

# Foreword

The *Occupational Safety and Health Act 1984* established the Commission for Occupational Safety and Health which comprises representatives of employers, unions, government and experts. The Commission has the function of developing the legislation and supporting guidance material and making recommendations to the Minister for implementation. To fulfil its functions the Commission is empowered to establish advisory committees, hold public enquiries and publish and disseminate information.

The Commission's objective is to promote comprehensive and practical preventative strategies that improve the working environment of Western Australians.

This code of practice has been developed through this tripartite consultative process and the views of employers and unions along with those of government have been considered.

The following information should be read as background for understanding this code of practice.

## The Act

The *Occupational Safety and Health Act 1984* provides for the promotion, co-ordination, administration and enforcement of occupational safety and health in Western Australia.

With the objective of preventing occupational injuries and diseases, the Act places certain duties on employers, employees, self-employed persons, manufacturers, designers, importers and suppliers.

In addition to the broad duties established by the Act, it is supported by a further tier of statute, the regulations, together with lower tiers of non-statutory codes of practice and guidance notes.

## Regulations

Regulations have the effect of spelling out the specific requirements of the legislation.

Regulations may prescribe minimum standards. They may have a general application or they may define specific requirements related to a particular hazard or a particular type of work.

Regulations may also be for the licensing or granting of approvals, certificates, etc.

## Codes of practice

A code of practice is defined in the Act as a document prepared for the purpose of providing practical guidance on acceptable ways of achieving compliance with statutory duties and regulatory requirements.

Codes of practice:

- should be followed, unless there is another solution which achieves the same or better result; and
- can be used to support prosecution for non-compliance.

## Guidance notes

A guidance note is an explanatory document issued by the Commission providing detailed information on the requirements of legislation, regulations, standards or matters relating to occupational safety and health.

## Definitions

Appendix A defines the terms used in this code of practice.

## AUTHORITY

This code of practice was approved by the Minister for Consumer and Employment Protection pursuant to Section 57 of the *Occupational Safety and Health Act 1984* on 10 November 2004.

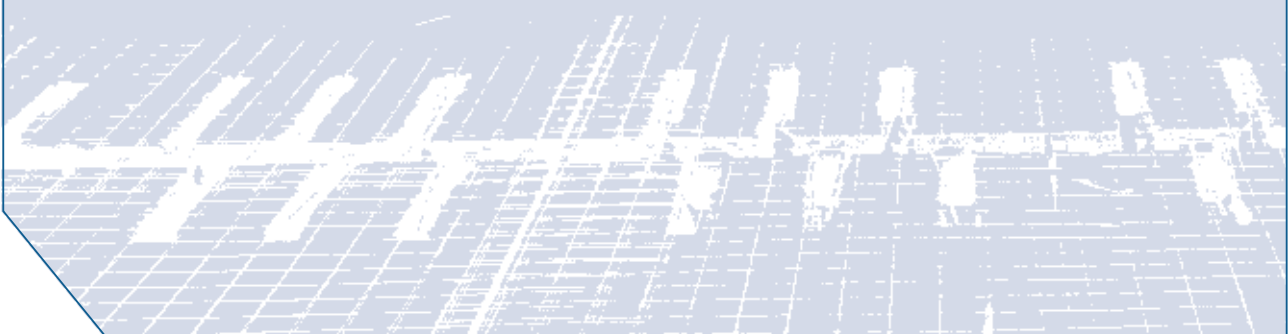
## SCOPE

This code of practice applies to all workplaces in Western Australia covered by the *Occupational Safety and Health Act 1984* where concrete wall panels, whether precast on or off-site, or other precast concrete elements are used in the building and construction industry.

It covers the areas of tilt-up and precast concrete construction where safety is a concern including casting of panels and other precast elements, handling, storage, transportation, lifting by crane, rigging systems and bracing and securing of panels.

## WHO SHOULD USE THIS CODE OF PRACTICE?

This code should be used by designers, employers, contractors, self-employed persons, managers, supervisors, persons in control of workplaces, employees and safety and health representatives to assist them to comply with the *Occupational Safety and Health Act 1984* and regulations where the tilt-up method of construction and precast concrete elements are used on building and construction sites.



