the most recent equivalent.

7.9 Levelling pads and shims

Shims carry the load of the concrete element to prevent movement until the concrete element is incorporated in the main structure. A levelling pad (concrete footing) or a level bearing area is used to provide a level seating for the shims.

Unless designed and specified otherwise, shimming should be a maximum height of 40mm, a minimum length of 150mm and a minimum width of 100mm.

Levelling pads and shims should comply with the relevant requirements of AS 3850 or the most recent equivalent.



Concrete elements should be designed to sit on only two localised shimming points when initially erected. Use of multiple shimming points cannot ensure uniform distribution of load due to difficulties with construction tolerances.

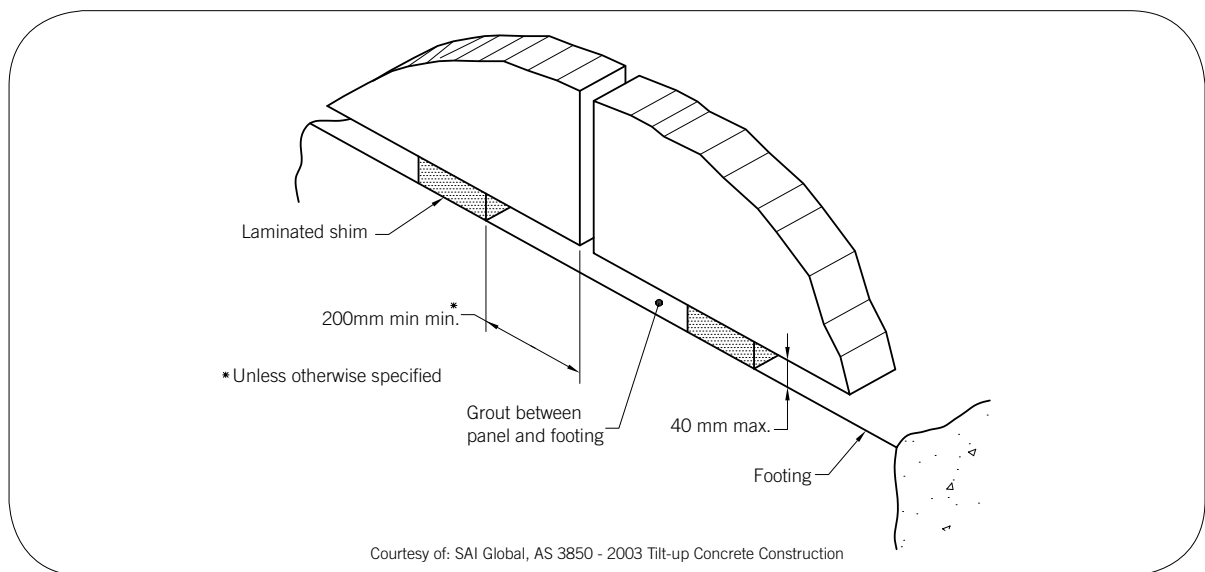
Shims should be used on solid foundations that are designed to carry the imposed loads.

Shims should be located at least 200mm in from the ends of the concrete element and bearing support, unless otherwise specified. This is particularly relevant for thin concrete elements where edge breakout can occur if shims are placed too close to bottom corners (see **Figure 13**).

Direct concrete-to-concrete or concrete-to-steel bearing should be avoided.

The gap between the bottom of the concrete element and the footing should ultimately be grouted or dry packed to transfer the load to the footings.

Figure 13. Levelling shims



7.10 Grouting

After a concrete element has been finally plumbed, the concrete element needs to be fully grouted, including grout pockets, unless otherwise stated on the drawings. Grouting and appropriate strength gain should take place before any formwork is removed from beams or slabs supported by a concrete element.

The weight of the concrete element, and any loads applied to it before grouting, will be applied to the supporting structure at two discrete points where the levelling shims are located.



8. INCORPORATION INTO FINAL STRUCTURE

8.1 Effect of construction process on the existing structure

During the erection of concrete elements, the effect of the construction activity on the structure is to be considered and planned for. Factors that should be considered and addressed include the following:

- > means of fixing concrete elements to the structure, including the effectiveness of the connection methods
- > the effect of impact loads to the existing structure during positioning of concrete elements in place
- > the effect of wind loading on the structure in its partially completed state
- > the ease of the construction process and the minimisation of risk for persons involved in the construction process, and
- > the potential need to store materials on the structure as it is being erected and the effect of these stored materials on the stability of the structure.

