
Industry Standard

Precast and Tilt-up Concrete for Buildings



Developing the standard in partnership



Foundations for Safety is Victoria's primary forum for dealing with occupational health and safety issues in the construction industry.

Foundations for Safety has brought together State Government regulatory agencies, accident research expertise, construction industry trade unions and employer associations representing principal contractors and construction sub-contractors. It meets in full session every three months and establishes working parties to progress various health and safety initiatives.

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- Australian Manufacturing Workers Union
- Air Conditioning and Mechanical Contractors Association
- Civil Contractors Federation
- CEPU Electrical Trades Union
- CEPU Plumbing Division
- CFMEU Construction and General Division
- CFMEU FEDFA Division
- Finishing Trades Association of Australia
- Housing Industry Association
- Master Builders Association of Victoria
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- Monash University Accident Research Centre
- National Electrical and Communications Association
- Office of the Chief Electrical Inspector
- Victorian Employers Chamber of Commerce and Industry
- Victorian Trades Hall Council
- Victorian WorkCover Authority

You can help improve health and safety in the construction industry by providing your feedback on this Industry Standard or on other health and safety issues to any of the Foundations for Safety member organisations.

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Introduction

Precast concrete construction is a method of prefabricating concrete in discrete elements and erecting and incorporating them by crane into their final position in the building structure.

This document sets out industry-wide guidelines for establishing and maintaining a safe working environment wherever precast and tilt-up concrete construction is used.

The precast and tilt-up concrete industry should be aware of the obligations to protect employees and members of the public under the various Victorian acts, regulations and codes of practice made under legislation relating to health and safety.

This industry standard provides practical advice about the safe design, manufacture, transportation and erection of precast concrete and tilt-up concrete elements. The emphasis is on ensuring a safe working environment whenever these elements are used. It is not intended to be an all-encompassing design, manufacture and erection manual.

Advice on the general design, manufacture and erection of precast and tilt-up concrete elements can be found in the referenced documents.

This Industry Standard is based on current knowledge and construction methods within the industry and is not intended to exclude other methods or processes that can be shown to meet the requirements of providing a safe workplace.

The August 2000 draft of this Standard was prepared by a committee comprising representatives from the building industry, industrial unions and WorkCover.

The committee comprised:

- | | |
|------------------|--|
| Chair | Pat Preston
<i>Construction, Forestry,
Mining & Energy Union</i> |
| Convenor | Barry Crisp
<i>Crisp Consultants Pty Ltd</i> |
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<i>Construction, Forestry,
Mining & Energy Union</i> |
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<i>Victorian WorkCover
Authority</i> |

Introduction cont.

Consultation with the Victorian WorkCover Authority ensured overall compatibility with WorkCover legislation and technical alignment with the revision of AS 3850, *Tilt-up Concrete Construction*.

The Foundations for Safety full committee endorsed this document as an Industry Standard in December 2000. Foundations for Safety is a forum comprising representatives of Victoria's key construction industry stakeholder organisations.

The Victorian WorkCover Authority publishes this Industry Standard on behalf of Foundations for Safety.

It supersedes WorkCover's 1987 *Code of Practice for Tilt-up Construction*, which has now been revoked.

Part 1: General

1.1 Purpose

This Industry Standard provides practical guidance for the design, manufacture, transportation and erection of precast and tilt-up concrete elements to ensure, as far as is practicable, a safe working environment for those in the industry.

1.2 Scope

This Industry Standard provides recommendations to assist in the safe construction of:

- precast concrete elements made off site for use in the building and construction industry
- tilt-up concrete elements, whether cast on or off site, for use in the building and construction industry
- reuse of precast and tilt-up concrete elements already erected within a building structure

1.3 Special provisions

Some types of precast elements require specific manufacturing and erection processes. These are dealt with in parts 5 and 9. The use of such elements is permitted, provided they comply with the general intent of this Industry Standard.

1.4 Exclusions

This Industry Standard does not cover civil engineering elements such as bridge beams and culverts or small concrete elements such as pavers, kerbs, drain pipes and pits, house stumps or other elements weighing less than 400 kg.

1.5 Relationship to Australian Standards

Precast and tilt-up concrete elements should be designed and constructed in accordance with the *Building Code of Australia* and the relevant Australian Standards.

This Industry Standard is intended to complement the key Australian Standards dealing with precast and tilt-up concrete construction, AS 3600 and AS 3850.

Where any technical conflict arises between a provision of either of these Australian Standards and a provision of this Industry Standard, the technical provision of the Australian Standard (as amended and reissued from time to time) must prevail.

Part 1: General cont.

1.6 Referenced documents and further reading

Documents referenced in this Industry Standard are listed in appendix A. This appendix also provides a list of suggested documents for further reading.

1.7 Definitions

The definitions of terms used in this Industry Standard are given in appendix B.

1.8 Pre-planning and coordination

Pre-planning and coordination between the relevant parties is essential to maximise the benefits of precast and tilt-up methods of construction.

It is the responsibility of the project design engineer to ensure that the building is designed and detailed so that it can be constructed as intended.

Prior to manufacturing the concrete elements, the builder, in association with the precaster and the erector, should have planned the complete construction and erection sequences.

Close collaboration between the project design engineer, the builder, the precaster and the erector is necessary to ensure safety in construction.

Part 2:

Training and hazard management

2.1 General

A principal objective of Victoria's *Occupational Health and Safety Act 1985* is to provide a safe working environment and to prevent harm to employees at work. To do this, it imposes duties of care on employers, employees, and others, and requires employers and employees to cooperate in ensuring that workplaces and work practices are safe and without risks to health.

One of the employer's primary obligations under the Act is to provide:

“such information, instruction, training and supervision to employees as are necessary to enable the employees to perform their work in a manner that is safe and without risks to health.”

[section 21 (2) (e)]

Employers owe this same duty of care to independent contractors and their employees working at the workplace.

In fulfilling this obligation, the precast concrete industry should maintain a structured system of education and training to enable both employers and employees to:

- identify and manage the risks involved in the manufacture, transportation and erection of precast concrete and tilt-up concrete elements

- keep abreast of the current state of knowledge within the industry on the means of eliminating hazards and controlling risks to health and safety.

2.2 Training

Employees need to work safely. They must be trained and instructed in safe systems of work and safe work practices.

Employers must ensure an appropriately experienced person maintains close supervision of employees who are not yet sufficiently skilled and experienced to carry out their work safely.

Training programs should emphasise occupational health and safety and should provide opportunities for individuals to have their existing skills recognised and to develop new knowledge and skills.

Education and training programs should be structured to lead to nationally recognised qualifications and should be delivered by a registered training organisation. Such training should be in addition to and not replace the requirement for site-specific induction.

Part 2: Training and hazard management cont.

Training and instruction programs should include:

- induction on this Industry Standard
- occupational health and safety (OHS) training to the industry competency standard as defined by the National Building and Construction Industry Training Board, Construction Training Australia
- first aid training to the minimum requirements of WorkCover's *Code of Practice for First Aid in the Workplace*
- supervised practical experience programs specific to the tasks being performed by the employee. Such training should be complementary to, or part of, a program leading to a national qualification
- identification of hazards associated with the use of plant and equipment
- the selection, care and use of protective clothing and equipment

2.3 Health and safety

Employers should ensure that all employees have the opportunity to be fully involved in the development of procedures including hazard identification, assessment of risk and control of risk methodology.

Employers have a general duty to ensure the health and safety of employees while at work. In particular they must take all practicable steps to:

- provide and maintain a safe working environment
- provide and maintain facilities for the safety, health and welfare of employees
- ensure that machinery and equipment is designed, made, set up, and maintained to be safe for employees
- ensure that employees are protected from hazards in the course of their work
- provide procedures to deal with emergencies that may arise while employees are at work

Before commencing work on a project, employees must be informed by their employer of:

- emergency procedures
- hazards they may be exposed to while at work
- hazards they may create while at work that could harm other people
- how to minimise the likelihood of hazards becoming a source of harm to themselves and others
- the location and correct use of safety equipment

Part 2: Training and hazard management cont.

Employers must inform employees of the results of any health and safety monitoring.

Employers are also responsible for the health and safety of people who are not employees. Employers must take all practicable steps to ensure that employees do not harm any other person while at work, including members of the public or visitors to the workplace.

Employees are responsible for their own safety and health while at work and must also ensure that their actions do not harm or place others at risk. They must cooperate with their employer on health and safety matters and *must not* interfere with or misuse anything provided by their employer to protect health and safety.

2.4 Hazard management

Employers must have in place an effective method to identify hazards and to determine whether there are significant hazards that require further action. A hazard is an existing, new or potential situation or event that could jeopardise the safe and healthy working environment.

In the precast and tilt-up concrete industry, risk is always present when handling, transporting and erecting elements. *Under no circumstances*

should personnel stand below or work on an element that is leaning towards them.

Although component failure is rare the consequences are always significant.

To ensure appropriate hazard management, an assessment of the risks must be carried out by the builder in conjunction with the health and safety representatives of the contractors and workers involved in the work.

A job safety analysis that lists the hazards and suggests safety procedures should also be prepared. The minimum requirements for this job safety analysis include:

- an identification of the hazards
- an assessment of the risks from the hazards identified
- control measures required to eliminate or minimise the risks from the hazards
- identification of the person responsible for implementing and monitoring the control measures

Where possible, the hazard should be eliminated or the risk reduced by changing or modifying the proposed work method, construction method, or by use of alternative equipment.

Part 2: Training and hazard management cont.

Where the hazard cannot be eliminated, control measures must be implemented to isolate the hazard and to minimise risk to employees. In these circumstances, measures such as barricading areas of danger, provision of specific safety training and work instructions, use of protective equipment, and posting of warning signs should be implemented. Such measures should be discussed with employees and evaluated to ensure that they are effective and do not create additional hazards.

The accepted means of planning to prevent injury is to identify, assess and then control the risk. At the control stage there is a recognised hierarchy of hazard control measures that should be applied. These processes for managing risk are included in various occupational health and safety (OHS) regulations, and should be followed as part of the hazard management process.

2.5 Incident notification

Under OHS regulations, WorkCover must be immediately notified in the event of a workplace fatality, an injury requiring medical treatment, or a dangerous occurrence. This includes the failure of a load during lifting, the collapse of a crane or the collapse of a panel or any other part of a building.

Further information is given in the WorkCover booklet, *WorkCover Incident Notification*.

Part 3:

General design provisions

3.1 General

In precast concrete construction, there are two separate phases of design.

The first, the structural design, is for the in-service condition and is usually carried out by the project design engineer as part of the design of the complete structure.

The second, the design for erection, is for the handling, transportation and erection of the individual elements and structure during the erection process. It may be carried out independently of the structural design by the project design engineer or by the erection design engineer.

The structural design should be carried out by a designer experienced in the field of precast concrete construction and who is a registered building practitioner in accordance with the requirements of the *Building Act 1993*.

The structural design should take into account the particular requirements of precast concrete structures to ensure that the elements can be erected.

3.2 Building stability

The stability of the whole building should be checked by the project design engineer or the erection design engineer at each stage during erection and under in-service load conditions.

Special care should be taken in design and during construction to guard against progressive collapse.

Progressive collapse means a continuous sequence of failures initiated by the local failure of one part of the structure. Precast concrete structures are susceptible to this type of failure.

Progressive collapse may be prevented by providing either:

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

The failure of a single member should not lead to the complete collapse of the structure. This is particularly important where structural stability is provided by steel roof-bracing systems.

3.3 Specification of concrete

The concrete specification should be clearly shown on the drawings and include any special requirements, for example, colour, cement content and water-cement ratio.

Part 3: General design provisions cont.

The specification of the strength of concrete should take into account the strength required at lifting as well as the requirements for in-service loading, durability and ease of construction. Some guidance on the early-age strength of normal-class concrete is given in AS 1379.

The concrete strength required at lifting should be in accordance with the lifting insert manufacturer's specifications. To obtain adequate concrete strength for early lifting, it may be necessary to specify 28-day concrete strengths of 32 MPa or higher.

Advice on the specification of concrete for brace footings is given in section 4.13.

3.4 Structural design

The structural design of the concrete elements should be carried out in accordance with the requirements of AS 3850 and AS 3600, as appropriate, and the provisions of this Industry Standard.

Slenderness and stability are major considerations in the design of precast and tilt-up concrete elements. Precast concrete construction may lack the continuity inherent in cast insitu concrete structures. The designer should address these issues.

Structural members supporting precast or tilt-up elements should be designed to allow for the situation where the element may bear on only two discrete points during erection.

Detailed information on the design of lightly loaded wall panels is available in *Recommended Practice, Design of Tilt-up Concrete Wall Panels*, published by the Concrete Institute of Australia and in the references given in appendix A.