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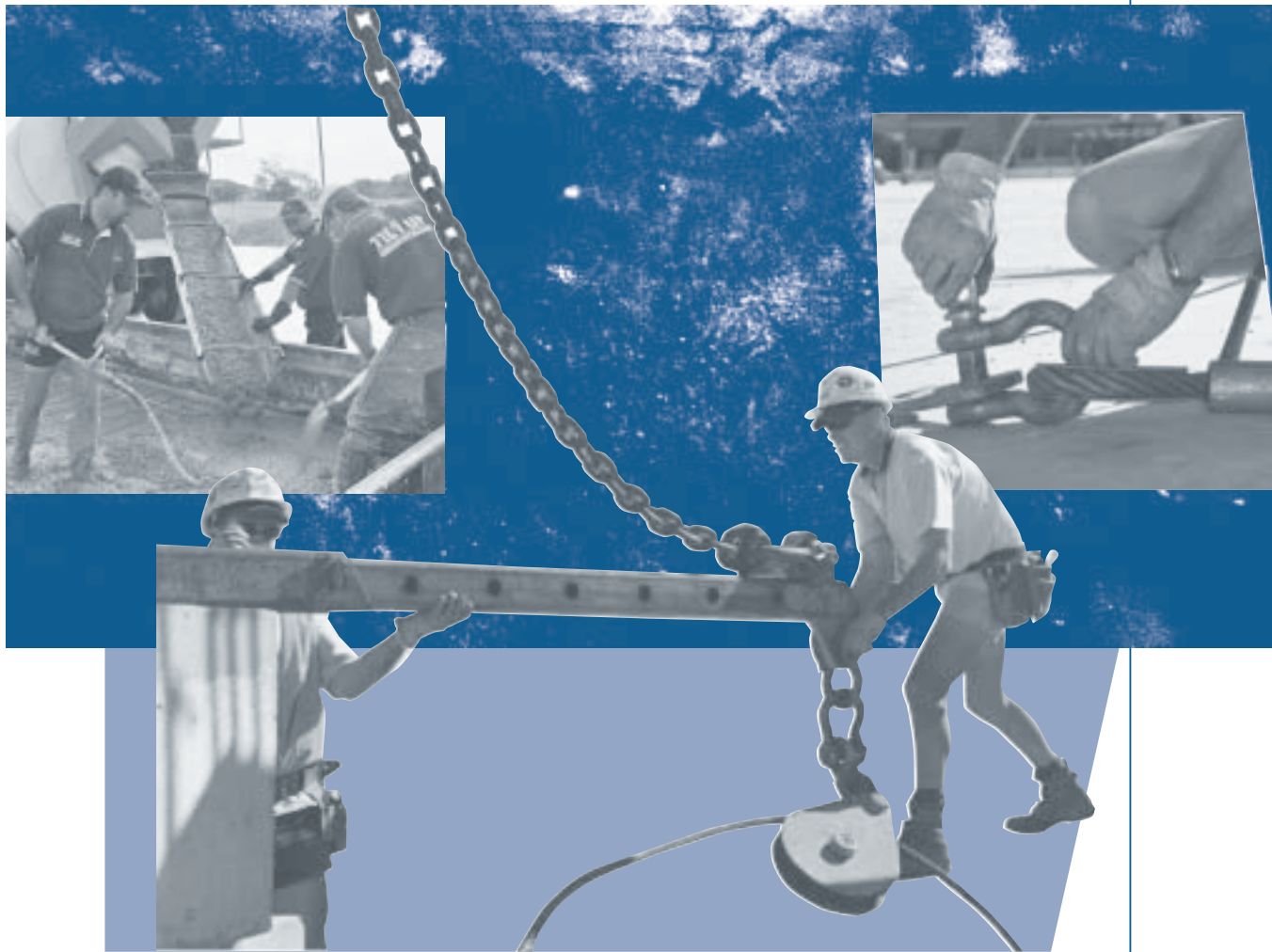
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# Introduction



Tilt-up and precast concrete construction is a method of prefabricating concrete in discrete elements and erecting and incorporating them by crane into their final position in a structure.

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

The tilt-up and precast concrete industry, from design to completion of construction, should be aware of its obligations to protect employees, contractors and members of the public under the *Occupational Safety and Health Act 1984*, regulations and codes of practice.

This code provides practical advice about the safe design, manufacture, transport, crantage, storage, erection and stabilisation of concrete wall panels and other precast concrete elements. The emphasis is on ensuring a safe working environment whenever these elements are used.

Advice can also be found in Australian Standards and other documents referenced in this code.

This code 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.

# 1

## Part General

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# General

## 1.1 Purpose

The purpose of this code is to provide practical guidance on the design and construction of structures using concrete wall panels and other precast concrete elements; to ensure, as far as is practicable, a safe working environment for those in the industry.

## 1.2 Scope

The code covers the safe design, manufacture, transport, craning, storage, erection and stabilisation of:

- concrete wall panels, whether precast on or off-site, and their use in the building and construction industry; and
- other precast concrete elements and their use in the building and construction industry.

The Definitions of terms used in this code are contained in Appendix A.

## 1.3 Regulations

Regulations 3.88 to 3.88J apply to the manufacture of concrete wall panels, including retaining walls, whether precast on site or off-site, and to tilt-up work as defined.

The regulations do not apply to other precast concrete elements.

However, this code of practice offers practical guidance on complying with the requirements of the regulations as well as practical guidance on the safe use of other precast concrete elements.

### 1.3.1 Notification to WorkSafe Western Australia Commissioner

The Commissioner must be notified of the intention to manufacture concrete panels as defined.

No casting of concrete panels or tilt-up work as defined (other than work relating to the manufacture of the concrete panel prior to casting) may be carried out without this notification.

For concrete panels cast on-site it is the builder's responsibility to ensure notification requirements are met. For concrete panels cast off-site this responsibility rests with the employer or self employed person who is also required to provide a copy of the notice to the builder.

The notification is made by completing a form available from WorkSafe and provided to the Commissioner at least 10 working days before casting of the concrete panels is intended to begin.

The notification must provide the Commissioner with the following information:

- the construction site or other workplace where the casting is to take place; and
- the construction site where the concrete panel is to be installed.

### 1.3.2 Documents on site

Regulation 3.88G requires the following documents be kept at the site at all times when tilt-up work is being carried out:

- a copy of the notification to the Commissioner referred to in section 1.3.1 above;
- a copy of any exemption from the requirements of the regulations granted by the Commissioner under Regulation 2.12, in relation to the work;
- a copy of the shop drawings (see section 5.2.2);
- a current plan setting out details of the proposed execution of the work together with a copy of any related instructions or diagrams received from an engineer by the builder (see section 1.3.3); and
- a copy of the inspection report of the formwork set-up referred to in AS 3850 section 4.10 (see section 6.7) for each concrete panel.

Regulation 3.88A

Regulation 3.88F

Regulation 3.88G

Regulation 3.88B

A copy of AS 3850 and this code of practice should also be available at the site.

See section 6.7 regarding the manufacturer's statement and the need for it to be available on site at the time of lifting the concrete elements.

A copy of the relevant local government building licence should be kept at the site.

### 1.3.3 Workplan

Regulation 3.88G requires that an up to date plan that sets out details of the proposed execution of the work be at the workplace whenever tilt-up work is carried out.

A copy of the workplan should be lodged with the relevant local government authority for filing with the relevant building licence. The Department of Local Government and Regional Development intend to make this lodgement a requirement of the Building Regulations 1989. Information contained in the workplan will greatly assist the safety of any future demolition work.