It is important that the connection details specified by the engineer in the design drawings for the structure are complied with. This includes the use of specified anchorage systems, compliance with the erection tolerances for connections, and adequate time allowance where required (i.e. with the use of grouts and epoxies). Where unforeseen obstacles mean that the design specifications must be varied, this should not take place unless an engineer has approved and signed off the variations. A competent person should ensure the engineer's instructions have been complied with.

Where the concrete elements are to be attached to structural steel, an engineer is to detail all connection methods and these are to be followed during construction. Welded connections should comply with AS 1554 or the most recent equivalent.

The risk of collapse of a structure from stored materials can potentially occur anywhere other than in the case of a floor slab on the ground. Therefore concrete elements, or any other material, should not be stored on the structure unless an engineer has verified that collapse cannot occur. Documentation signed by the engineer should be provided that clearly shows where materials can be stored, the maximum allowable quantity of stored materials and any other conditions that need to be met. This documentation should preferably include a diagram that shows the relative locations of the storage areas.

The engineer should take into account the following factors when determining whether the structure is suitable for storing materials:

- > the design loadings of the final structure and assurance that the loads applied by stored materials will be less than these loadings
- > consideration of both point and distributed loads applied during the lifting and storage process (i.e. storing concrete panels on timbers on a suspended slab will transfer concentrated loads to the slab in the area of the timber)



- > the effect of incomplete bracing and stiffening on the structure's stability compared to the stability that would exist if the building was complete, and
- > additional loading other than the dead weight of the concrete element applied during crane landing of the element on the structure (i.e. impact loading).



APPENDIX A. DEFINITIONS

'Braces' are structural members which are required to provide lateral stability to other structural members or transfer horizontal loads to supports.

Since they must be able to be installed at any angle to the supporting surfaces or members, they have pinned ends (swivel) thus allowing a degree of freedom for varying the angles.

Braces are generally not recommended to be used as props, but if and when they are used, measures should be taken to fix the ends at right angles.

'Bracing insert' means a component cast into the concrete element or tilt-up wall panel, or cast into or fixed to a brace footing for later attachment of a brace.

'Builder' see 'person with control'.

'Client' means any person who commissions design work for a structure.

'Concrete element' means a concrete wall panel or other precast concrete element made in either an on-site or off-site casting yard that is cast and then lifted into position to form part of a building but does not include concrete pipes, bridge beams or culverts.

'Construction project' means a project involving construction work and includes design, preparation and planning.

'Construction site' means a place at which construction work is undertaken and any other area in the vicinity where plant or other material used or to be used in connection with the construction work is located or kept during the construction work. It does not include a place where elements are manufactured 'off-site' or where construction material is stored as stock for sale or hire.

'Construction work' means any work on or in the vicinity of a construction site carried out in connection with the construction, alteration, conversion, fitting out, commissioning, renovation, repair, maintenance, de-commissioning, demolition or dismantling of any structure, and includes:

- a. the demolition or dismantling of a structure, or part of a structure, and the removal from the construction site of any product or waste resulting from the demolition or dismantling
- b. the assembly of prefabricated elements to form a structure or the disassembly of prefabricated elements, which immediately before such disassembly, formed a structure
- c. any work in connection with any excavation, landscaping, preparatory work or site preparation carried out for the purpose of any work referred to in this definition, and
- d. any work referred to in this definition carried out under water, including work on buoys, obstructions to navigation, rafts, ships and wrecks.

Construction work does not include the exploration for or extraction of mineral resources or preparatory work relating to the extraction carried out at a place where such exploration or extraction is carried out.

'Connections' means a method by which one or more concrete or steel elements are joined together to transfer loads and/or provide stability.



'Crane standing area' means the base on which the crane is supported during erection of the concrete elements and is referred to as the erection platform in AS 3850 or the most recent equivalent.

'Design' in relation to any structure means any drawing, design detail, scope of works document or specification relating to the structure.

'Designer' means a person whose profession, trade or business involves them in:

- > preparing designs for structures including variations to a plan or changes to a structure, or
- > arranging for people under their control to prepare designs for structures.