3.5 Loads

Precast and tilt-up concrete elements should be designed for the loads and conditions likely to be experienced during the manufacturing, lifting, transportation, erection, braced and in-service phases.

In addition to the normal design considerations, special consideration should be given to:

- construction loads
- handling and transport loads
- erection loads
- wind load on the braced elements prior to incorporation into the structure
- seismic (earthquake) loads

Erection-load design should consider variations to the precast element load-distribution during lifting, rotation and impact during placement.

3.6 Element size and reinforcement

In determining the size and shape of precast and tilt-up concrete elements, consideration should be given to factors including:

- whether elements are to be cast on site or off site
- size, capacity and configuration of crane(s) available to undertake erection
- access to and around the site
- bracing and propping requirements
- transport restrictions

Where precast elements are to be cast off site, consideration should be given to limiting one dimension so that the element can be transported by conventional means without the need for a pilot or special permit.

For concrete wall panels, the thickness should be determined by limiting the extreme fibre tensile stresses so that the section remains “uncracked”. Appropriate reinforcement should then be determined by using a cracked-section analysis.

Extra reinforcement may be required at openings and at temporary support points to control cracking in precast and tilt-up concrete elements.

In determining reinforcement for precast concrete elements, consideration should be given to the possibility of load reversal due to mishandling during transport or erection. This is particularly relevant to prestressed concrete elements.

3.7 Joints

Joint widths (gaps) between adjacent precast and tilt-up concrete elements should be sufficient to maintain designed position and alignment during erection and accommodate tolerances and expected movements.

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

- 15 mm for joints with flexible sealant
- 20 mm for mortar or grouted joints
- 150 mm for insitu concrete infills

When selecting joint filling materials, consideration should be given to:

- thermal and shrinkage movement of the element
- fire resistance level

Part 3: General design provisions cont.

- weather resistance
- structural movements to be accommodated

3.8 Composite construction

Composite concrete elements formed by adding insitu concrete to a precast concrete or steel section should be designed by the project design engineer to accommodate the progressive loading and strength at each stage of the construction.

Loading cases can include uneven loading of the precast element during erection and while pouring the insitu concrete.

Where the design of the composite element is based on a specific erection and insitu pouring sequence, this should be clearly specified on the drawings.

Where steel beams are used to support precast concrete elements, care should be taken in assessing the stability of the beam during construction. Friction forces between steel and concrete should not be considered as providing stability to the beam.

Where specific roughness is required on the surface of the precast element to provide a key for the insitu concrete, this should be clearly specified on the drawings.

Where temporary propping is required during erection or for supporting the insitu concrete, these requirements should be clearly shown on the drawings. This should include prop capacities and configurations, taking into account the pouring sequence for the insitu concrete.

3.9 Connections

Connections between precast or tilt-up concrete elements, or connections to other structural members, must be designed to resist the forces imposed on the connections in accordance with the requirements of AS 3600 and AS 3850, as appropriate.

The design of the connections must take into account the capacity of both the fixing and the concrete.

Fixings must be designed to fail in a ductile manner.

For cast-in fixings or undercut drilled-in anchors, the ultimate capacity should be the lesser of fixing failure in tension and/or shear, or concrete cone failure.

For all drilled-in expansion anchors the ultimate capacity should be determined in accordance with AS 3850.

Part 3: General design provisions cont.

Deformation controlled expansion anchors, drop-in anchors, spring-set bolts and self-drilling anchors are unreliable and must not be used in lifting or bracing connections.

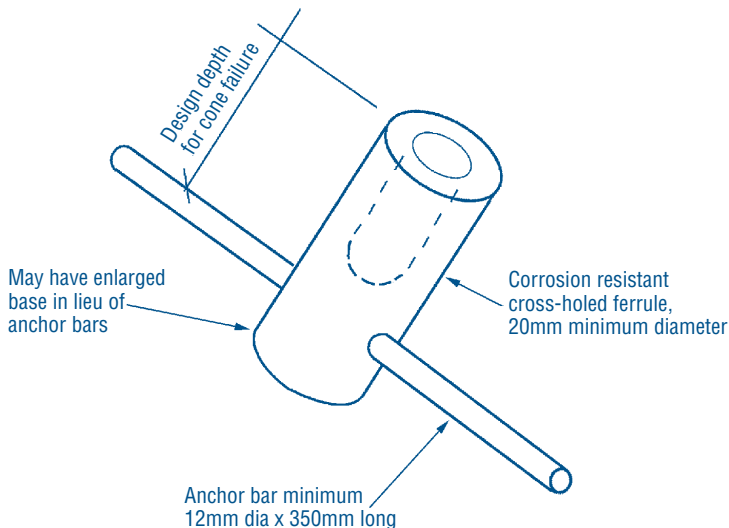
Impact driven fixings including explosive charge driven fixings are not appropriate as fixings in structural connections between precast or tilt-up elements and must not be used.

Further information is given in WorkCover's Guidance Note, *Use of Anchors as Bracing Inserts in Precast Concrete Panels*.

Where possible, cast-in fixings such as fully anchored threaded inserts, weld plates or brackets should be used.

Threaded inserts, cast-in weld plates and brackets must be fully anchored to transfer the loads into the concrete. Anchorage and load transfer is achieved for threaded inserts by an enlarged "foot" on the embedded end or by the use of a crossbar fitted through a cross-hole (see figure 3.1). Note that connections must be designed to fail in a ductile manner and that this may require fixings to have anchor bars of sufficient length to develop their full capacity.

Fig 3.1: Threaded inserts



Part 3: General design provisions cont.

Weld plates and brackets must be anchored with anchor bars of a diameter and embedment depth capable of inducing a full shear cone.

In shallow embedments, where the concrete strength is insufficient to develop the required design load, consideration should be given to increasing anchorage by using fully developed reinforcing bar(s) of sufficient capacity to anchor the fixing.

Fixing capacities are reduced when fixings are placed in near proximity to each other or near edges and openings. Due consideration must be given to the effects of interference with other fixtures, fittings, reinforcing and proximity of openings and edges. In these cases, consideration should be given to providing additional reinforcement or other means to prevent failure.

Where fixings are to be exposed to the weather after construction, they should be manufactured from corrosion-resistant materials or protected by suitable coating systems.

3.10 Lateral restraint

All precast concrete and tilt-up concrete elements should be incorporated into the structure in such a manner that the risk of progressive collapse is minimised.

In assessing the requirements for connections between elements, consideration should be given to the effects of abnormal loads on the building, such as gas explosions or vehicle impacts. For detailed information and recommendations on these issues, refer to the *Planning and Design Handbook on Precast Building Structures* listed in appendix A.

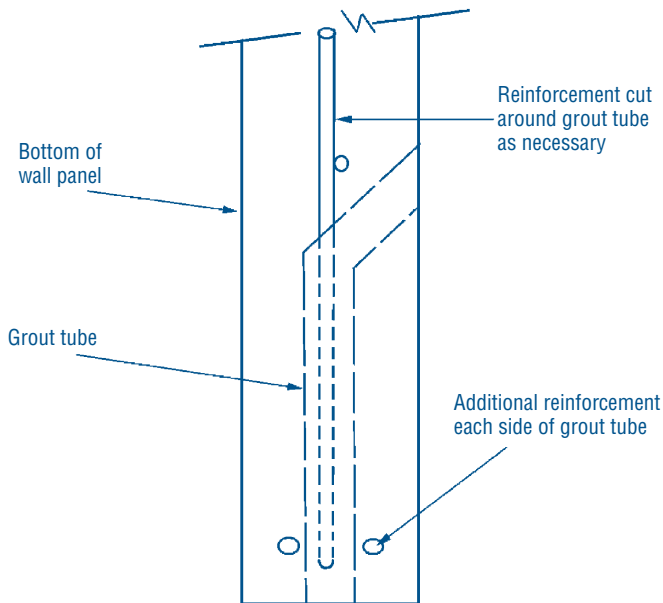
Positive connections between elements and other parts of the structure should be specified and detailed. Such connections must be designed to resist imposed lateral and vertical forces and should ensure that brittle failure cannot occur. See also section 4.11.

Frictional forces cannot be considered sufficient to provide horizontal restraint between elements.

Part 3: General design provisions cont.

Grout tubes, particularly in the edges of thin panels, should be provided with restraining reinforcement on each side of the tube (see figure 3.2).

Fig 3.2: Grout tube



3.11 Tolerances

Recommended tolerances are given in part 5 and should be taken into consideration in the design.

Because precast and tilt-up concrete elements cannot be manufactured to exact dimensions, provision should be made in the design for dimensional variation.

Where required tolerances are less than the recommended values given in part 5, the specific requirements should be clearly stated on the drawings.

Part 3: General design provisions cont.

3.12 Structural drawings

Drawings and details must provide sufficient information for the shop detailer to prepare detailed shop drawings.

The information provided on structural drawings should include:

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

3.13 Shop drawings

The project design engineer should ensure that the shop drawings comply with the structural design. The builder should check the shop drawings for compliance with dimensions. The shop drawings should include all the information outlined in part 4.

3.14 Casting and erection sequences

The casting and erection sequences of the precast and tilt-up concrete elements should be agreed as outlined in part 4.

Part 4:

Design for erection

4.1 General

This section provides specifications for the design of the precast elements to ensure that they resist the forces to which they will be subjected during handling, transportation and erection.

Shop drawings should be prepared for each element and should incorporate all of the details and requirements for the handling, transportation and erection requirements.

Shop drawings are normally the responsibility of the precaster.

As part of the structural design process, the project design engineer must provide sufficient details to allow the shop detailer to prepare shop drawings and the erection design engineer to prepare the erection design.

The shop drawings and erection design should be submitted to the project design engineer for review to ensure that they comply with the requirements of the structural design.

4.2 Planning

Prior to 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 elements and on the erection process.

4.3 Shop drawings

Where possible, the orientation of the elements on the shop drawings should be the same as the proposed casting orientation, i.e. the shop drawing should view the element as set out on the casting bed.

Shop drawings must include the following:

- date and issue number of the drawing
- project location
- element number
- the mass of each element

Part 4: Design for erection cont.

- element dimensions and centre of gravity
- structural reinforcement
- the location, orientation and depth of all inserts and the configuration and cover of any component reinforcement that is required*
- where applicable, the type, make, capacity and technical specifications of:
 - element braces
 - lifting inserts
 - bracing inserts and fixings
 - fixing inserts and, if required,
 - strongbacks, strongback fixing inserts and locations
- the size, configuration and cover of any additional reinforcement required for the transport and lifting of the element
- levelling pad details
- the class and strength grade designation of the concrete as defined in AS 3600
- the required concrete compressive strength of the element and bracing footings as applicable at the time of lifting and erecting**
- the surface finish of each element
- where appropriate, the tolerance limits on the element

- the orientation of the elements
- rigging details

In addition, the shop drawings must include a layout drawing (marking plan) showing the following:

- location of each element
- where applicable, rigging diagrams detailing the required configurations with sling lengths, spreader/lifting beam requirements and arrangement of sheaves
- configuration of erection braces, and where applicable, knee braces and lateral restraints
- required capacities of erection braces
- requirements for erection brace footings, brace fixings and concrete strength of footing at time of erection

The shop drawings should be signed and dated.

Notes: *All edge lift inserts and some other inserts require component reinforcement and details should be obtained from the suppliers of these items.

**Concrete strength grades higher than that specified on the structural drawings may be necessary to achieve the concrete strengths required at the time of lifting.

4.4 Loading

As well as the in-service design, precast and tilt-up concrete elements must be designed for the loads and conditions likely to be experienced during the manufacturing, lifting, transportation and erection phases.

Special consideration should be given to the following:

- construction loads
- handling and transport loads
- erection loads
- wind load on the braced elements

Erection-load design should consider variations to the precast element load-distribution during lifting, rotation and impact during placement.

The effect of suction and adhesion at separation from the form or casting bed (lift-off) and dynamic and impact loading during transportation, erection and bracing should be considered.

Suction loads may vary according to the finish of the panel and the type of form or casting bed. Recommended minimum values are:

- for concrete cast onto a steel bed, a 20% increase should be applied to the dead load
- when casting concrete onto concrete casting beds, a 40% increase should be applied to the dead load
- where the casting bed has a profiled or textured surface the “suction” load may exceed 100% of the dead load.

Consideration should be given to the casting bed profile to ensure that adequate draw (slope) is provided to the fixed edges of the form not struck prior to lifting. A minimum draw of 1:12 is recommended

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

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

Part 4: Design for erection cont.

4.5 Composite construction

The structural design of composite concrete elements formed by adding insitu concrete to a precast concrete or steel section must take into account the progressive loading and strength of the element at each stage of the construction.

The design for erection of such elements also requires the progressive loading and strength of the structure to be assessed at each stage of construction. This can be a complex process and may require detailed analysis and design. Such analysis and design must comply with the requirements of section 4.14.