The workplan should contain the following information:

- proposed sequence of work and proposed work method statement (see sections 8.2 and 8.3 of this code). Prior to manufacturing the concrete elements, the complete construction and erection sequences should have been planned;
- methods of stabilisation (temporary and permanent) of the structure. The method of stabilising the structure while concrete panels are being erected needs to guard against collapse of a panel and progressive collapse of the structure. The method needs to ensure adequate structural strength and continuity of the structure and its parts while being

erected, or in its finished form, to safely transmit applied loads through the structure (see section 4.4 of this code). Of critical importance is the stability of the structure while roof members are being erected. See AS 3828, Guidelines for the erection of building steelwork;

- traffic management plan (see section 7.4.6 of this code);
- job safety analysis and risk assessment (see section 2.4 of this code); and
- signed copies of any changes made to specifications and/or signed instructions, advice or diagrams made or issued by an engineer.

Information and guidance on these requirements may also be found in AS 3850.

## 1.4 Relationship to Australian Standards

Regulations 3.88 to 3.88J require, amongst other things, that the design, manufacture, transport, craning, storage, erection and stabilisation of concrete panels be carried out in accordance with the relevant parts of AS 3850.

This requirement underpins most of the information contained in this code.

This code is intended to complement AS 3850 and other key Australian Standards AS 3600, AS 3610 and AS 3828 dealing with tilt-up and precast concrete structures.

Other relevant Australian Standards are referenced in this code.

## 1.5 Referenced documents and further reading

Appendix C provides a list of documents where further information may be obtained.

# 2

## Part Training, supervision and hazard management

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# Training, supervision and hazard management

## 2.1 General

A principal objective of Western Australia's *Occupational Safety and Health Act 1984* is to promote safe working environments 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 co-operate in ensuring that workplaces and work practices are safe and without risks to health.

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

*“such information, instruction, and training to, and supervision of, his employees as is necessary to enable them to perform their work in such a manner that they are not exposed to hazards.”*

Employers owe this same duty of care to independent contractors and the contractor's employees working at the workplace. The Commission for Occupational Safety and Health *Guidance Note General Duty of Care in Western Australian Workplaces* provides detailed information on the duty of care.

In fulfilling this obligation, there should be a structured system of education and training to enable both employers and employees to:

- identify and manage the risks involved in the manufacture, transport, craning, storage, erection and stabilisation of concrete panels and precast concrete elements; and
- keep abreast of the current state of knowledge within the industry on the means of eliminating hazards and controlling risks to safety and health.

## 2.2 Training and supervision

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

The builder must ensure that the manufacture of concrete panels and other tilt-up work is directly supervised by a person who has completed an approved training course for managers and supervisors in the construction industry regarding the manufacture of concrete panels or other tilt-up work as appropriate.

Approved training course means a training course approved by the WorkSafe Western Australia Commissioner.

Direct supervision means overseeing the work while it is being carried out having regard to ensuring by way of direction, demonstration, monitoring and checking that the work is being performed in a safe manner in accordance with agreed procedures (the work plan) and ensuring a capacity to respond immediately in an emergency.

The builder must also ensure that all personnel involved in the manufacture of concrete panels or other tilt-up work have completed an approved training course concerning the aspect of the work in which the person is involved.

Training programs should include:

- induction on this code and AS 3850;
- first aid training to the minimum requirements of the Commission for Occupational Safety and Health *Code of Practice for First Aid Facilities and Services*;
- identification of hazards associated with the use of plant and equipment; and
- the selection, fitting, care, use and storage of protective clothing and equipment.

Regulation 3.88I and 3.88J

Regulation 3.88I and 3.88J

The Act, section 19 (1)(b)

All personnel directly undertaking casting, transport, craning, storage, erection and stabilisation of panels will be undertaking tilt-up work. Other personnel working on a site while casting of panels through to permanent stabilisation is being carried out may also be undertaking tilt-up work as defined.

A risk assessment should be carried out to determine which of these other personnel, and any visitors to the site, require training, and the extent of this training.

## 2.3 Safety and health

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 methods used to control the risk.

In particular, they need to take all practicable steps to:

- provide and maintain a safe working environment;
- provide and maintain facilities for the safety and health of employees;
- ensure that machinery and equipment is designed, manufactured, 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; and
- consult and co-operate with safety and health representatives, if any, and other employees at the workplace regarding safety and health at that workplace.

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

- 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; and
- emergency procedures.

Employers should inform employees of the results of any safety and health monitoring carried out in the workplace.

Employers, so far as practicable, are also responsible for the safety and health of people who are not employees. Employers need to take all practicable steps to ensure that the work of the employer or employees does 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 should take reasonable care to ensure that their actions do not harm or place others at risk. One of their obligations is to co-operate with their employer on safety and health matters and not to interfere with or misuse anything provided by their employer to protect safety and health.

## 2.4 Hazard management

Employers need to 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 result in injury or harm to health.

In the tilt-up and precast concrete industry, risk is always present when handling, transporting and erecting concrete elements. Although failure of material, components or equipment is rare the consequences are always significant.

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

A job safety analysis that lists the hazards and suggests safety procedures should 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; and

The Act, section 21

The Act, section 20

- 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 or construction method, or by use of alternative equipment.

Where the hazard cannot be eliminated, control measures should 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 hazards and then assess and 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 should be followed as part of the hazard management process.



# 3

## Part

### Materials, components and equipment

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# Materials, components and equipment

## 3.1 General - compatibility of components

All materials, components and equipment should comply with the relevant Australian Standards, in particular the requirements of AS 3850.

All components used on site within a particular system should be compatible and different proprietary components should not be mixed without verification of compatibility. Verification of compatibility should be obtained from suppliers and the designer of any other equipment to be used.

Incompatibility of different types of inserts or sizes may lead to failure. This is particularly relevant to lifting inserts, bolts, ferrules and lifting clutches.