'Elevating work platform' means a telescoping, scissor or articulating device, or any combination of these, that is used to position personnel, material or equipment at an elevated work area.

'Engineer' means a person qualified for membership of the Institution of Engineers Australia, and includes:

- a. 'Erection design engineer' - the engineer responsible for the design for the erection of the precast elements of the building. The erection design engineer should be a person qualified for membership of the Institution of Engineers Australia and be competent to practice in the structural engineering field. The erection design engineer will usually be responsible to the builder, the precaster or the shop detailer, or may also be the project design engineer
- b. 'Project designer engineer' - the consulting engineer responsible for the engineering design of the building. The project design engineer should be a person qualified for membership of the Institution of Engineers Australia and be competent to practice in the structural engineering field. The project design engineer will usually be responsible to the client.

'Erector' means the company or person responsible for erecting the concrete elements.

'Expansion anchor' means an anchor placed in holes drilled into hardened concrete which rely on expansion devices within the hole to prevent pullout under load.

- > **Load controlled expansion inserts** are the **only permissible anchor** in concrete element construction work. For further information see **Section 5.1.7**.
- > **Deformation controlled expansion anchors** are **not permitted** in concrete element construction work.

'Fixing insert' means a component cast into the concrete element and used to tie it into the structure.

'Fixings' means the hardware components of all connections including bolts, washers, weld plates and anchors.

'Hazard' means any thing (including an intrinsic property of a thing), or situation with the potential to cause harm to people.

'Joint' means the space between adjoining concrete elements or between a concrete element and some other portion of the structure.

'Levelling shims' means proprietary material used under concrete elements to support them in their correct position until the final connection is made.

'Lifting clutch' means a certified proprietary quick-release device used to connect the crane rigging to the lifting insert.



‘Lifting insert’ means a component cast into the concrete element to facilitate the lifting of the element during erection.

‘Limit state factor’ means the sum of each of the appropriate load components multiplied by the appropriate load factors, divided by the sum of the unfactored load components.

‘Load controlled expansion inserts’ see ‘expansion anchors’.

‘OHS induction training’ means training which covers the relevant health and safety topics set out in the National Standard.

‘Person with control’ means:

- a. a person with control over the workplace, or
- b. a person with control over work.

‘Person with control over a workplace’ means a person who has management or control of a workplace.

Note: *An owner of a workplace and an occupier of a workplace can be persons with control of workplaces, to the extent that they have management or control of the workplace. An employer may also be the owner or occupier of a workplace.*

‘Person with control of work’ means a person who has management or control over work.

Note: *An employer, owner, manager of a labour hire company, franchisee and franchisor, will be a person with control of work and a self-employed person, such as a sub-contractor, can be persons with control of work. Each is considered a person with control of work to the extent that they have management or control of the work.*

‘Prefabricate’ means to manufacture concrete elements, either on or off-site so that they are ready for assembly on a construction site to form a structure.

‘Prefabricator’ means the person responsible for the manufacture or casting of prefabricated concrete elements either on or off-site.

‘Proprietary components’ means components carrying a trademark or registered name.

‘Proprietary documentation’ means documents prepared by an individual or a corporation specific to a proprietary item, a component or a system of components and concrete elements forming a building or structure. They include drawings and instructions for the erection, installation, operation, inspection and testing of the items, components or system.

‘Props’ are structural members that are loaded in direct compression. Props are positioned perpendicular between two parallel surfaces when it may be supporting only one of these surfaces (formwork) or supporting both surfaces from moving in (excavations). In the latter case they are more often called struts. Props have both their ends at 90 degrees to the supporting surfaces.

‘Rated capacity’ means the maximum gross load which may be applied to the crane while in a particular working configuration and under a particular condition of use.



'Reasonably practicable' means what can be done and what is reasonable in the circumstances, taking account of:

- > the probability (likelihood) of a hazard or risk occurring
- > the degree of harm arising from the hazard or risk
- > the state of knowledge about the hazard or risk and ways it may be removed or mitigated
- > the availability and suitability of ways to remove or mitigate the hazard or risk, and
- > the cost of removing or minimising the hazard or risk.