The following are some of the issues that should be addressed here:

- where the design of the composite element is based on a specific erection and insitu pouring sequence, this should be clearly specified on the shop drawings
- where specific roughness is required on the surface of the precast concrete elements to provide a key for the insitu concrete, this should be clearly specified on the drawings
- where steel beams are used to support precast concrete elements, care should be taken to ensure the stability of the beam during construction. Friction forces between steel and concrete should not be considered as providing stability to the beam
- the requirements for temporary propping during erection or for supporting the insitu concrete should be clearly specified on the shop drawings. These requirements should include prop capacities and configurations. The pouring sequence for the insitu concrete should be clearly specified on the shop drawings

4.6 Additional reinforcement

Additional reinforcement may be required in the precast elements to accommodate forces during handling, transportation and erection.

For elements that are intended as uncracked sections, additional reinforcement or strongbacks should be provided where the maximum flexural tensile stress in the element exceeds the limits recommended in AS 3850.

For wall panels:

- additional reinforcement may be required along the bottom of the panel to resist stresses arising from thermal and shrinkage movements while the panel is supported only on the levelling pads
- additional reinforcement may be required at edges and around openings to resist thermal and shrinkage stresses and to prevent cracking due to panel mishandling

Additional reinforcement may be required in prestressed concrete elements where there is a possibility of load reversal during transport or erection.

4.7 Design for lifting

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

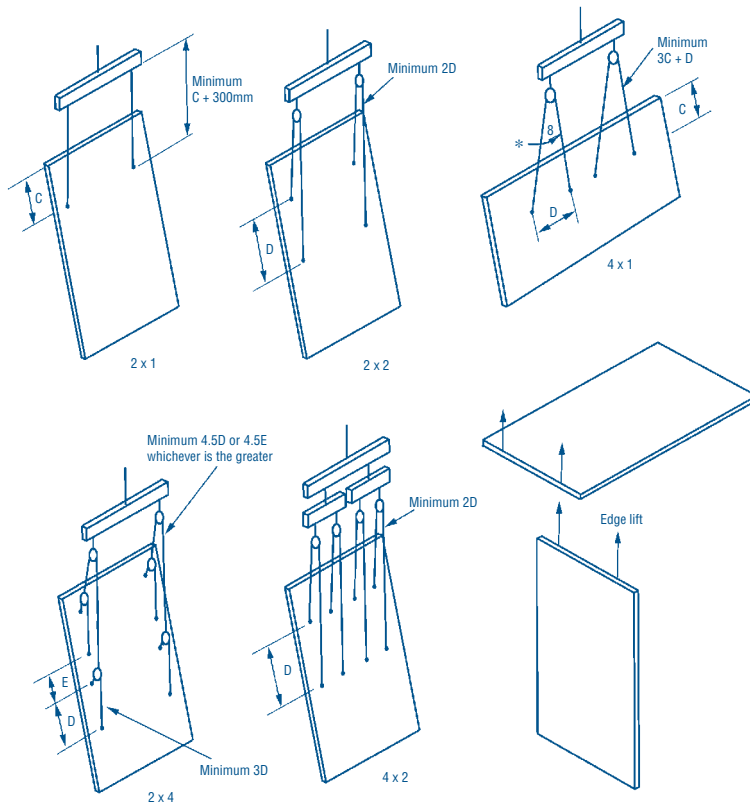
When locating lifting inserts, consideration should be given to the need for strongbacks if the precast element has large or awkwardly located openings.

Part 4: Design for erection cont.

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, the lifting of systems comprising 3, 6, 9 or 12 lifting points should be avoided. Preferred lifting insert configurations for tilt-up wall panels are shown in figure 4.1.

Fig 4.1: Wall panel rigging



Note that dimensions on slings are total length through sheaves

*The lifting insert supplier may specify a maximum value for this angle

Part 4: Design for erection cont.

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. Where this is the case, such requirements should be clearly specified in the shop drawings.

Where fixed length multi-legged slings are to be used to lift an element, the lifting inserts must be designed to carry the full mass of the element on any two lifting inserts.

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

Lifting inserts may be positioned in the face or edges of a precast or tilt-up concrete element. The actual locations of the lifting inserts are determined according to the:

- method of lifting (face or edge)
- mass of the element

- size of the element
- shape of the element and presence of openings and cut-outs
- structural capacity of the element
- concrete strength at the time of lifting
- capacity of the lifting inserts, including edge effects and embedment depth

When it is intended that wall panels 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 panels should be designed to hang no more than approximately 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.

For multi-storey construction, precast walls elevated above the ground must be edge-lifted unless there is a working platform on each side of the final location of the element.

Part 4: Design for erection cont.

4.8 Lifting inserts

Proprietary cast-in lifting inserts should be specified. The inserts should have test certificates available, issued by a NATA or an equivalent testing authority.

Lifting inserts must comply with the requirements of AS 3850.

Lifting inserts should be positioned to ensure that after casting, the following information is still visible:

- the insert manufacturer's symbol or name
- the lifting capacity of the insert
- the insert length

Lifting inserts must be designed, manufactured and installed to provide a working load limit (WLL) with a design factor of at least 2.5 against concrete failure. In determining this, the applied load should include the mass of the element as well as suction and impact load due to lifting.

Lifting inserts should be installed in accordance with the manufacturer's instructions. Particular care must be exercised when inserts require tying to reinforcement, or where component reinforcement or special reinforcing elements are required for the proper installation of lifting inserts.

The load capacity of the inserts depends on several factors (see figure 4.2), including:

- the concrete strength of the element at the time of lifting
- embedment depth of the insert
- direction of load, shear or tension

When selecting a lifting insert, ensure that the nominated capacity from the manufacturer's catalogue is for the direction of the load being applied.

All lifting inserts require adequate embedment or anchorage to function effectively. Anchorage is affected by:

- proximity to edges
- proximity to holes, recesses or edge rebates
- proximity to other loaded lifting devices
- concrete thickness
- concrete strength at lifting
- embedment depth
- the presence of cracks
- the proximity of reinforcement or pre-stressing tendons

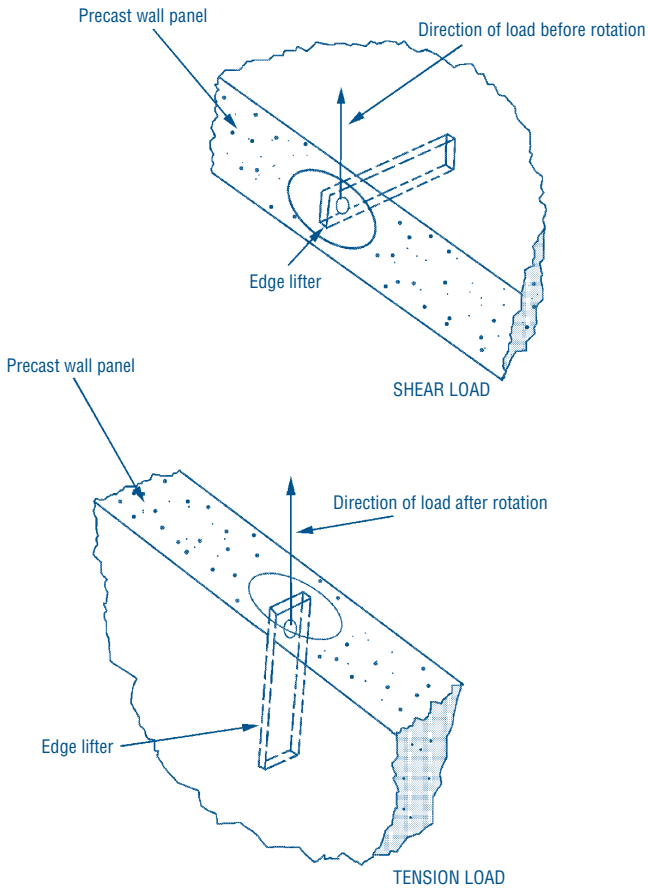
Horizontal bars placed around the foot of a lifting insert may provide very little additional lifting capacity to the insert.

Part 4: Design for erection cont.

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

Where prestressing strand is used as a lifting loop, it must comply with the requirements of AS 1311.

Fig 4.2: Shear loads and tension loads in edge-lifted panels



Part 4: Design for erection cont.

4.9 Strongbacks

Precast and tilt-up concrete elements that are odd shaped, elongated or with large or awkwardly positioned openings may require the addition of strongbacks to enable them to be successfully lifted and placed. Strongbacks may be used to strengthen the elements or to locate additional lifting points to prevent out-of-plane rotations of odd-shaped elements.

Where strongbacks are used, their weight must be included in the calculation to determine the element's centre of gravity.

Strongback fixing inserts should be either cast-in or post-installed heavy duty structural expansion anchors designed in accordance with the requirements of section 4.12.

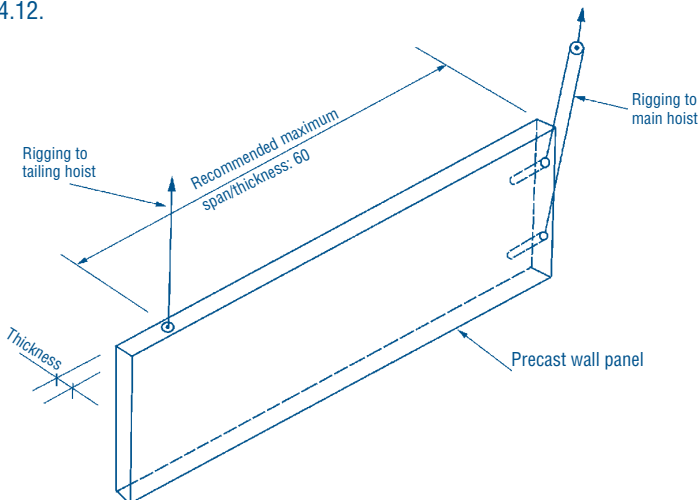
4.10 Slenderness effects

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

Lifting inserts should be located to ensure that compression flange buckling (as in a long slender beam) cannot occur, particularly during rotation of wall panels.

The span/thickness ratio of the element between lifting points should be limited to a maximum of 60 unless a detailed buckling analysis is undertaken (see figure 4.3).

Fig 4.3: Panel rotation



4.11 Bracing and propping

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

- construction loads
- wind loads for temporary structures in accordance with AS 1170.2

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

- the supplier or manufacturer
- 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 kilonewtons (kN), at maximum and minimum extension, on the permanent identification plate
- for composite braces, the WLL, in kilonewtons (kN), at maximum and minimum extension, suitably and clearly marked on the brace

The working load limit for braces at maximum and minimum extension must be determined in accordance with the requirements of AS 3850, taking into

account the forces and eccentricities associated with the complete assembly of components that comprise the brace. Where this involves testing, such tests should be conducted by a registered NATA laboratory or equivalent.

The working load limit for props must be determined in accordance with the requirements of AS 3610.

Brace and prop requirements and details for each type of precast or tilt-up 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 element, unless specifically designed and detailed and approved by the erection design engineer. Such requirements and details must be clearly shown on the layout and shop drawings.

Brace adjustment mechanisms must have stops on the threads to prevent over-extension and retaining devices to prevent unintentional dislodgment of the locking pin. The locking pin should be constructed so that it cannot be undone without the use of a tool.

Part 4: Design for erection cont.

The bracing foot or shoes should be designed to prevent lateral displacement of the shoe from the fixing insert after installation.

Two braces or props may not be necessary where precast or tilt-up concrete elements are provided with erection brackets or permanent connections to other restrained elements such as steel portal columns or walls forming a stable “box” structure.

Where single braces are used, they should be clearly specified on the shop drawings and have a minimum of two fixings at each end.

Where single braces are used, particular care is required on site to prevent any damage that could be caused by impact or failure of the brace or fixing insert.

A brace connected to one element *must never* be connected to another element for support, unless this is clearly specified on the shop drawings.

The ideal location of bracing points in a wall panel is at two-thirds of the height, measured from the base of the panel. Where it is necessary to locate bracing points below the element’s centre of gravity, this should be specifically designed and detailed on the shop drawings. Special provisions should be

made to prevent “kick-out” of the base of the element.

Where brace angles are outside the range of 45–60 degrees to the horizontal, design computations must be prepared to verify brace, brace fixing and brace footing capacities (see figure 4.4).