## 3.2 Concrete and reinforcement specifications

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

Testing of concrete and verification of concrete strength should be determined in accordance with the requirements of the appropriate parts of AS 3600 and AS 1012.

## 3.3 Curing compounds and release agents

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

Consideration should be given to the following factors:

- solubility - the product should not be able to be washed off by rain;
- temperature effects – exposure to extreme temperatures should not 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 by the curing compound and release agents; and
- discolouration - if it is a pigmented product, the pigmentation should weather off within a reasonable time.

If any curing compound or release agent or proprietary combination product is a hazardous substance in accordance with regulation 5.3, a Material Safety Data Sheet (MSDS) must be supplied by the manufacturer and made available to all workers who may be exposed to the substance. The builder must consult with all workers who might be exposed to the substance about the intention to use the substance and the safest method of use. Workers likely to be exposed must receive training on health risks, control measures and correct use in accordance with regulation 5.21. They must also be informed about the need for, and details of, health surveillance.

Part 5 of the Occupational Safety and Health Regulations 1996 provides further information on the responsibilities of persons who manufacture or supply hazardous substances and those who are responsible for their use at workplaces.

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

Regulation 5.3

Regulation 5.21



### 3.4 Lifting, bracing and fixing inserts

#### 3.4.1 General

Lifting, bracing and fixing inserts should comply with the requirements of AS 3850.

All lifting, bracing and fixing inserts should be manufactured from ductile materials and site welding of reinforcement to inserts (other than weld plates) should not be carried out.

Product documentation for proprietary inserts should be provided by the supplier, available on site and include full technical specifications, make, type and working load limit (WLL).

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

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

#### 3.4.2 Lifting inserts

Lifting inserts within a concrete panel should be specified as cast-in products. Where cast-in inserts are found to be unusable after casting, approval should be obtained from the erection design engineer to use an alternative type prior to installation.

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

Prestressing strand is not suitable as lifting inserts and should not be used. The strand may bend and weaken at the point of exit from the concrete.

Steel reinforcement bar is also not suitable as lifting loops and should not be used. Certain high tensile strength steel bar has properties that make it suitable only to resist tensile forces and

should not be used in any part of an insert anchorage.

#### 3.4.3 Bracing inserts

Bracing inserts within a concrete panel should be cast-in products where possible. Where cast-in inserts are found to be unusable after casting, approval should be obtained from the erection design engineer to use an alternative type prior to installation.

Bracing inserts should be designed, manufactured and installed to provide a WLL with a limit state factor of at least 2.5 against concrete failure. In determining this, the applied load needs to include all expected loads including construction loads and wind loads.

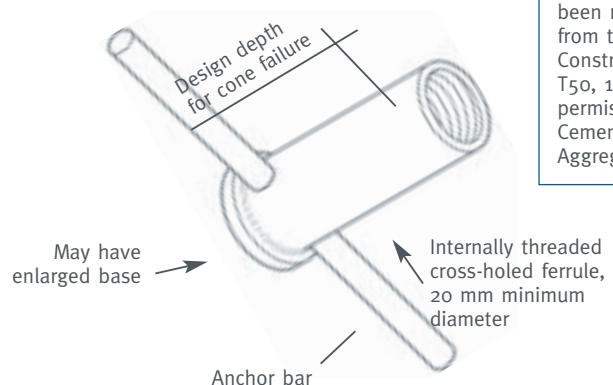
Where cast-in bracing inserts are not used in brace footings, an acceptable alternative is the use of drilled through fixings, undercut anchors or load controlled expansion anchors.

#### 3.4.4 Fixing inserts

Fixing inserts for the panel connection to roof framing and other structural members should be designed in accordance with the appropriate Australian Standard and the Building Code of Australia (BCA) to resist the forces imposed on the connections.

Cast-in fixings such as threaded inserts, weld plates or brackets should be used where possible. They need to be fully anchored to transfer load into the concrete.

Anchorage and load transfer for threaded inserts is achieved by a crossbar fitted through a cross-hole (see Figure 3.1).



This illustration has been reproduced from the Tilt-up Construction Notes T50, 1997 with permission of Cement Concrete & Aggregates Australia

Figure 3.1: Threaded insert

Where possible, fixings should be standardised for all panels on an individual project to minimise the chance of error.

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

### 3.4.5 Anchors

Expansion anchors are either load controlled or deformation controlled as defined in Appendix A. Only load controlled (see Figure 3.2) are permitted in tilt-up and precast concrete construction. Where these anchors are used, the WLL should be limited to 0.65 of the first slip load determined in accordance with AS 3850.

Anchors used should be tested in accordance with Appendix A3.2 of AS 3850.

Deformation controlled expansion anchors, including self drilling, drop in and spring coil anchors should not be used because they may fail without warning, are highly sensitive to installation procedures and have no additional load capacity after the initial setting process.

Expansion anchors should be manufactured from ductile material.

Chemical anchors relying on chemical adhesion should not be used because they may fail without warning and are highly sensitive to installation procedures.

Expansion anchors are more susceptible to installation errors than drilled-through fixings. A calibrated torque wrench should be used to ensure correct installation torque is achieved when installing expansion anchors, and special attention needs to be given to the correct drilling of the holes.

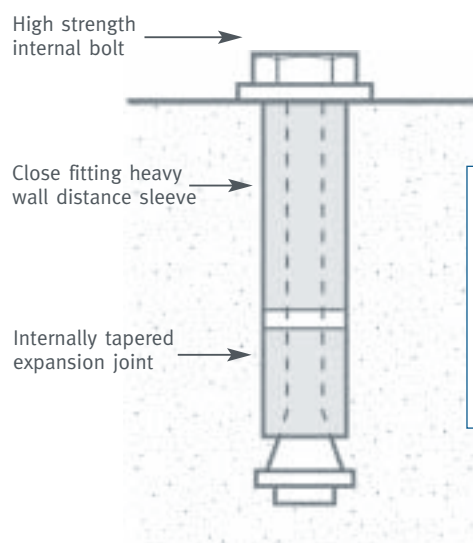
There needs to be an adequate checking system to ensure expansion anchors are installed correctly.