'Reinforcement' means any one of the following:

- > structural reinforcement, including reinforcing steel and prestressing tendons, provided for crack control or to resist forces caused by in service loading and thermal and shrinking movements
- > reinforcement additional to the structural reinforcement, provided to resist forces caused by transport or erection loads, and
- > component reinforcement which is placed in conjunction with lifting, bracing and fixing inserts so that they can attain their design capacities.

'Rigging system' means a system of certified re-useable lifting equipment that may include lifting clutches, slings, sheaves, lifting or spreader beams or other mechanical devices to connect the crane to the concrete element being lifted.

'Risk' means the likelihood and consequences of a hazard causing harm to a person.

'Safe Work Method Statement' means a statement that:

- > identifies work activities assessed as having safety risk or risks
- > states the safety risk or risks
- > describes the control measures that will be applied to the work activities
- > describes how safety measures will be implemented to do the work safely, and
- > includes a description of the equipment used in the work, the qualifications of the personnel doing the work, and the training required to do the work safely.

'Shop detailer' means the person responsible for preparing the shop drawings of the elements. The shop detailer may also be the precaster or a company or person responsible to the precaster. The shop detailer should be a person who, through training or experience, is qualified to undertake the work as described in this document.

'Shop drawing' means a detailed drawing of a precast or tilt-up concrete element used in the manufacturing process.

'Strongback' means a temporary member fixed to a concrete element to provide localised reinforcement during lifting, transport or erection.

'Tagline or tail rope' means the lines attached to the load being lifted, usually to control the load suspended by the crane.

'Transporter' means the company or person responsible for transporting the concrete elements.



'Tilt-up' means:

- > an essentially flat concrete panel
- > cast in a horizontal position, usually on site; initially lifted by rotation about one edge until in a vertical or near vertical position, and
- > transported and lifted into position if necessary; and then stabilised by bracing members until incorporated into the final structure.

'Working load limit' means the maximum unfactored load that may be applied to an item, component or system.



APPENDIX B. RE-USE OF CONCRETE ELEMENTS

The re-use of concrete elements refers to those concrete elements which are relocated on a building or from another building to form part of the structure.

This National Code does not preclude the re-use of concrete elements. However, if the original design documentation is not available, the concrete panels cannot be reused as their suitability cannot be verified.

The intent to re-use should be subject to a full assessment of the:

- > suitability of the concrete elements
- > condition and structural integrity of the concrete elements, and
- > intended work procedure for the relocation exercise.

This assessment, with or without any amendments, must be carried out by a suitably qualified engineer and certified in writing.

The assessment should give consideration to the:

- > adequacy of the concrete element, which may have to be modified to be safely loosened from its existing location, handled, transported (if required), erected and built into the new structure, and
- > stability of the remaining structure which may be affected by the removal of the intended concrete element and to ensure that the remaining structure is adequately braced.

It should be noted that:

- > loosening an existing concrete element may introduce additional construction loads from likely impact
- > concrete elements may require new lifting points for handling and erection as the older lifting points could have been sealed, and
- > amendments to the concrete panel may have affected their structural integrity.



APPENDIX C. DEMOLITION OF CONCRETE ELEMENTS

Structural assessment

An integral part of the safe demolition of concrete elements is the assessment and instruction given by an engineer with expertise in building construction. Detailed guidance can be found in AS 2601 or the most recent equivalent.

An engineer should review the structural design drawings as part of the evaluation process before prescribing the method of demolition. Documents may be inspected, with the consent of the owner, at the building surveyor's office, local government authority.

An engineer should assess each concrete element individually as the scope and nature of the work for each concrete element may be different. Written instruction provided by the engineer should include, but not be limited to, how best to ensure the stability or overall integrity of the building or structure during demolition, along with specific processes or procedures to follow during demolition.

The engineer should be satisfied that the prescribed method of demolition is safe.

Work comprising the total or partial demolition of a building or structure containing concrete elements erected by the tilt-up method of construction can only be undertaken by a person carrying the appropriate demolition licence (where required by the jurisdiction). Each jurisdiction may include conditions when issuing a licence for demolition. The licence holder must ensure there is compliance with these conditions.

The licenced demolition person must ensure an engineer has conducted an investigation of the building or structure and the results are recorded in writing. The results will form the basis for decisions made about the sequence of work and actual process of demolition.