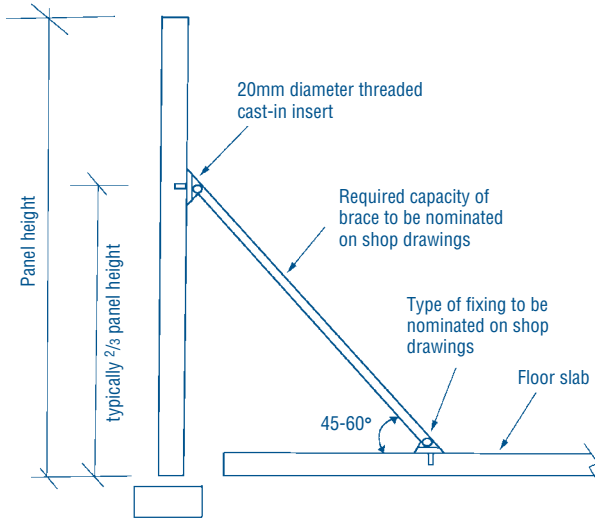
For face-lifted wall panels, bracing inserts should be on the same face of the panel as the lifting inserts. This is to ensure that personnel are not required to fix a brace to a wall panel that is leaning towards them.

Props supporting precast concrete floor units should have rigid saddles to support the top bearer. The top bearer should be located in the saddle in such a way as to prevent rolling of the bearer and to ensure that the load is transferred concentrically into the prop. Where bearers are lapped over a prop, the capacity of the prop must be sufficient to resist eccentricity due to loading on one side only.

Precast and tilt-up concrete elements must remain braced or propped until they are adequately restrained or incorporated into the final structure.

Braces must be maintained and inspected between each use to ensure that all components are correct and in good working order.

Fig 4.4: Panel bracing



4.12 Bracing inserts

Bracing inserts provide the connection between the brace and the braced element or brace footing.

Bracing inserts must be designed to resist all expected loads, including:

- construction loads
- wind loads for temporary structures in accordance with AS 1170.2

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 anchors and drilled-through fixings, used in accordance with the manufacturer's or supplier's recommendations
- load-controlled (torque-controlled) expansion anchors with a permissible load limited to 0.65 of the "first slip load", established in accordance with AS 3850.

Chemical anchors relying solely on chemical adhesion *must not* be used for bracing inserts unless each insert is

Part 4: Design for erection cont.

individually proof tested to the working load limit.

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

Bracing insert capacities are sensitive to:

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

Unless expressly designed and clearly specified, no bracing insert should be closer than 300 mm to the edge of the element or the bracing support.

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

Bracing insert requirements and details for each type of precast or tilt-up 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 200 mm 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. Bracing footings are frequently cast only a few days prior to erecting the precast elements. Concrete strength required in the brace footing at the time of erection must be clearly specified on the shop drawings.

Further information is given in WorkCover's Guidance Note, *Use of Anchors as Bracing Inserts in Precast Concrete Panels*.

4.13 Brace footings

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

- construction loads
- wind loads for temporary structures in accordance with AS 1170.2

Brace footing requirements and details for each type of precast or tilt-up concrete element must be clearly specified on the shop drawings. This must include the required concrete strength at the time of installation of the bracing.

Unless specifically designated otherwise, the concrete strength of the brace footing at the time of installation of the bracing must be at least 20 MPa.

Written confirmation of the required concrete strength of the brace footing

must be provided to the erector by the builder before erection commences.

In calculating the capacity of the brace footing, the direction of the applied brace loads, both in compression and in tension, must be taken into account. Combined vertical and sliding mode failure must also be taken into account. The design of the brace footing should be in accordance with the relevant Australian Standards.

The likely concrete strength at the time of erection should be considered in the design of the brace footing.

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

4.14 Special provisions

This section sets out additional requirements that apply in the case of buildings, or portions of buildings:

- greater than one panel in height
- incorporating wall panels greater than 8 m in height
- incorporating wall panels weighing more than 8 t
- incorporating wall panels which are not nominally flat or rectangular
- where wall panels are not directly fixed and supported by a free-standing structural frame

A work method statement should be prepared by the precaster and erector in conjunction with the builder and in consultation with the workers' health and safety representative(s).

The work method statement should be specific to the project and be approved in writing by the builder and the site safety officer. The work method statement should include the following:

- a general description of the erection process, identifying the objectives of the erection process and broadly describing how these objectives are to be realised
- a statement identifying who will be responsible on site for each phase of the erection process
- a risk analysis to identify critical activities involved in the erection and a clear statement describing how the risks in each activity are to be eliminated or minimised
- design computations prepared by a registered building practitioner who is a suitably qualified and experienced engineer.

These computations should be based on the requirements of the relevant Australian Standards and should confirm the stability of the structure

Part 4: Design for erection cont.

during the erection process and include, but not be limited to;

- temporary brace and bracing insert capacities. Under these special provisions the braces should have a minimum capacity in tension or compression of 10 kN;
- propping or falsework requirements
- brace or prop footing sizes
- temporary fixings required to provide stability during erection
- lifting insert and rigging system

Design requirements should be reviewed by the project design engineer to ensure that they comply with the requirements for the completed structure

- a component casting schedule

For tilt-up components this schedule should be derived from the erection sequence and should be a plan showing the casting location for each component in relation to its final erected position

- an erection schedule

This should detail the erection sequence and identify the crane location for each lift, crane capacity and equipment required and minimum numbers of personnel required.

It should show:

- temporary brace and bracing insert details
- propping or falsework requirements
- brace or prop footing sizes and concrete strength required at the time of erection
- temporary fixings required to provide stability during erection
- required concrete strength of elements at the time of erection and
- lifting insert and rigging system details

4.15 Erection design engineer's certificate of compliance

The erection design engineer must provide the builder with a statement that the design of the elements is in accordance with the relevant Australian Standard and with this Industry Standard.

The statement should be in the form of the erection design engineer's certificate of compliance shown in appendix C.

Part 5:

Manufacture

5.1 Pre-planning

Prior to manufacturing the precast elements, the parties involved in the design, manufacture transport and erection process should liaise and have planned the complete construction and erection sequences. Factors that need to be taken into account in this process include:

- site limitations and local street access
- panel size
- crane size, configuration, mobility and access
- delivery sequence
- transport requirements
- overhead obstructions, especially tram or train wires, overhead power lines and construction site overhead power

5.2 Shop drawings

The precaster should provide detailed shop drawings of each precast or tilt-up concrete element in accordance with the requirements of part 4.

These shop drawings should be approved by the builder and reviewed by the building designer and project design engineer prior to commencing manufacture of the elements.

5.3 Casting and erection sequences

The casting and erection sequences of the precast or tilt-up concrete elements should be agreed between the builder, precaster, erector and, where necessary, the erection design engineer and/or project design engineer. The precaster, in association with the builder and erector, should prepare plans showing the erection sequence and bracing layout in accordance with the requirements of part 4.

The casting and erection sequences should take into account the required crane capacity and configuration.

When assessing crane requirements, note that:

- a crane's rated capacity refers to its capacity at a minimum radius and often bears little relation to its actual capacity to lift large panels
- the selection of crane size must be made with consideration to the working radius and boom extension required

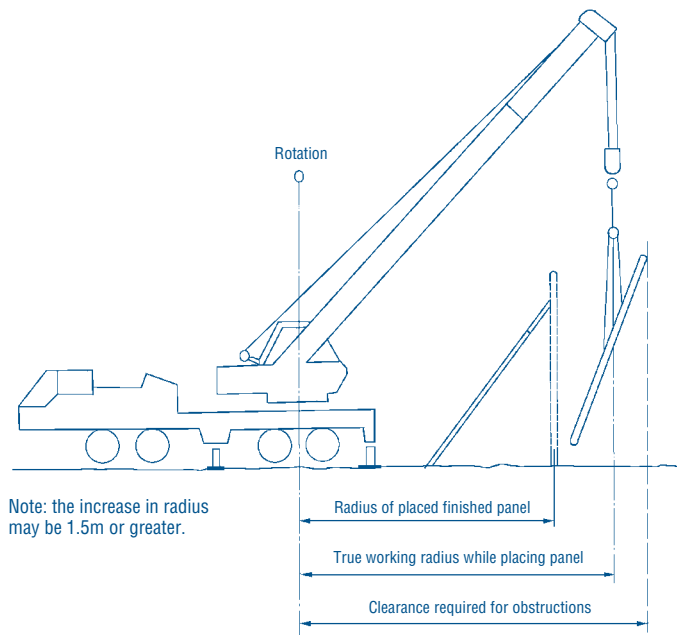
Part 5: Manufacture cont.

- for face-lifted wall panels, assessment of the true working radius of the crane should be made by adding at least 1.5 m to the final panel position radius. This may need to be increased for tall panels (see figure 5.1)

For tilt-up panels, the casting sequence should reflect the erection sequence.

To avoid multiple handling with stack-cast tilt-up panels, the top panel should be erected first.

Fig 5.1: Crane lifting radius



5.4 Formwork

Formwork must be in designed and constructed in accordance with AS 3610.

Precast and tilt-up concrete construction usually requires multiple use and early stripping of formwork and these requirements should be taken into account in the design of the formwork.

Formwork or mould design for precast or tilt-up concrete elements can have a direct bearing on how elements are cast and handled and on the loads imposed during manufacture. In particular, the following should be noted:

- surface finish requirements can influence the preferred orientation of a precast element in the mould. The quality of the finish of vertical mould faces may differ from that cast against a horizontal surface. Two-stage casting can be used to avoid this problem
- moulds for elements such as beams and columns may require special provisions to accommodate prestressing. Generally, the side forms should be released or removed prior to releasing stressing strands. Stop ends should be detailed to accommodate sliding of the component during release

- both suction and friction can be reduced by the use of high quality mould release compounds
- suction on flat mould surfaces is increased by the presence of water. Suction pressure can be relieved by lifting gently at one end or edge of the element
- friction forces are increased by vertical or near vertical sides on a mould. To reduce friction, mould sides should be detailed with adequate draw, or should be released to allow them to spring back. To avoid overloading lifting inserts, the mould can be vibrated while gently lifting one end of the precast element

Manufacturers of prestressed elements should be aware of the inherent hazards and risks of the stressing operation and should have adequate control measures in place to safeguard workers from all such risks.

5.5 Tolerances

Unless otherwise specified, tolerances should be in accordance with the appropriate Australian Standards.

For tilt-up panels, the appropriate Standard is AS 3850.

For other precast concrete elements, the appropriate Standard is AS 3610.

Part 5: Manufacture cont.

The tolerance on deviation from planeness of the casting bed should be such that the as-cast element meets the above requirements.

The effects of cumulative tolerances should be considered. It is recommended that the total accumulation of tolerance be no greater than 20 mm. Where more stringent tolerances are required, these should be clearly specified on the drawings by the project design engineer.

The visual impact of element misalignment may be reduced by the use of various details such as chamfers and arrises.

5.6 Reinforcement

Reinforcement should comply with the requirements of the appropriate Australian Standards.

Reinforcement should be securely fixed in accordance with AS 3600 and supported in the correct position to prevent displacement during concrete placement.

Where plastic-tipped metal bar chairs are used to support reinforcement in external wall panels, care should be taken to ensure that the plastic tips are not damaged during or after manufacture.

5.7 Lifting inserts

Inserts should be cast-in proprietary products that comply with the requirements of part 4. They must be of the type and capacity specified on the shop drawings.

Factors affecting the load capacity of the inserts include:

- the concrete strength of the element at the time of lifting
- embedment lengths of the insert
- direction of loading; shear or tension.

See figure 4.2 for further details.

No variations should be made to the specified lifting insert locations on the approved shop drawings without the written approval of the shop detailer. If changes are made, the shop drawings should be amended accordingly.

Inserts must be accurately positioned and securely tied in accordance with the supplier's recommendations and as detailed on the shop drawings. Inserts *must not* be welded without prior approval of the shop detailer or the erection design engineer.

Where different types of inserts are used on a single project, particular care must be taken to ensure that all components are compatible.

5.8 Strongbacks

Precast or tilt-up concrete elements that are odd shaped, elongated or with large awkwardly located openings may require strengthening for lifting and erection by the addition of strongbacks.

The shop detailer or the erection design engineer should approve any changes to the specified strongback system. The shop drawings should be amended accordingly.

5.9 Concrete placement

Prior to placing concrete, the arrangement must be inspected for compliance with the shop drawings. In particular, this must include checks on:

- formwork dimensions
- formwork stability
- edge details and penetrations
- connection details
- insert locations, types and fixing to reinforcement
- reinforcement sizes, locations and fixing
- bond-breaker effectiveness

The inspection should be carried out by a trained and competent person who was not involved in the original set-up. For stack casting, an inspection should be done prior to the casting of each panel.

Bond-breaker effectiveness can be checked by sprinkling water over the casting bed. It should form into beads if the bond is effective.

Records should be kept to substantiate the manufacturer's certificate of compliance.

The concrete supplier should be advised of:

- the specified characteristic concrete compressive strength
- the concrete compressive strength required at time of lifting
- the maximum aggregate size
- the slump
- special design requirements, if any, e.g. colour, cement content and water to cement ratio
- the site access, required rate of supply and the method of placement, e.g. type of pump

Vibrators should be used to compact the concrete. Particular attention and care should be paid to vibrating the concrete around the inserts and adjacent to the corners and edges. Concrete must be placed in a uniform manner and properly spread over the area before commencing vibration.