With brace footings, the capacity of anchors may be less than the capacity of

the brace itself requiring additional braces to support the panel. The use of inserts with higher capacities may avoid this. As mentioned in section 9.1 of this code there is difficulty in ensuring an even load distribution where more than two braces are used.

### Figure 3.2: Load controlled expansion anchors

Example of load controlled (torque controlled) heavy duty safety anchors



This illustration has been reproduced from the "Precast Concrete Handbook" with permission from the National Precast Concrete Association Australia.

## 3.5 Re-usable lifting equipment

### 3.5.1 Strongbacks

Concrete panels that are odd shaped, elongated or with large or awkwardly positioned openings may require the addition of steel strongbacks to enable them to be successfully lifted and placed.

Strongbacks may be used to strengthen the panels or to locate additional lifting points to prevent out-of-plane rotation of odd-shaped panels.

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

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

### 3.5.2 Lifting clutches

Lifting clutches should be designed with a limit state factor of 5. Lifting clutches should be proof tested to a load of 2 times the WLL, certified and individually identified by permanent marking or attachment of a durable tag prior to use.

A proof test using a load equal to 1.2 times the WLL should be conducted and recorded at least at 12 monthly periods.

## 3.6 Braces and props

The safe erection of concrete panels and precast concrete elements relies, to a large extent, on the integrity of the braces and props used and their correct installation.

Bracing and propping systems should be designed to resist all expected loads, including:

- construction loads; and
- wind loads for temporary structures in accordance with AS/NZS 1170.2.

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

- the supplier or manufacturer; and
- the model type or designation.

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

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

The WLL for braces at maximum and minimum extension should 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 National Association of Testing Authorities

(NATA) laboratory or equivalent. Braces should be designed with a limit state factor of at least 2 against failure.

Brace adjustment mechanisms should have stops on the threads to prevent over-extension and retaining devices to prevent unintentional dislodgment of the shear pin. The shear pin should be purpose made, simple to install and be constructed so that it cannot be undone without the use of appropriate equipment or the application of deliberate force.

The WLL for props should be supplied by the manufacturer.

Brace and prop requirements and details for each type of concrete panel or precast concrete element should be clearly specified on the shop drawings. Where applicable, this includes requirements and details for knee bracing and any other secondary bracing required.

**Braces should never be used as props and props should never be used as braces.**

## 3.7 Levelling pads and shims

Levelling pads and shims should comply with the relevant requirements of AS 3850.

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

## 3.8 Crane and rigging equipment

Crane charts should be used to determine the required crane capacity. The correct selection of cranes, however, requires that the configuration of the crane (its location in relation to the lift) needs to be considered as well as the actual load that is to be lifted. The actual load should include the weight of the lifting gear, crane block and rope and any strongbacks.

Cranes should be selected and operated in accordance with the appropriate parts of AS 2550.

All rigging equipment should comply with the relevant Australian Standards and have a WLL adequate for its intended application. It should be in a serviceable condition.

The selection of the rigging gear used during lifting and erection of concrete elements should ensure the rigging is not subjected to forces for which it has not been designed.

Snatch blocks and other sheave blocks need to be equipped with thrust races or separate swivel bearings if rotation of sheave block swivels under load is unavoidable. Blocks with standard plain bearings are not intended to be rotated under load.

### 3.9 Proprietary documentation

Proprietary documentation should set out the information required for the correct use of the component or system. It should include the following information, where applicable:

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

- criteria for rejection and reworking of the component or system;
- detailed information including, where appropriate, the following:
  - part number;
  - dimensions;
  - section properties;
  - self-weight;
  - details of any special attachments, eg coupling sleeves; and
  - locations for attachment points and bracing points;
- the strength and serviceability limit state capacities;
- the WLL; and
- a statement that the component or system depicted in the documentation complies with AS 3850.

Proprietary documentation should be readily available on site, if required. Full documentation need not be held on site but should be obtainable within a reasonably short period.

# 4

## Part Design

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# Design

## 4.1 General

In tilt-up and precast concrete construction there are two separate phases of design.

The first, the in-service or 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 in-service design provides for the performance of the concrete panel or precast concrete element as part of the complete structure. The project design engineer needs to be experienced in the field of precast construction.

The second, the design for erection, is for the handling, transportation, erection and bracing of the individual concrete elements during the erection process. It may be carried out independently of the structural design by the erection design engineer. During the braced condition the structure may be regarded as a temporary structure and particular care is required to minimise the risk of progressive collapse.

The structural design should take into account the particular requirements of precast concrete structures to ensure that the elements can be safely erected without any component failure occurring.

Important obligations under the *Occupational Safety and Health Act 1984* are placed on those who design or construct any building or structure, including a temporary structure, to have regard for persons who are to erect or use the structure. Section 23 (3a) of the Act states that:

*“A person who designs or constructs any building or structure, including a temporary structure, for use at a workplace shall, so far as is practicable ensure that the design and construction of the building or structure is such that –*

- (a) persons who properly construct, maintain, repair or service the building or structure; and*
- (b) persons who properly use the building or structure,*

*are not, in doing so, exposed to hazards.”*

The structural design should also give consideration to the safety of any future demolition of the building or structure.

## 4.2 Preplanning

Preplanning and close co-ordination between the relevant parties is essential to ensure safety in the use of concrete panels and precast concrete elements.

It is not possible to obtain the full benefit and economies inherent in their use without preplanning and co-ordination between the relevant parties.

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 needs to be given to details such as site limitations, local street access, delivery sequence, transport requirements, crane requirements and overhead obstructions. These aspects can have a significant effect on the size of concrete elements and on the erection process.