Adequate control measures must be taken, by the holder of the demolition licence, to protect people in adjoining buildings and other members of the public.

Fire damaged or ruinous buildings

Fire damaged concrete elements may present particular safety issues. Appropriate safety precautions should be taken during the assessment and demolition of buildings and structures that have been identified as fire damaged, ruinous or otherwise dangerous.

Supervision

The demolition supervisor must oversee the work while it is being carried out, ensuring that the work is being performed in a safe manner in accordance with agreed procedures and that there is a capacity to respond immediately to emergency situations.



Safe design for concrete element demolition

Hazard identification and risk assessment should be considered during the design process to eliminate or minimise the OHS risks throughout the life of the building or structure. The life of the structure includes its demolition.

While an engineer is best placed to advise on the process, connection methods such as pour strips have been shown to assist in supporting concrete panels during the demolition of concrete elements, particularly when the structural integrity of the building or structure has been compromised through fire or unexpected events. Consequently the use of pour strips or similar methods that might minimise health and safety risks during planned or unplanned demolition should be considered in the design phase.



APPENDIX D. REFERENCED DOCUMENTS AND FURTHER READING

Word content in this document is based on WorkSafe Victoria, Industry Standard Precast and Tilt-Up Concrete for Buildings, 2001. For further information and future updates, please access www.worksafe.vic.gov.au

Hazardous Substances Information System <http://hsis.ascc.gov.au/>

Guidance on the Principles of Safe Design for Work www.ascc.gov.au/ascc/HealthSafety/SafeDesign/Guidelines

National Transport Commission's Load Restraint Guide www.ntc.gov.au

Precast Concrete Handbook, published by the National Precast Concrete Association Australia and the Concrete Institute of Australia, 2002.

Guide to Tilt-Up Design and Construction, jointly published by the Concrete Institute of Australia and Cement Concrete & Aggregates Australia (CCAA T55 CIA Z10)

Building Code of Australia, published by the Australian Building Codes Board

Workplace Health and Safety Queensland, Tilt-Up and Pre-cast Construction Code of Practice, 2003

Western Australia WorkSafe publications

Commission for Occupational Safety and Health

Guidance Note: General Duty of Care in Western Australian Workplaces

Codes of Practice: First Aid Facilities and Services, Workplace Amenities and Facilities, Personal Protective Clothing and Equipment

Guidelines for Work in the Vicinity of Overhead Powerlines

Australian Standards

(At the time of publication, the Australian Standards referenced in this publication are current. Users of this document should check that the referenced standard has not been updated or replaced.)

Series AS 1012	Methods of testing concrete
AS 1111	ISO metric hexagon bolts and screws – product grade C – Bolts
AS/NZS 1170.0 - 2002	Structural design actions – General principles
AS/NZS 1170.1 - 2002	Structural design actions – Permanent, imposed and other actions
AS/NZS 1170.2 - 2002	Structural design actions – Wind actions
AS 1170.4 - 2007	Structural design actions – Earthquake actions in Australia



AS/NZS 1252 - 1996	High strength steel bolts with associated nuts and washers for structural engineering
AS 1379 - 2007	Specification and supply of concrete
AS 1418.4 - 2004	Cranes, hoists and winches – Tower cranes
AS 1554.1 - 2004	Structural steel welding – welding of steel structures
AS 2550.1 - 2002	Cranes, hoists and winches – Safe use – General Requirements
AS 2550.4 - 2004	Cranes, hoists and winches – Safe use – Tower Cranes
AS 2550.5 - 2002	Cranes, hoists and winches – Hi Safe use – Mobile Cranes
AS 2550.10 - 2006	Cranes, hoists and winches – Safe use – Mobile elevating work platforms
AS 2601 - 2001	Demolition of structures
AS 3600 - 2001	Concrete structures
AS 3610 - 1995	Formwork for concrete
AS 3799 - 1998	Liquid membrane-forming curing compounds for concrete
AS 3828 - 1998	Guidelines for the erection of building steelwork
AS 3850 - 2003	Tilt-up concrete construction
AS 4100 - 1998	Steel structures
AS 4991 - 2004	Lifting devices

Further information

Additional and more detailed information can be obtained from the following organisations.