Part 5: Manufacture cont.

5.10 Minimum strength for lifting

The minimum concrete strength at which precast or tilt-up concrete elements can be lifted from the mould depends on:

- the concrete stresses at the lifting points
- the flexural and shear stresses caused by handling
- the stresses caused by the transfer of prestressing forces

The strength of the concrete at initial lift *must not* be less than the value specified on the shop drawings.

The minimum strength of the concrete at initial lift should be determined by a method that reflects the concrete strength in the element.

Concrete grades higher than that specified by the project design engineer may be required to develop the full capacity of the lifting inserts for early lifting, transport or erection.

5.11 Curing and release

The strength, watertightness and durability of concrete depend on the concrete being adequately cured.

Release agents used in the manufacture of precast or tilt-up concrete elements should be checked for compatibility with the

curing compound and other applied finishes and joint sealants.

5.12 Special provisions for on-site casting

For tilt-up panels cast on site, the floor slab is commonly used as the casting bed and erection platform.

Additional casting beds may be constructed as required. They should be designed to support formwork fixings and loads. The casting bed must be constructed of suitable material compatible with the tilt-up process.

Impact-driven fixings should not be used to fix formwork if the floor slab is required to have a quality finish.

The builder or precaster should obtain verification from the project design engineer that the erection platform can carry the construction loads.

Panels are usually cast with their external face down to minimise external patching after erection.

To ensure that personnel are not required to fix a brace to a wall panel that is leaning towards them, bracing inserts should be on the same face of the panel as the lifting inserts.

5.13 Release agents

Before a release agent is chosen for use in the manufacture of the precast element, it should be checked for compatibility with the curing compound and other applied finishes and joint sealants. A proven proprietary combination curing compound or release agent should be used. Consideration should be given to the following factors:

- solubility – the products should not be washed off by rain
- discolouration – if it is a pigmented product, the pigmentation should weather off within a reasonable time
- temperature effects – extreme temperatures may blister the product and cause it to lose its properties
- compatibility with finishes – the adherence of applied finishes, including joint sealants, should not be affected

The curing compound and release agent should be applied in accordance with the manufacturer's specifications.

5.14 Stripping and repair

Formwork should be carefully stripped to prevent damage.

If the precast or tilt-up element is damaged, the proposed repair system should be submitted to, and approved by, the project design engineer before being attempted.

5.15 Modification

Modifications to precast or tilt-up concrete elements should only be carried out with the approval of the project design engineer.

5.16 Element identification

During or immediately after manufacture, all precast and tilt-up concrete elements must be permanently marked with a unique identification designation, commonly the element number, and date of casting.

5.17 Manufacturer's certificate of compliance

Prior to the transportation or erection of precast or tilt-up concrete elements, the builder or precaster must prepare a manufacturer's certificate of compliance stating that the manufacture of the elements was carried out in accordance with the approved shop drawings.

The manufacturer's certificate of compliance must be supplied to the erector and must be available on site at the time of lifting the elements listed on the certificate.

The statement should be in the form given in appendix D.

Part 6:

Handling and storage

6.1 General

This part relates to:

- the handling and storage of precast concrete elements in the factory or casting yard
- the storage of precast and tilt-up elements on site
- precast or tilt-up concrete elements that are removed from an existing building for reuse

There is no standard method of handling and storage for precast or tilt-up concrete elements. Methods will vary depending on the type of element and whether the element is in the factory or on site. The important criteria are firstly, safety of personnel, and secondly, protection of the concrete element.

As well as providing a safe workplace and protecting the concrete element, the objective of a handling and storage system is to ensure safe transfer of the element from the mould to the storage area and easy access to the element for removal.

At no time should a precast or tilt-up element be placed in a position without positive restraint unless it is inherently stable.

Inherently stable elements are those elements that, due to their geometry, cannot tip or rotate when stored and subjected to wind loads, construction loads and impact loads generated during placement and removal of the element and, where appropriate, accidental impact from vehicles.

6.2 Handling

The general requirements for rigging and lifting systems are specified in parts 5 and 8.

Handling methods may vary from precaster to precaster depending on the facilities available and the types of elements being manufactured.

Where elements require multiple handling or rotation for processing or finishing, the rigging systems and lifting insert configurations should be designed and detailed on the shop drawings.

The rigging system to be used and method of handling each element or type of element should be shown on the shop drawings or set out in an appropriate work method statement. No element should be lifted without the appropriate methods being documented.

6.3 Concrete strength for handling

Precast or tilt-up concrete elements should not be removed from the moulds and placed in storage until the concrete strength has attained the minimum value required for lifting as specified on the shop drawings.

6.4 Storage

The storage area should be large enough for elements to be stored properly with adequate room for lifting equipment and for manoeuvring trucks and cranes.

The area should be reasonably level and hard surfaced with adequate drainage to ensure that a safe workplace can be maintained.

Elements should not be stored directly on the ground. Generally, two discrete support points should be provided unless specifically noted otherwise by the project design engineer. Timber supports raised above the ground or dedicated racking systems should be used in all cases.

Elements should be stored in such a manner that each element supports only its own weight without any load being imposed by other elements.

Where elements are stacked horizontally on top of each other, the following should apply:

- support points should be directly above each other unless specifically documented otherwise
- the stacked height of elements should be limited to ensure that the ground bearers and lowest elements can support the loads from above and that the stack remains stable
- stack height should not be higher than twice the element width unless specifically documented otherwise and provisions are made to minimise the likelihood of accidental impact from vehicles or other elements

Points of contact between elements and supports should be covered with protective material to prevent breakage and staining.

Special consideration should be given to prestressed elements to ensure that they are only supported at designated bearing points. Prestressed elements *should never* be supported, even temporarily, at any other points. Equally, they *should never* be tipped sideways or stored directly on the ground.

Part 6: Handling and storage cont.

6.5 Storage systems

Storage systems for elements that are not inherently stable must be designed to resist the loads and forces applied to them. This includes wind loads, construction loads and impact loads generated during placement and removal of the element and, where appropriate, accidental impact from vehicles. The design of the storage system should be fully documented.

To minimise the effects of vehicle and other uncontrolled impact, the element support systems (racks and frames etc.) should be robust and be designed so that failure at one point does not result in progressive failure. Racking systems should be designed so that if one element falls it does not create a domino effect.

Racking systems for vertically stored wall panels should be designed and constructed as follows:

- at least two restraint points should be provided so that the panel is stable under the above loads. The top restraint should be above the mid-height or centre of gravity of the panel
- the restraint system should be designed to withstand the loads, as noted above, as well as loads generated when the panel is up to 5 degrees off vertical

- where necessary, provision should be made in the design of the restraint system for panels with corbels and nibs, and panels should be firmly held in the racking system

The racking system should be constructed in accordance with a design prepared by a qualified engineer suitably experienced in the field of precast concrete construction.

Frames, either single-sided, or double-sided A frames used to store wall panels, should be designed and constructed as follows:

- the frame and its supports should be designed to remain stable and withstand the forces as noted above
- panels should remain stable in the frame when the panels are not restrained. The slope of the panels should be such that the panel will not tip out of the frame
- the frame and its supports should be designed to accommodate uneven loading of panels. The limitations for uneven loading should be clearly shown on the frame

The frame and its supports should be constructed in accordance with a design prepared by a qualified engineer suitably experienced in the field of precast concrete construction.

6.6 Site storage

Generally the sequence of erection should be such that storage and multiple handling of elements on site are avoided.

When storage and multiple handling are unavoidable, the required work method should be clearly documented.

Storage of elements on site should be in accordance with the general requirements for handling and storage and the following:

- elements should only be stored in a position approved by the project design engineer
- ground conditions should be checked to ensure that the mass of the element can be supported
- where an element is to be stored on a suspended floor slab, approval and written instructions must be obtained from the project design engineer before proceeding
- wall panels may be stored in a suitable A frame or stood and braced in a vertical position. Bracing should be in accordance with the general requirements of this Industry Standard

- wall panels may only be stored horizontally (“on the flat”) in accordance with a written instruction from the erection design engineer or project design engineer

Wall panels should preferably be stored in the vertical position. Where edge-lifted panels are stored horizontally, they should be placed as originally cast to ensure that component reinforcement around edge-lifting inserts is correctly orientated for re-lifting.

6.7 Impact protection

For precast and tilt-up concrete elements stored in areas of vehicular movement, additional protection may be required to maintain a safe workplace. This could include the use of bollards or other physical barriers.

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

Part 7: Transport

7.1 General

Secure restraint of loads on vehicles is important in preventing accidents and injuries.

The transporter must ensure that any load is securely restrained. This means that the load:

- must not be placed in a way that makes the vehicle unsafe or unstable
- must be secured so that it is unlikely to fall or be dislodged from the vehicle and
- must be restrained by an appropriate method

Methods of restraint should comply with the VicRoads publications *Load Restraint Guide*, Section D: *A Guide to Restraining Concrete Panels*. These guides describe the performance standards that any restraints must meet and provide information on the principles of restraining, requirements for positioning, and how to secure loads.

The adequacy of a particular method of restraint will depend on the type of element being transported and the type of vehicle being used.

7.2 Basic principles

Before the shop drawings are prepared, element sizes and transportability should be reviewed to confirm that the proposed elements are able to be transported to the building site and be erected. The feasibility of transporting a crane of the required type and capacity to lift the elements also needs to be taken into account. The precaster must ensure that the concrete strength of the precast elements has reached the design strength for transport and erection.

The precaster must ensure that the elements are loaded in a sequence compatible with the required unloading sequence on site.

Precast components should not be transported within three days of casting unless concrete in the specific components is tested to confirm that design strength for erection has been attained. These test results must be available on site prior to erecting the element.

The transporter must ensure that the vehicle used is suitable to transport the elements and that they are properly secured. A vehicle *must never* be moved without the load being secured in the appropriate manner.

The transporter must ensure that drivers have been adequately instructed in the safe transportation of precast elements, with particular attention given to:

- power lines
- tram lines
- train lines
- OD routes (recognised truck routes for over dimensional loads)
- roundabouts and “reverse camber in the road”

The transporter is responsible for obtaining the permit for all over dimensional loads. Drivers must be able to produce the permit upon request.

Vehicles used to transport precast elements should be such that the centre of gravity of the load is as low as possible. Placement of the elements should evenly spread the load along the vehicle’s centre line.

Where precast elements are carried on a flat top trailer, a safety chain must be placed around the front edge of the elements to prevent forward movement. The rated safe capacity of a safety chain must be at least half the weight of the load it is safeguarding.

Restraint equipment and anchor points must be strong enough to hold the load. The equipment should be inspected before use to ensure that it is serviceable.

Elements should be loaded so that identification marks are visible during unloading.

Drivers should stop and check the load and the restraints shortly after commencing the journey to ensure that the load has not moved or settled.

7.3 Support frames

Frames used to support elements during transport should be designed to withstand loads and forces acting on the system during loading, transportation and unloading.

A frame system that is not an integral part of the trailer must be separately and individually secured. The fixing method must be capable of withstanding any forces applied during loading, transportation and unloading.

Particular care should be taken during loading and unloading elements from frames to ensure that the frames remain stable at all stages. Semi-trailers should be stabilised by lowering the support legs onto a firm base.

Part 7: Transport cont.

Where unloading cannot take place on a firm level surface, elements must be individually restrained and the loading configuration must be checked to ensure that removing individual elements does not result in instability of the load or the vehicle. Restraints *must not* be removed until the crane takes the initial weight of the element.

7.4 Element protection

Points of contact between 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 element.

Where 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 elements should be limited to ensure that the bearers and lowest elements can support the loads from above and that the stack remains stable during transportation.

Special attention should be given to prestressed elements to ensure that they are only supported at designated bearing points and that restraint systems do not impose excessive loads. Prestressed elements *should never* be supported, even temporarily, at any other points and they *should never* be tipped sideways.

7.5 Delivery

Delivery of the precast elements onto the site requires cooperation between the builder, the transporter and the erector.

The builder must provide a recognised traffic control management plan that includes, where necessary, flagmen, barricades and road closure permits to allow unimpeded access to the site.

The precaster must ensure that the transporter has detailed instruction on how to enter the site.

Part 7: Transport cont.

The transporter should inspect the site prior to entry to verify that there are no dangers such as backfilled excavations or overhead services. The area to receive the delivery vehicle should be firm and level.

The transporter must position the vehicle as directed by the erector and stabilise the vehicle prior to releasing the element restraints. Semi-trailers should be stabilised by lowering the support legs onto a firm base. The transporter should be aware of which elements are to be unloaded first.

If the unloading sequence can lead to instability of loads, the precast elements should be individually secured. Individual elements should not be released until the crane has taken the initial load of that element.