The floor slab should be designed to cater for all construction loads likely to occur, such as from cranes and concrete trucks.

## 4.3 Design loads

### 4.3.1 General

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

Consideration should be given to the following:

- handling loads;
- storage and transport loads where applicable;
- erection loads;

The Act,  
section 23(3a)



- construction loads including any backfill and surcharge loads;
- permanent, imposed and other loads in accordance with AS/NZS 1170.1;
- wind load in accordance with AS/NZS 1170.2 on the braced elements; and
- seismic load in accordance with AS/NZS 1170.4.

The increase in design loads due to wind load and seismic load is not cumulative.

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 also be considered.

#### 4.3.2 Suction loads

Suction loads are reduced by use of an appropriate release agent (see section 3.3 of this code) and will vary according to the finish of the concrete 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 50% increase should be applied to the dead load; and
- 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.

#### 4.3.3 Impact loads

Impact loads generated during handling and transport can be significant and need to be considered in the design of the lifting inserts and rigging systems. 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

concrete panel from the casting bed. The increase in design loads due to suction and impact is not cumulative.

#### 4.3.4 Wind loads

Wind loading on concrete panels will vary depending on the size of the panels, wind speed and wind direction. In built-up areas the wind effect may be less than in open areas although "funnelling" effects can increase wind loading in built up areas.

In cyclone prone areas of the State the potential wind loading applied to panels will be greater. Sudden and severe wind gusts frequently occur throughout the State particularly in coastal areas.

Generally wind loading varies directly to the square of the wind speed and small increases in wind speed will result in much higher loadings. This may result in the need for more braces to be provided or a larger brace footing.

#### 4.3.5 Erection loads

Concrete panels and precast concrete elements need to be designed for the loads and conditions likely to be experienced during the manufacturing, lifting, transportation, erection, braced and in-service phases in accordance with AS 3850 and AS 3600.

Erection load design should consider variations to the load-distribution on the concrete elements during lifting, rotation and impact during placement.

### 4.4 Building stability

It is the responsibility of the builder to ensure the stability of the structure during the erection phase.

The stability of the building for the in-service condition is the responsibility of the project design engineer.

The stability of the whole building should be checked for each stage during erection and under in-service load conditions. Special care needs to be taken in design and construction to guard against progressive collapse both during construction and in the completed structure.

Tilt-up concrete structures are susceptible to progressive collapse type failures. The failure of a single member such as a roof bracing member due to an event such as fire, accident or other cause, should not lead to the complete collapse of the structure. Consideration also needs to be given to the situation during construction when the dislodgement of a single concrete panel could lead to progressive collapse.

Progressive collapse may be prevented by providing either:

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

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

The workplan referred to in section 1.3.3 of this code includes documented methods of stabilisation, both temporary and permanent, of the structure. In considering methods of stabilisation, the requirements of AS 3828 should be taken into account.

## 4.5 Structural design

### 4.5.1 General

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 code.

See section 8.14 of this code regarding approvals necessary for modifications to any concrete elements, including the design.

Slenderness and stability are major considerations in the design of concrete elements. Precast concrete construction may lack the continuity inherent in cast in-situ concrete structures. The building designer and project design engineer need to address these issues for the in-service condition while the builder and

erection design engineer should consider them during the erection phase of the structure.

Structural members supporting concrete elements should be designed to allow for the situation where the concrete element bears on only two discrete shimming points during erection. The erection sequence of concrete panels can produce more adverse loading conditions in a supporting member than the final in-service loads.

### 4.5.2 Fire

The Building Code of Australia (BCA) sets out the requirements for the design of buildings against fire. It specifies the fire resistance level (FRL) for various building elements. The FRL depends on the type of construction, determined for the occupancy class of building and height in stories, and proximity to the fire source. The FRL gives the fire resistance periods (FRP) for structural adequacy, integrity and insulation. AS 3600 provides methods for determining the FRP of concrete members. Concrete panels should comply with these requirements. AS 4100 provides periods of structural adequacy for the steel elements of the building.

Joints between the panels should also satisfy the appropriate FRP and not adversely affect the behaviour of the wall.

In addition to setting out the requirements for the design of buildings against fire, the BCA also sets out requirements for the performance of buildings subject to fire. These requirements are set out in Part C 1.11, Performance of external walls in a fire. To comply, the concrete panel design will require connection details such that the panels during and after a fire will either remain standing or tend to collapse inwards.

Detailed information on the design of lightly loaded wall panels is available in *Recommended Practice, Design of Tilt-up Concrete Wall Panels* referenced in Appendix C.



### 4.5.3 Design tolerances

Because concrete elements cannot be manufactured to exact dimensions, provision needs to be made in the design for dimensional variation in accordance with the appropriate Australian Standard.

For concrete panels the standard is AS 3850. For other precast concrete elements the standard is AS 3600.

Figure 4.1 shows recommended tolerances on as-cast concrete panels and insert location.

## 4.6 Specification of concrete

The concrete specification should be clearly shown on the shop drawings and include any special requirements, eg slump, maximum size aggregate, cement content, water-cement ratio and colour.

The specification of the strength of concrete needs to take into account the flexural strength required to develop insert strength at lifting as well as the requirements for in-service loading, durability and ease of construction.

PANELS

Tolerance (mm)							
Panel Height (m)	Linear			Angular	Profile		
	Width	Height	Thickness	Squareness (Note 1)	Twist (Note 2)	Warp (Note 3)	Straightness of edges and flatness of surfaces
<3	+0,-6	±3	±3	±4	±3	±3	± Length/1000
≥3<6	+0,-6	±6	±3	±5	±3	±3	± Length/1000
≥6<10	+0,-6	±6	±3	±6	±3	±3	± Length/1000
≥10	+0,-6	±6	±3	±8	±3	±3	± Length/1000

Figure 4.1: Recommended tolerances

#### NOTES:

- 1 Expressed in terms of the distance by which a shorter side of the concrete panel deviates from a straight line perpendicular to the longer side and passing through the corner of the unit.
- 2 Per metre width in 3m length.
- 3 Per metre width.