Cement Concrete & Aggregates Australia (CCAA)

Construction Notes

Briefing Notes (monthly publication)

National Precast Concrete Association Australia (NPCAA)

Newsletter of the NPCAA

In addition to the above organisations and publications, manufacturers of hardware associated with the precast and concrete industries, as well as manufacturers of precast concrete elements, all publish design and technical information on their products. Designers and users should refer to a particular supplier's technical information for advice before specifying or using any of their products.



APPENDIX E. OHS AUTHORITIES

AUSTRALIAN GOVERNMENT

COMCARE Australia

CFM Building

14 Moore Street

Canberra ACT 2600

Phone: (02) 6275 0000 (Switch)

Phone: 1300 366 979 (Workers' Comp)

Phone: 1800 642 770 (OHS Hotline)

Phone: 1300 366 979

Fax: (02) 6248 0322

www.comcare.gov.au

STATE & TERRITORY GOVERNMENT OHS AGENCIES

New South Wales

WorkCover Authority of NSW

92-100 Donnison Street

Gosford NSW 2250

Phone: (02) 4321 5000 (Switch)

Phone: 13 10 50 (Information Centre)

Phone: (02) 8260 5881 (Construction Hotline–24 hours)

Fax: (02) 4325 4145

www.workcover.nsw.gov.au

Western Australia

WorkSafe Western Australia

6th floor, 1260 Hay Street

West Perth WA 6005

Phone: (08) 9327 8777 (Switch)

Fax: (08) 9321 8973

www.safetyline.wa.gov.au



Victoria

Victorian WorkCover Authority

222 Exhibition Street

Melbourne VIC 3000

Phone: (03) 9641 1555 (Switch)

Phone: 1800 136 089 (Advisory–Vic only)

Phone: (03) 9641 1444 (Advisory)

Fax: (03) 9641 1222

www.workcover.vic.gov.au

South Australia

SafeWork SA

GPO Box 465

Adelaide SA 5001

Phone: (08) 8303 0400 (Switch)

Phone: 1300 365 255 (Help and Early Intervention Centre)

Fax: (08)8303 0277

www.safework.sa.gov.au

Tasmania

Workplace Standards Tasmania

Department of Infrastructure, Energy & Resources

PO Box 56

Rodney Park TAS 7018

Phone: (03) 6233 7657 (Switch)

Phone: 1300 366 322

Fax: (03) 6233 8338

www.wsa.tas.gov.au



Queensland

Workplace Health & Safety

Department of Industrial Relations

GPO Box 69

Brisbane QLD 4001

75 William Street

Brisbane QLD 4000

Phone: 1300 369 915 (Information)

Phone: (07) 3225 2000 (Switch)

Fax: (07) 3225 1540

www.deir.qld.gov.au

Australian Capital Territory

ACT WorkCover

4th Floor, FAI House

PO Box 224

Civic Square ACT 2601

Phone: (02) 6205 0200 (Switch)

Fax: (02) 6205 0336

www.workcover.act.gov.au

Northern Territory

WorkSafe

GPO Box 4821

Darwin NT 0801

66 The Esplanade, Darwin NT 0800

Phone: (08) 8999 5141 (Switch)

Phone: 1800 019 115 (NT only)

Fax: (08) 8999 6260

www.worksafe.nt.gov.au

APPENDIX F. SAFE WORK METHOD STATEMENT

(Blank form - Copy for use at the workplace)

Safe Work Method Statement (SWMS) - No. _____

Name of organisation completing the work: Work Activity/Task:	Project Name/No and Location:
------------------------------------------------------------------	-------------------------------

Legislation/Codes of Practice relevant to this task:	Person with Control:	ABN:
	Representative:	
	Sub-Contractor:	ABN:
	Representative:	

This SWMS has been prepared by:	This SWMS has been reviewed by:	This SWMS has been discussed with:
Person with Control or Representative: _____ Position: _____ Signature: _____ Date: _____	Name: _____ Position: _____ Signature: _____ Date: _____	Employee / Subcontractor: _____ Signature _____ Employee / Subcontractor: _____ Signature _____ Employee / Subcontractor: _____ Signature _____ Date: _____ Date: _____ Date: _____

Responsibility:

The person with control must issue a SWMS for review. The person with control must ensure that all people working on site have been briefed on their SWMS, trained in the control measures identified and listed in the SWMS, and agree to perform the work according to the SWMS. They must also ensure that immediate corrective action is taken if the SWMS is not being followed.