Under no circumstances should a vehicle be moved without the load being secured in the appropriate manner. The transporter is responsible to ensure that the load is secured in the appropriate manner at all times, even during the unloading operation.

Part 8: Erection

8.1 General

Safe erection of precast and tilt-up concrete elements depends on the pre-planning process. All personnel should be aware that erection of any precast element is potentially hazardous and that the purpose of the pre-planning process is to identify hazards and control any risk in the erection process. Although the risks may be small, the consequences of a failure can be death, serious injury or damage to the building or equipment.

8.2 Planning the construction and erection sequence

Prior to manufacturing the precast elements, the precaster and the erector in association with the project design engineer and the builder, should have planned the complete construction and erection sequences.

The planning process should take into account:

- site limitations
- local street access
- element sizes
- crane size, mobility and access
- casting sequence
- overhead obstructions, including overhead power lines

The planning process should ensure the on-site provision of:

- adequate and hygienic amenities for the erection crew in accordance with WorkCover's *Code of Practice for Building and Construction Workplaces* or the WorkCover Safety Guidance Note *Amenities for Housing Construction (Cottage Industry) Sites*, as appropriate
- adequate site access for the type of construction methods to be employed
- adequate access for the size of the crane to be used
- adequate access for semi trailers
- serviceable height access equipment appropriate to the construction methods

8.3 Planning crane requirements

Cranes and elevating work platforms should be selected and used in accordance with the appropriate parts of AS 2550.

Crane planning should commence as early as possible in development of the work or project. In the case of new buildings or structures, architects, designers and engineers should give consideration to crane loadings and access at the initial design stage, especially where methods such as tilt-up

construction are contemplated and where cranes may be supported on concrete slabs.

Planning the crane activities should be divided into various stages including initial design, builder or contractor site set out, and the stage immediately prior to the crane's use.

Wherever feasible, the planning should include consultation with the erector.

At appropriate stages, the planning process should deal with:

- crane selection, access and siting in accordance with AS 2550
- protection of the public
- the location of any excavations or underground services likely to be adversely effected by imposed crane loads
- proximity of overhead power lines
- written procedures for setting up and dismantling of the crane and the lifting method
- the make-up of the rigging crew appropriate to the particular circumstances of the job
- the communication system
- ground support conditions
- selection of lifting gear
- personal protective equipment for the rigging crew
- emergency procedures

8.4 Operating near overhead power lines

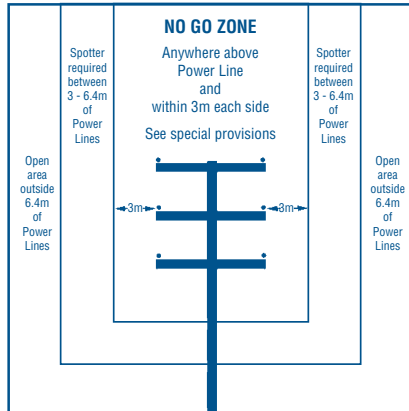
Contractors should plan ahead as far as possible. Electricity distribution authorities can isolate most overhead power lines when sufficient notice is given.

Where overhead power lines are isolated, the electricity distribution authority's access permit should be kept in the crane operator's possession during operations.

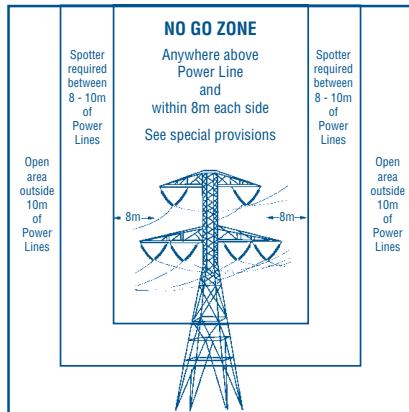
Where there is no access permit, the power lines must be treated as being live.

Fig 8.1: Clearance for cranes from overhead power lines

Overhead Power Lines on Poles



Overhead Power Lines on Towers



In instances where, as depicted in figure 8.1, it is necessary to operate the crane within 6.4 metres of power lines on poles or 10 metres of power lines on towers,

a dedicated qualified spotter must be used throughout these phases of the erection sequence.

In these circumstances, the erector should implement the following measures also:

- slow down the normal operating cycle of the crane to increase the available reaction time for assessing distances
- keep persons not authorised by the erector away from the area
- clearly instruct all ground staff to stand clear of the crane and load at all times
- install warning notices in a prominent position in crane cabin to alert operators to check for the presence of power lines. Typical wording should be **“DANGER - WATCH OUT FOR THE OVERHEAD POWER LINES”**
- dry taglines (tail ropes) made of natural fibre such as hemp, sisal or other non-conductive material should be used to control the load. Due to their conductive properties, synthetic ropes *must not* be used. The tagline should be prevented from approaching or being blown into contact with any power line
- mobile cranes should be provided with an earthing chain with links of at least 10 mm in diameter. The chain should be bolted or welded to the carrier chassis and be of sufficient length to allow at least one metre of chain to be in contact with the ground when the crane is set up

on outriggers. *It is important to note that the earthing chain should not be used when the crane is set up with carrier within six metres of the rails of an electric train system*

- when operating or travelling in an unfamiliar area, the crane operator should check for the presence of overhead power lines

In the event that the crane does contact live power lines, 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, rope 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, get someone to inform the electricity distribution authority at once. Take no action until the distribution authority has confirmed that the conditions are safe
- if it is essential to leave the cabin because of 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

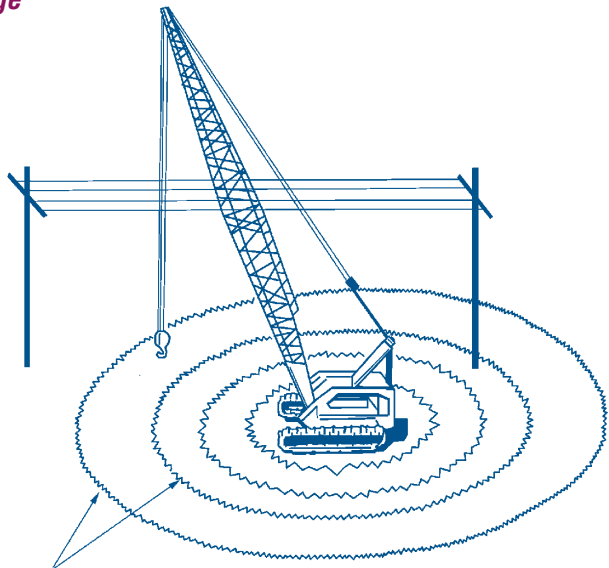
Part 8: Erection cont.

- when moving away from the crane, shuffle or hop slowly across 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 8.2)
- inform the electricity distribution authority of the situation immediately. Until assistance arrives, someone should remain near the crane, but at a safe distance, to warn others of the danger of approaching

Following any contact with live power lines, a competent person should inspect the crane for possible damage caused by the contact before further use. Wire rope should be replaced if it touches the power line as the arc will usually weld, melt or badly pit the rope.

Proximity warning devices, insulating boom guards and similar devices all have limitations and should not be relied upon to give protection against electric shock.

Fig 8.2: High voltage contact



High voltage contact will result in electrical current flowing down the boom and through the crane to the ground. The ground will then be energized with a high voltage near the crane and lower voltage further away.

8.5 Erection preparation

Before erection commences, the builder and erector should:

- confirm that the erector's risk assessment is appropriate and has dealt with all aspects of the erection procedure
- inspect crane access to the site and the erection platform and confirm that it is safe
- obtain verification that the erection platform can safely support the erection loads
- make sure the immediate area for truck and crane access has been cleared to provide adequate room for crane outriggers, counterweight tail swing, boom swing, and under-hook and overhead obstructions
- make sure that sufficient clear space is available for the safe propping or panel bracing of the precast or tilt-up elements
- make sure that the locating dowels and levelling shims are correctly located;
- make sure that adequate temporary base restraint is provided for any pre-cast element to prevent a sliding failure (kick-out) at the base or support of the element
- confirm that the means of support, including falsework, is adequate for the intended purpose and is correctly located
- verify that the element concrete has attained the specified strength for lifting
- verify that the brace footing concrete has attained the specified strength
- check that the strongbacks, if required, are available and are correctly installed
- determine if it is necessary to equalise loads on lifting points
- ensure that the appropriate rigging equipment is available and is serviceable
- check that the lifting inserts are in their correct location and that recesses are cleaned out in preparation for lifting

If incorrectly located, faulty or missing lifting inserts are identified, immediate contact should be made with the precaster to establish an appropriate solution.

8.6 Crane capacity and operating radius

The rated capacity or working load limit (WLL) of a crane refers to its maximum load capacity at the minimum radius. This should not be confused with its actual capacity at working radius when lifting.

Part 8: Erection cont.

The required crane capacity is determined by several factors including the distance from the centre of rotation of the crane to the centre of gravity of the precast element being lifted. The capacity of a crane decreases as the distance of the load increases from the centre of rotation of the crane.

Precast elements are usually lifted at extended radii and this will usually determine the required crane capacity, rather than the maximum element weight. Crane charts should be referred to for the correct selection of cranes.

For all face-lifted wall panels, the true working radius of the crane should include an allowance over the radius to the panel's final position to take account of the hang of the panel from the lifting inserts and any lifting beams etc. (see figure 5.1). An assessment of the true working radius should be made according to individual panel details. The necessary increase in radius may be 1.5 m or greater.

Where it is necessary to use two cranes to “dual lift” elements, the required crane capacities should be carefully assessed. *Under no circumstances* should the capacity of either crane be less than 70% of the mass of the element. For further advice on multiple crane lifting, refer to chapter 18 of WorkCover's *A Guide to Rigging*.

8.7 Erection crew

The erector must nominate one person in the erection crew to be directly responsible for the direction and coordination of the erection sequence. This person must hold a rigging certificate of competency in either the Intermediate Rigging Or Advanced Rigging certificate classes (class codes RI or RA).

The crane operator must hold, or be under the direct supervision of the holder of a certificate of competency appropriate for the type of crane and, in the case of a slewing mobile crane, the crane's capacity (WLL).

The size and make-up of the remainder of the erection crew will vary depending upon the nature of the site and the particular circumstances. As a general rule, it should also include at least one additional certificated rigger (holding at least the Basic Rigging – RB – certificate class) and additional appropriately skilled persons as required.

At least one of the erection crew, preferably the rigger in charge of the crew, should have been trained in this Industry Standard.

At least one of the erection crew or another person who remains on site throughout erection should hold a current qualification as a Level 2 First Aider.

8.8 Erection platform

Before erection commences, the builder should supply the erector with written verification that the erection platform (floor slab, suspended slab, surrounding ground etc.) can safely carry the construction and erection loads.

Backfilled excavations and trenches 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 construction and erection loads.

If a suspended slab is used to support the crane, the slab should be designed for the crane point loads. A suitable propping system may be required and, if so, should be designed in accordance with the requirements of the appropriate Australian Standards.

8.9 Rigging

Setting up a rigging system requires careful and thorough pre-planning. The selection of the rigging system connecting the precast or tilt-up element to the crane should be agreed between the precaster and erector. The selected configuration must be specified in the shop drawings and *must not* be altered without the approval of the precaster or the erection design engineer.

Reusable lifting devices (lifting clutches) must be designed and manufactured so that the failure load is five times their WLL (i.e. with a design factor of 5.0).

The rigging system should distribute equal loads to all lifting points unless specifically designated otherwise on the shop drawings.

Where offset lifting arrangements are used, the increase in load applied to particular lifting inserts must be taken into account in selecting the capacity of the lifting insert.

Sling lengths are critical where the rigging system includes the use of spreader beams or lifting beams with slings running through sheaves. The rigging system should be designed to suit the spacing and layout of the lifting inserts.

Single, double and four-leg slings are commonly used in the handling of precast 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.

When lifting precast elements with fixed length multi-legged slings, any two legs of the slings must be capable of supporting the total load.

Part 8: Erection cont.