INSERT LOCATION	
Type of insert	Tolerance (mm)
Face lifting	±20
Bracing	±50
Strongback	±5
Edge-lifting	
longitudinal	±20
thickness	±5
Fixing	±5

Where required tolerances are less than the recommended values, the specific requirements should be clearly stated on the shop drawings.

The concrete strength required at lifting should be in accordance with the erection design engineer's specifications. Some guidance on the early-age strength of normal-class concrete is given in AS 1379. To obtain adequate concrete strength for early lifting it may be necessary to specify 28-day concrete strengths of 32 MPa or higher, which should develop a strength of 25 MPa at 7 days, the minimum concrete strength for most proprietary brand lifting inserts to achieve the required limit state factor of 2.5 during lifting. Higher strength concrete may be used to enable concrete panels to be lifted earlier than 7 days.

Verification of concrete strength should be carried out by testing in accordance with AS 3600 and AS 1012.

## 4.7 Design for manufacture and erection

### 4.7.1 Design and manufacture

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

- whether concrete elements are to be cast on-site or off-site;
- size, capacity and configuration of crane(s) available to undertake lifting and erection;
- location and proximity of overhead power supplies;
- access to and around the site;
- bracing and propping requirements; and
- transport restrictions.

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

### 4.7.2 Additional reinforcement

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

Additional reinforcement or strongbacks should be provided where the maximum flexural tensile stress in a concrete panel exceeds the limits recommended in AS 3850.

For concrete panels additional reinforcement may be required:

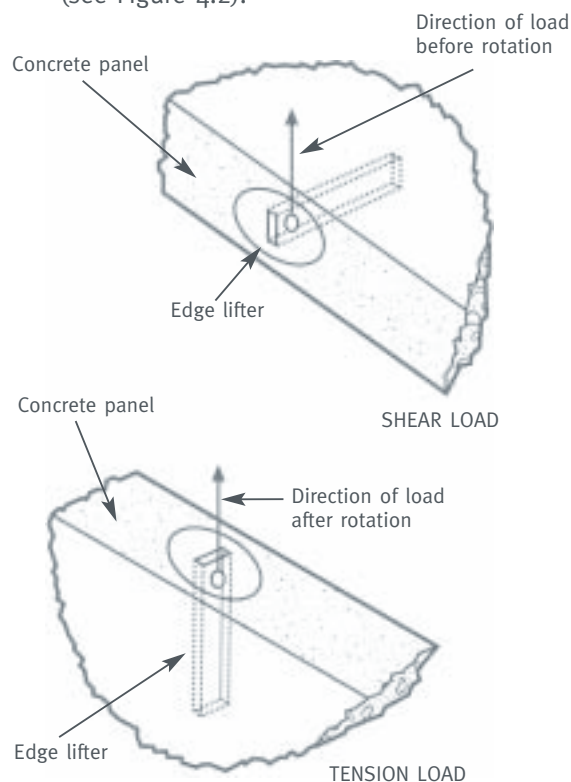
- near the base of the panel to resist stresses arising from thermal and shrinkage movements whilst the panel is supported only on the levelling shims;
- at edges and around openings in the panel to resist thermal and shrinkage stresses and to prevent cracking due to panel mishandling; and
- where there is a possibility of load reversal due to mishandling during transport or erection.

### 4.7.3 Design for erection

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

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

- the concrete strength of the concrete element at the time of lifting;
- embedment depth of the insert; and
- direction of load, shear or tension (see Figure 4.2).



**Figure 4.2: Shear loads and tension loads in edge-lifted concrete panels**

When selecting a lifting insert, ensure that the nominated capacity from the manufacturer's catalogue is for the directions 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; and
- the proximity of reinforcement or prestressing tendons.

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

Lifting inserts should be configured in accordance with the manufacturer's recommendations, including component reinforcement requirements.

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

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

Multiples of three rows or columns of lifting points where equal loading is required should be avoided because of the complex rigging configurations required. For example, lifting arrangements comprising 3, 6, 9 or 12 lifting points should be avoided.

Preferred lifting insert configurations for concrete panels are shown in Figure 4.3.

Although loads in the slings attached to each insert in Figure 4.3 are equal, the loads on the inserts may not be equal for face-lifted concrete panels because of the varying inclination of the slings to the panel which also varies during rotation of the panel.

In general, the rigging system should be designed to distribute equal loads to all lifting points. In some circumstances the design may require unequal loading on lifting points causing an increased load to be applied to particular lifting inserts. This needs to be taken into account in selecting the capacity of these inserts.

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

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

Lifting inserts may be positioned in the face or edges of a concrete panel. The actual locations of the lifting inserts is determined according to the:

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

When it is intended that concrete 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  $10^\circ$  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.