Item	Work Activity	Identified Hazard	Risk Control Measures	How will safety measures be implemented?	Equipment, qualifications and training
	Break the job down into sequential steps	What could harm someone? Discuss possible hazards with people working on the site	What can be done to make the job as safe as possible?	Describe how the identified control measures will be implemented and who will undertake the task(s)	What is required to do the job properly?
1.					



APPENDIX G. ENGINEER CERTIFICATION LETTERS – LIFTING AND IN-SITU LOADS

Sample letter for lifting and in-situ loads

Company Letterhead - Engineer

6 February 2008

Hector Smith

Hector Panel Erections Pty Ltd

21 Concrete Drive

Urbanville NSW 2130

Dear Mr Smith

Heritage Waters Project - Spiky Road, Golden Beach

I certify that the concrete panels detailed below, have been designed in accordance with AS 3850 - Tilt-up concrete and pre-cast concrete elements for use in buildings and AS 3600 - Concrete structures for both in-situ loads and erection loads:

Panel Number	Drawing Number
P-1	302 – 1 Rev 1
P-2	302 – 2 Rev 2

The lifting inserts have a minimum factor of safety of 2.5 provided the inserts are used in accordance with the manufacturer's specifications and the concrete has reached a minimum strength of _____ Mpa (as recommended by the insert manufacturer).

The panels will be suitable for lifting when the concrete strength has reached _____ Mpa.

Yours faithfully

Signature

Engineer's Name

Professional membership number



APPENDIX H. ERECTION DESIGN ENGINEER CERTIFICATION LETTERS – BRACING AND WIND LOADING

Sample letter for temporary bracing and wind loading

Company Letterhead - Engineer

6 February 2008

Hector Smith
Hector Panel Erections Pty Ltd
21 Concrete Drive
Urbanville NSW 2130

Dear Mr Smith

Heritage Waters Project - Spiky Road, Golden Beach

I certify that the temporary bracing layout as detailed in the drawings listed below has been checked for wind loading and complies with AS 3850 Tilt-up concrete and pre-cast concrete elements for use in buildings and AS/NZS 1170.2 Structural Design Actions – Wind actions:

Drawing description	Drawing number
Site plan showing panel locations	SP - 107
Brace configurations (i.e. showing brace types, angles, extensions, etc)	BC – 1 to 23
Deadmen	DM – 1, DM 2, DM 3.

I have checked the capacity of braces, deadmen anchor blocks (or slab design), panel inserts and anchors used between the brace foot and deadmen.

I have selected the following parameters from AS/NZS 1170.2 in determining the adequacy of the temporary bracing system:

Yours faithfully

Signature
Engineer's Name
Professional membership number

APPENDIX I. PROJECT DESIGN ENGINEER'S CERTIFICATE OF COMPLIANCE

Site name

Site address

Company employing the project design engineer

This is to certify that the structural design and detailing for the above project as carried out by this firm is in accordance with:

- > **AS 3600** and/or **AS 3850** (as appropriate), and
- > This National Code of Practice for Precast, Tilt-up and Concrete Elements in Building Construction

Name

Signature

Building practitioner's registration number

Date

The person completing and signing this certificate must be an engineer, a person qualified for corporate membership of the Institution of Engineers Australia (or equivalent) and be competent to practise in the design of precast concrete.

APPENDIX J. PANEL CASTING CHECKLIST

This is to certify that the concrete elements listed below have been manufactured in accordance with the approved shop drawings.

Job address: _____ Panel manufacturer: _____

Principal contractor: _____ Panel erector: _____

Panel ID number	Casting date	Drawing No.	Concrete specification for lifting (MPa)	Constructed as per drawing	Verifiers name	Initials & Date

APPENDIX K. QUALIFICATION REGISTER FOR PANEL ERECTION

Project name & address: _____

Prescribed Activities Register (Ticket holders) _____

Name	Certificate type	Certificate number	Activity involved in*

* i.e. crane operation, supervision, panel securing, etc

Trainee Register

Trainee name	Activity involved in	Trainee logbook supplied?	Supervisor	Period of experience in activity