The rigging system should be arranged to allow the precast element to lie in or near its correct attitude for erection into the structure. This can be accomplished through one or more of the following means:

- appropriate location of the lifting inserts
- use of a lifting beam with offset lifting points
- correct location of the slinging point or points in the element
- use of a counterweight

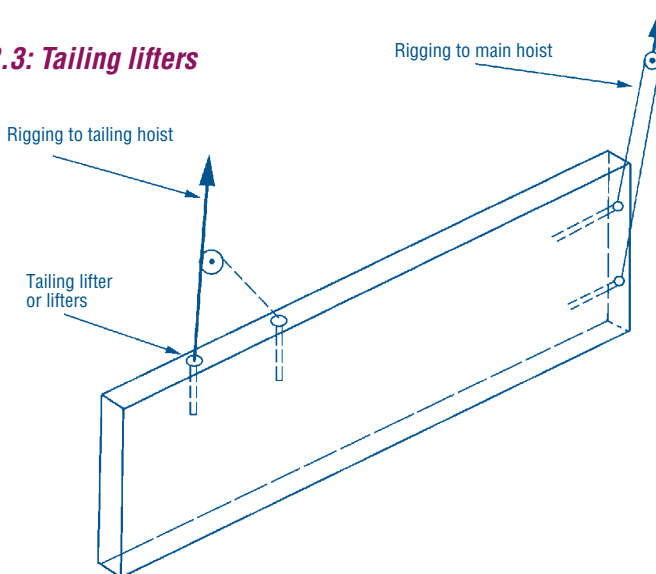
Where possible, three rows of inserts should be avoided due to the complex rigging configurations required. Preferred configurations are shown in figure 4.1.

Where precast elements need to be rotated by use of a tailing lifter (lifting insert at the bottom of the element), the required capacity of the crane winch being used to rotate the element must be determined.

Up to 70% of the mass of the element can be taken by the tail lifter during rotation. This is particularly critical for edge-lifted wall panels (see figure 8.3).

General rigging practices not dealt with specifically in this Industry Standard should be consistent with the advice provided in WorkCover's *A Guide to Rigging*.

Fig 8.3: Tailing lifters



8.10 Strongbacks

Panels that are odd-shaped, elongated, or with large or awkwardly located openings are often strengthened for lifting by the addition of strongbacks.

Strongbacks must be located and fixed in accordance with the details shown on the shop drawings.

The mass of the strongbacks is to be included when assessing the load on the crane.

Any changes to the specified strongback system *must not* be made without the approval of the shop detailer.

8.11 Erection sequence

Precast and tilt-up elements should be erected in accordance with the pre-planned sequence referred to in part 4.

Elements *must not* be lifted or erected before attaining the minimum concrete strength on the shop drawings for lifting or erection.

Elements *must not* be erected on site within three (3) days of casting unless the concrete in the specific elements has been tested to confirm that the design strength for erection has been attained. Test results must be available on site prior to erecting the element.

The builder must provide the erector with verification that the concrete in brace footings has attained its required strength before elements are erected.

The lifting and placing method must ensure that a sudden failure of the element or rigging will not endanger the crane operator or the crane.

8.12 Erection of tilt-up panels

For panels cast on site, the adhesion of the panel to the casting bed has to be broken.

For face-lifted panels, lifting must be stopped if the panel does not come free when the crane's load indicator registers the combined mass of the panel, rigging and any attachments such as strongbacks.

For edge-lifted panels, lifting must be stopped if the panel does not come free when the crane's load indicator registers 60% of the weight of the panel plus 100% of the weight of the rigging and any attachments such as strongbacks.

In these circumstances, procedures such as wedging or jacking should be as determined by the shop detailer. Such procedures should be undertaken or directly supervised by the rigger in charge of the erection.

Part 8: Erection cont.

Whenever possible, braces should be fixed to the panel before it is lifted.

The following rules apply during the lifting and placing of panels:

- whenever possible, panels should be lifted with the rigging equipment in view of the crane operator
- all personnel must be outside the drop zone when lifting, tilting or rotating the panel from horizontal to vertical
- when taglines (tail ropes) are used to control the swing of the panel, personnel must position themselves clear of the panel edges as the panel may slew sideways
- *under no circumstances* should any worker position themselves underneath a precast element or on the underside of a tilt-up panel during erection
- no attempt should be made to lift and erect panels in strong winds where control of the panel may be lost (it is the responsibility of the rigger in charge, in consultation with the erection crew, to determine that conditions are suitable for erection to proceed)
- where it is necessary to attach braces to the panel after it has been positioned, the panel must be held firmly and safely by the crane while the braces are attached
- a minimum of two braces should be connected before releasing the lifting equipment, unless otherwise specified on the shop drawings (two braces may not be necessary where wall panels are provided with erection brackets or permanent connections to other restrained elements such as steel portal columns or precast walls forming a stable “box” structure)
- *under no circumstances* should there be less than two connections providing support to each precast element unless specifically designed and detailed and approved by the project design engineer
- no brace should be connected to another panel for support unless clearly specified on the shop drawings

8.13 Erection of other precast elements

The mass of all elements should be calculated prior to the commencement of erection. This information should be shown on the shop drawings and made available to the erection crew.

The shop detailer should determine the configuration of the required rigging and lifting equipment in consultation with the erector.

The lifting equipment should be attached to the precast elements by a competent person and the immediate area should be cleared in preparation for lifting.

Taglines (tail ropes) may be required in some circumstances.

Under no circumstances should personnel pass or stand beneath a suspended element.

The effect of wind upon the safe handling and erection of elements must be taken into account.

8.14 Levelling shims

Levelling shims carry the load of the pre-cast or tilt-up concrete element that must be supported adequately to prevent movement until it is incorporated in the main structure.

Levelling shims must be manufactured to comply with the relevant requirements of AS 3850.

Levelling shims must be used on solid foundations that are designed to carry the imposed loads.

Shimming should be limited to a maximum height of 40 mm and a minimum width of 100 mm unless specifically designed otherwise. Where the total shim height is greater than 40 mm, steps should be taken to ensure stability.

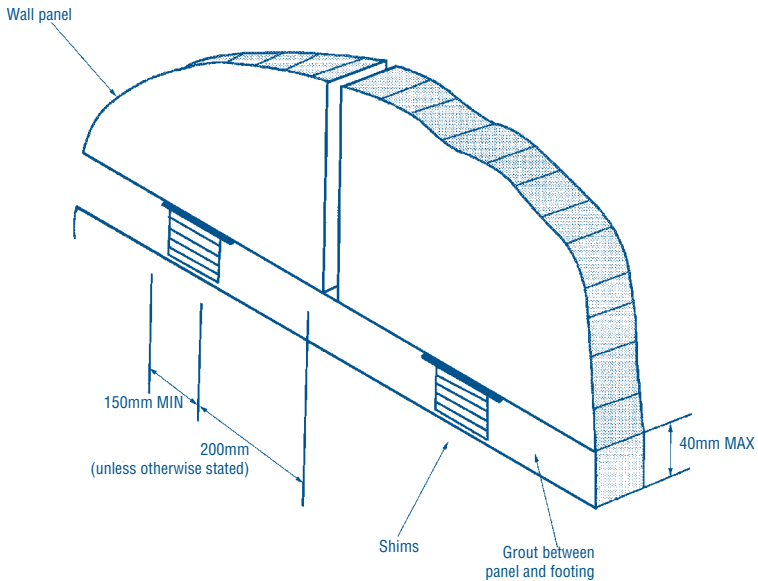
Part 8: Erection cont.

Where practical, shims should be located at least 200 mm in from the ends of the element, unless otherwise specified. This is particularly relevant for thin wall panels where edge breakout can occur if shims are placed too close to bottom corners (see figure 8.4).

Direct concrete-to-concrete, or concrete-to-steel bearing should be avoided unless some edge spalling and cracking is acceptable to the builder.

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

Fig 8.4: Levelling shims



8.15 Fixing inserts

Where permanent fixings or connections are to be utilised for temporary use during construction, the builder or the erector should verify that the fixings are suitable for the temporary use and that such use will not compromise their long-term performance.

8.16 Missing or unusable lifting inserts

If incorrectly located, faulty or missing lifting inserts are identified, immediate contact should be made with the shop detailer to establish an appropriate solution.

Solutions could include:

- fixing a plate with undercut anchors
- fixing a plate with chemical anchors. Anchors must be individually proof tested
- drilling through the element and attaching lifting plate(s) by bolting

All of the above solutions must have a WLL based on a design factor of at least 2.5 against failure.

Expansion inserts should not be used as lifting points.

8.17 Temporary bracing

Braces are temporary components providing stability in preventing a tilt-up or precast concrete element from overturning.

All elements should be braced in accordance with the requirements of the shop drawings. The shop drawings should specify the required bracing forces and show details of the fixings to the element and the bracing footing.

Brace footings are to be in accordance with the requirements of the shop drawings and, in particular, the specified concrete strength of the footing at the time of erection. The location of bracing inserts within the brace footing must also be as specified in the shop drawings.

Braces must be maintained and inspected between each use to ensure that all components are correct and in good working order.

Brace feet or shoes must be of a type that will physically prevent lateral displacement of the shoe from the insert connections after installation.

Part 8: Erection cont.

Braces must be marked as set out in section 4.11.

Brace adjustment mechanisms must have stops on the threads to prevent over-extension and retaining devices to prevent unintentional dislodgment of the shear pins. The shear pins should be constructed so that they cannot be undone without the use of a tool.

Whenever possible, the braces should be fixed to the precast or tilt-up concrete element before lifting.

Bracing insert capacities are sensitive to:

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

Unless specified otherwise in the shop drawings, bracing inserts *must not* be closer than 300 mm to the edge of the element, footing or other bracing support.

During the lifting process, the braces should not hang below the base level of the element. This may be achieved by the use of adjustable brace lengths or by the use of taglines (tail ropes).

For face-lifted wall panels, bracing inserts should be on the same face of the panel as the lifting inserts.

When, under unusual circumstances, it is necessary to attach the braces after a wall panel has been positioned, the wall panel should be held firmly, safely and just past vertical by the crane while the braces are installed.

Until it is secured, no one should ever work on a panel that is leaning towards them.

Generally, a minimum of two braces should be used for all tilt-up and precast elements.

Two braces may not be necessary where elements are provided with erection brackets or permanent connections to other restrained elements such as steel portal columns or precast walls forming a stable “box” structure.

If expansion anchors are to be used as bracing inserts in the floor or brace footings, the type and their capacity should be assessed in accordance with part 4 and should be clearly specified on the shop drawings.

After erection, it is the builder's responsibility to check braces, bracing bolts and pins at regular intervals to ensure that they maintain the required capacity.

Prior to the removal of braces, it is the responsibility of the erection design engineer or the project design engineer to inspect the structure to ensure that all structural elements affecting stability are securely fixed to the precast or tilt-up concrete elements. A written instruction authorising the removal of the braces should then be supplied.

It is the responsibility of the builder to ensure that no brace is removed without written instructions from the erection design engineer or project design engineer.

It is the responsibility of the brace owner to inspect and service the braces at regular intervals and to keep service records.

8.18 Temporary propping

Props are temporary components supporting loads which produce compression forces.

Propping systems should allow for possible changes to the distribution of loads during the construction process.

Where beams are post-tensioned after erection, the stressing process will change the shape of the member, thereby reducing the load on some props and increasing the load on others. This particularly applies where the stressing induces a camber into the beam which can lift the beam off props at mid-span, transferring all the load to the props at the ends.

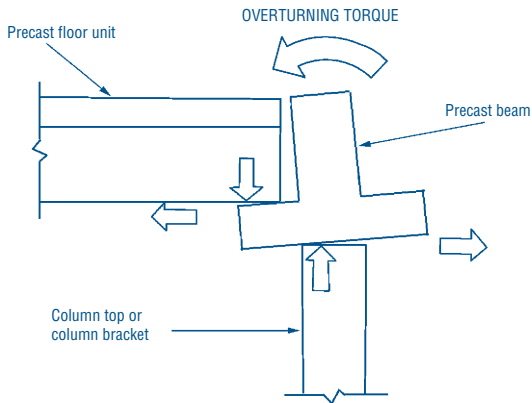
Where the seating for precast beams can not transfer loads during construction, the beams must be propped at each end to carry the full load.

Part 8: Erection cont.

Where beams are to have floor systems placed on them prior to the beams being fully built into the structure, allowance should be made for uneven loading on the

beam during construction. With floor units placed only on one side of a beam, additional temporary propping may be required to each edge of the beam (see figure 8.5).

Fig 8.5: Uneven erection loading



Part 8: Erection cont.

Where required, all temporary propping should be in place and fully braced prior to commencement of erection of any precast elements.

Unless specifically detailed otherwise, temporary propping should provide full support to all construction loads including the full self-weight of the completed floor system and possible local concentrations of load during construction. Construction loads may include reinforcing steel or excess concrete.

Subject to the precaster's work method statement, it may be satisfactory to erect temporary props after the precast floor units are in place, and for the props to take only a portion of the full construction load.

Props should be vertical. They should also be braced to prevent side-sway of the whole assembly and the buckling of individual props.

Props should be adequately seated, levelled and capable of transferring the full load through whatever structure they are bearing on and into the ground without adverse settlement.

The shop drawings should clearly specify the required propping forces and show details of the fixing to the precast element and the prop footing.

Prop footings are to be in accordance with the requirements of the shop drawings and, in particular, the specified concrete strength of the footing at the time of erection.

Prior to the removal of props, it is the responsibility of the erection design engineer or project design engineer to inspect the structure to ensure that all structural elements affecting stability are securely fixed to the precast or tilt-up concrete elements. A written instruction should be supplied prior to the removal of props.

It is the responsibility of the builder to ensure that no prop is removed without written instructions from the erection design engineer or project design engineer.

Part 8: Erection cont.

8.19 Modifications

Modifications to precast elements should only be carried out with the approval of the project design engineer.

8.20 Compliance requirements

Prior to lifting any tilt-up or precast element, the erector must be provided with:

- the project design engineer's certificate of compliance
- the manufacturer's certificate of compliance
- the component schedule

The component schedule must be provided by the precaster and must include the following information:

- project name and address
- element designation
- element mass
- concrete strength required at the time of erection for the element and, where applicable, the bracing footing
- type, capacity and length of the lifting inserts
- a diagram of the rigging system(s) between crane and precast element for both rotation and erection

The information required for the component schedule may be included as part of the shop drawings or layout drawings. The shop drawings may be used to form the component schedule.

Part 9:

Proprietary elements

9.1 Application

This part relates to precast elements that are manufactured by a mechanical process in a factory environment. Such proprietary elements are frequently based on specific design processes that are only available to the precaster and where the component is usually supplied on a design and manufacture basis.

Examples of proprietary elements include:

- hollowcore floor slabs
- transfloor slabs and beams
- ultrafloor beams and infills

Proprietary elements are deemed-to-satisfy the overall requirements of this Industry Standard if they comply with the following clauses and with the intent of the remaining parts of this Industry Standard.

9.2 General design provisions

Where the precaster is responsible for the design of the elements, the precaster must ensure that the design complies with all the requirements specified by the project design engineer.

The design must be in accordance with the relevant Australian Standards or, where not specifically covered by Australian Standards, the relevant sections of US or European standards.

Design computations must be prepared by a suitably experienced engineer and certified by a registered building practitioner in accordance with the requirements of the *Building Act 1993*.

Design computations or suitable certification for the proprietary elements must be submitted to the project design engineer for review and for verification of compliance with the overall design requirements.

9.3 Design for erection

The design for erection should comply with the requirements of part 4, including the section on special provisions.

Shop drawings must be prepared and issued to the builder for approval and review by the building designer and project design engineer.

9.4 Manufacture

Elements must be manufactured in accordance with a work method statement provided by the precaster. The work method statement should comply with the general requirements of this Industry Standard and specifically address the issues relating to the manufacturing process of the elements in question.

Part 9: Proprietary elements cont.

The manufacturing process is the responsibility of the precaster who must ensure that it is conducted in compliance with the *Occupational Health and Safety Act 1985*, relevant OHS regulations and any other relevant statutory requirements.

Documentation associated with the manufacturing process must be available for inspection and auditing.

9.5 Storage

Elements must be stored in accordance with a work method statement provided by the precaster. The work method statement should comply with the general requirements of this Industry Standard and specifically address the issues relating to the storage of the elements in question, including any special requirements specified by the project design engineer.

Storage is the responsibility of the precaster who must ensure that it is conducted in compliance with the *Occupational Health and Safety Act 1985*, relevant OHS Regulations and any other relevant statutory requirements.

Documentation associated with the storage process must be available for inspection and auditing.

9.6 Transport

Elements must be transported in accordance with a work method statement provided by the precaster. The work method statement should comply with the general requirements of this Industry Standard and specifically address the issues relating to the transport of the elements in question including any special requirements specified by the project design engineer.

The method of transportation is the responsibility of the precaster, who must ensure that it is conducted in compliance with the *Occupational Health and Safety Act 1985*, relevant OHS regulations, road transport legislation and any other relevant statutory requirements.

Documentation associated with the transportation process must be available for inspection and auditing.

9.7 Erection

By definition, proprietary elements will have a specific lifting and erection procedure.

Proprietary elements must be erected in accordance with a work method statement provided by the precaster. The work method statement should comply with the general requirements of this Industry Standard and in particular the section dealing with special provisions in part 4. It should also address the issues specifically relating to the erection of the elements in question.

Consideration should be given to the specific requirements for bracing, propping and fixing of elements during erection.

Issues such as site safety and handling of the elements must be clearly described and dealt with.

The work method statement must be approved by the builder and be reviewed by the project design engineer.

Once approved, the precaster or erector *must not* modify the work method statement without resubmitting it for approval.

Appendix A: Referenced documents and further reading

Acts referenced

- *Building Act 1993*
- *Occupational Health and Safety Act 1985*

WorkCover publications referenced

- *A Guide to Rigging*
- *Code of Practice for Building and Construction Workplaces*
- *Code of Practice for First Aid in the Workplace*
- *Guidance Note for Amenities on Housing Construction (Cottage Industry) Sites*
- *Guidance Note for Use of Anchors as Bracing Inserts in Precast Concrete Panels*
- *WorkCover Incident Notification*

Australian Standards referenced

- AS 1170.2, *Minimum Design Loads on Structures, part 2: Wind Loads*
- AS 1311, *Steel Tendons for Prestressed Concrete – 7-wire Stress-relieved Steel Strand Tendons in Prestressed Concrete*
- AS 1379, *Specification and Supply of Concrete*
- AS 2550, *Cranes – Safe Use*
- AS 3600, *Concrete Structures*
- AS 3610, *Formwork for Concrete*
- AS 3850, *Tilt-up Concrete Construction**

Note: *This Standard has undergone review and revision. It is expected to be published in its revised format during 2001.

Appendix A: Referenced documents and further reading cont.

Other documents referenced

- *Building Code of Australia*, published by the Australian Building Codes Board
- *Load Restraint Guide*, Section D: *A Guide to Restraining Concrete Panels*, published by VicRoads
- *Planning and Design Handbook on Precast Building Structures*, published by the Federation International Beton, FIP/FIB
- *Z10: Recommended Practice, Design of Tilt-up Concrete Wall Panels*, published by the Concrete Institute of Australia

Further reading

Precast concrete and tilt-up concrete elements should be designed and constructed in accordance with the *Building Code of Australia* and relevant Australian Standards and codes of practice.

Overseas codes and design references may be used for guidance where Australian Standards and Codes of Practice do not cover a particular aspect.

Additional and more detailed information can be obtained from other organisations and some of these documents are listed below:

American Concrete Institute

- *Tilt-up Concrete Structures*, ACI 551R-92
- *Tilt-up Construction*, SCM-20 (89)

Canadian Prestressed Concrete Institute

- *Design Manual, Precast and Prestressed Concrete*

Cement & Concrete Association of Australia

- *Tilt-up Construction Notes*

Concrete Institute of Australia

- *Z4: Recommended Practice, Design and Detailing of Precast Concrete*

Elliott, Kim S.

- *Multi-Storey Precast Concrete Framed Structures*, Blackwell Science, 1996

National Precast Concrete Association Australia

- *National Precaster* (Newsletter)

New Zealand Concrete Society

- *Guidelines for the use of Structural Precast Concrete in Buildings*

Appendix A: Referenced documents and further reading cont.

Precast Concrete Institute, USA

- *Erection Safety for Precast and Prestressed Concrete*
- *PCI Design Handbook*

Portland Cement Association, USA

- *Connections for Tilt-up Wall Construction*

In addition to the above organisations and publications, the manufacturers of the hardware associated with the precast and tilt-up concrete industries all publish design and technical information on their products. Reference should be made to the particular supplier's technical information before specifying or using any of their products.

Appendix B: Definitions of terms used in this Industry Standard

B1: General definitions

builder

The company or person responsible for the construction of the completed building and who has control of the building site. The builder may also be the client or a company or person responsible to the client.

building designer

The project architect or project designer responsible for the design of the building. The building designer will usually be responsible to the client.

client

The owner of the building or the company or person responsible for developing the building.

erector

The company or person responsible for erecting the precast or tilt-up concrete elements. The erector may be responsible either to the builder, precaster, or client.

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, be a registered building

practitioner 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.

precaster

The company or person responsible for manufacturing the precast or tilt-up concrete elements. The precaster will usually be sub-contracting to, and be responsible to, the builder. The precaster may sometimes be referred to as the precast concrete manufacturer or tilt-up manufacturer.

precast concrete element

A concrete element manufactured under controlled conditions in a factory or casting yard and subsequently transported to and erected on a building site.

project design 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, be a registered building practitioner and be competent to practice in the structural engineering field. The project design engineer will usually be responsible to the client.

Appendix B: Definitions of terms used in this Industry Standard cont.

shop detailer

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.

tilt-up panel

A flat concrete panel, frequently cast in a horizontal position, lifted by rotation about one edge until in a vertical or near vertical position, which may then be lifted into position where it may be temporarily braced until incorporated into the permanent structure. It may be cast on site or off site. The term does not cover other precast concrete elements such as columns, beams, flooring panels and non-rotated facade panels.

transporter

The company or person responsible for transporting the precast concrete element. The transporter may also be the precaster or a company or person responsible either to the builder, precaster or erector.

B2: Technical definitions

braces

Temporary components providing stability in preventing a tilt-up or precast concrete element overturning. Both ends are fitted with a pinned foot, allowing a degree of freedom for variable fixing angles. They are intended to resist horizontal construction and wind loads.

bracing insert

A component or system cast into or fixed to the element or into an element supporting member for later attachment of a temporary brace.

connections

A method by which one or more elements are joined together. The purpose of connections is to transfer load and/or provide stability.

design factor

The number by which the failure load is divided to give the working load limit (WLL). This was previously referred to as the safety factor.

Appendix B: Definitions of terms used in this Industry Standard cont.

edge-lifting

A method of lifting whereby lifting inserts are cast within the element edge so that the element is lifted and hangs vertically from that edge.

erection platform

The base on which the crane is supported during erection of the elements.

face-lifting

A method of lifting whereby lifting inserts are cast within the face of an element so that when the element is lifted it hangs at an angle to the vertical.

fixing insert

A component or system cast into or fixed to the element and used to tie the element into the structure or support other structural members.

fixings

The hardware component of connections. Fixings provide for load transfer between the members being connected.

joints

The gap between adjoining elements or between an element and some other portion of the structure. Joints may be horizontal, vertical or inclined.

levelling shims

A single or series of thin strips of appropriate material used under elements to support the element in its correct position until the final connection is made.

lifting beam

A device within the rigging system that transfers the load from the element to the crane hook by acting in bending.

lifting clutch

A quick-release device used to connect the crane rigging to the lifting insert.

lifting insert

A component or system cast into or fixed to the element for lifting the element during erection.

lifting spreader

A device that spreads the lifting ropes and is in compression.

proprietary components

Components manufactured in a factory environment and carrying a trademark or registered name.

proprietary elements

Precast concrete elements that are manufactured by a mechanical process in a factory environment.

Appendix B: Definitions of terms used in this Industry Standard cont.

props

Temporary components supporting loads, which produce compression forces. Both ends of the prop are fitted with rigid foot plates that provide support between two parallel surfaces.

reinforcement

structural reinforcement

Reinforcement, including reinforcing steel and prestressing tendons provided for crack control or to resist forces caused by applied loads and thermal and shrinkage movements.

additional reinforcement

Reinforcement additional to the structural reinforcement provided to resist forces caused by transport or erection loads.

component reinforcement

Reinforcement placed in conjunction with lifting, bracing and fixing inserts so that they can attain their design capacities. Note that component reinforcement is normally specified by the insert supplier and may not always be shown on the shop drawings.

rigging system

A mechanism that may include a series of slings, sheaves, lifting or spreader beams, or other mechanical devices to connect the crane to the element being lifted.

reusable lifting equipment

The lifting device that is directly connected to the lifting insert e.g. a lifting clutch or bolt-on bracket.

shear cone failure

The type of failure achieved when tension is applied to an insert embedded in concrete. When failure occurs a 'cone' of concrete as well as the insert is pulled from the main body of the element.

shop drawing

A detailed drawing of an element used in the manufacturing process.

strongback

A temporary member fixed to an element to provide localised strengthening of the element during lifting, transport or erection.

tagline or tail rope

A fibre rope attached to the element being erected to help control the element during lifting and placement.

WLL (working load limit)

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

Appendix C: Erection design engineer's certificate of compliance

Site name _____

Site address _____

Company employing the erection design engineer _____

This is to certify that the erection 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
- The Victorian Industry Standard *Precast and Tilt-up Concrete for Buildings*

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), a registered building practitioner and be competent to practise in the design of precast concrete.

Appendix D: Manufacturer's certificate of compliance

Precast and tilt-up concrete elements

Project _____

Site address _____

Precaster/manufacturer _____

Builder _____

Project design engineer _____

Schedule of elements

Identification number	Casting date	Identification number	Casting date

This is to certify that the abovelisted precast or tilt-up concrete elements have been manufactured in accordance with the approved shop drawings.

Name _____

Signature _____

Date _____