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

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

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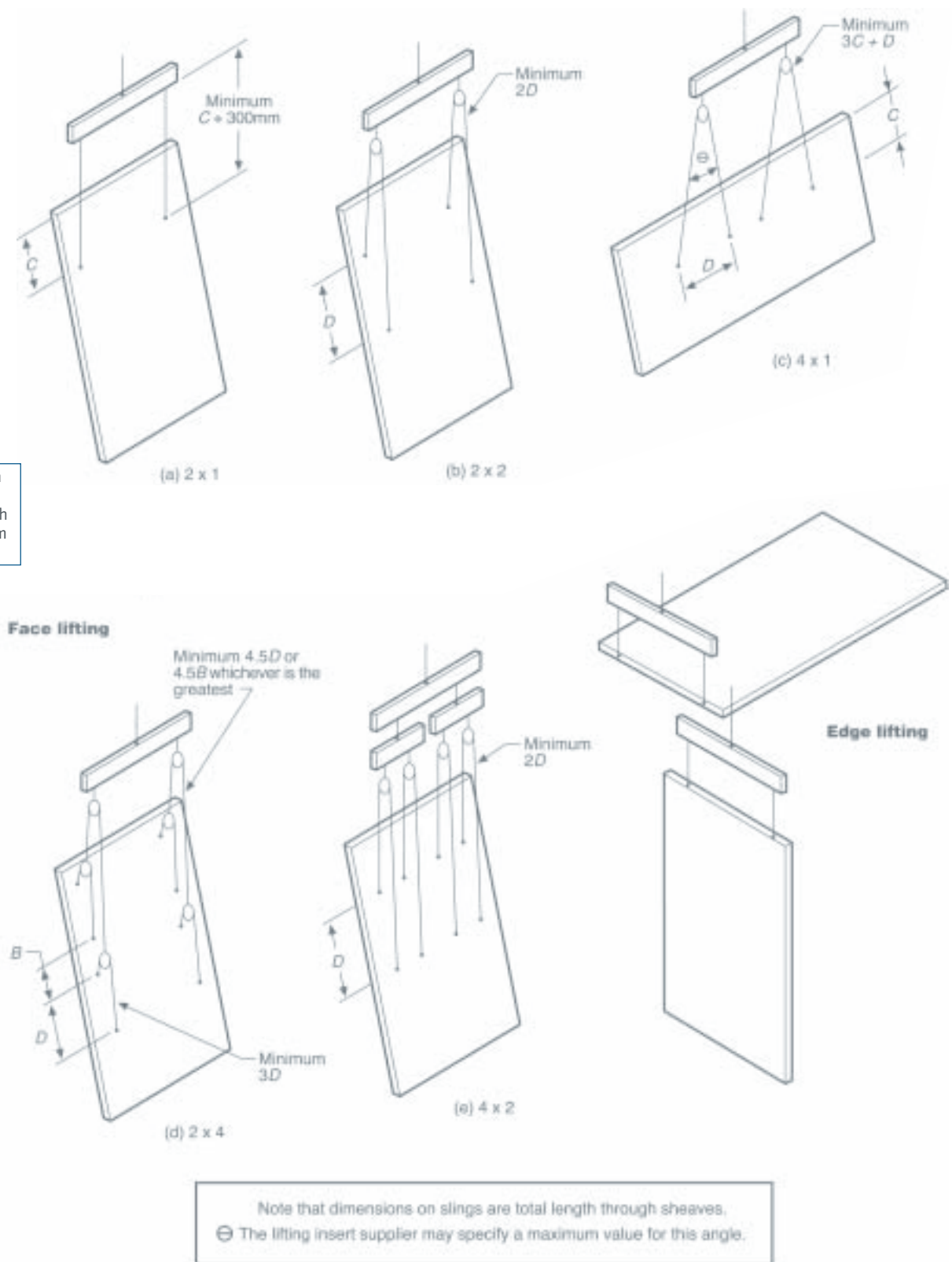
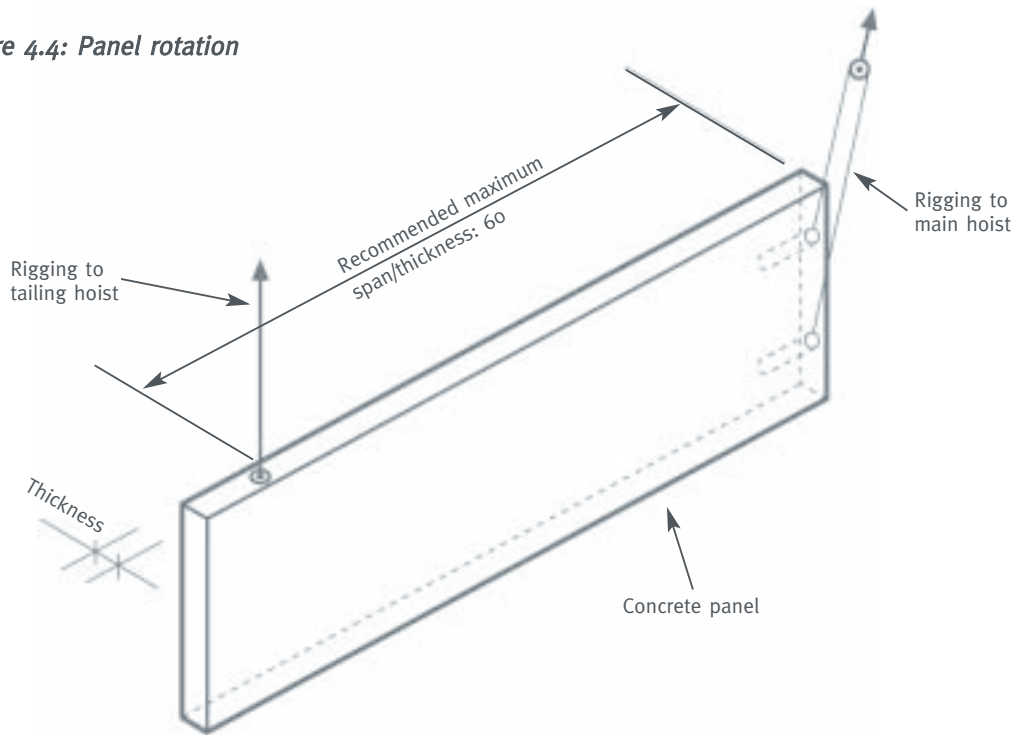


Figure 4.3: Preferred concrete panel rigging configurations

**Figure 4.4: Panel rotation**



## 4.8 Panel thickness

The thickness of a concrete panel needs to be adequate to:

- carry the design loadings;
- limit the lateral deflection of the panel to  $1/250$  of the panel span under serviceability loadings as required by AS 3850; and
- meet the minimum thickness required by AS 3600 for the specified fire resistance level (FRL) where the panel is required to have a fire resistance.

## 4.9 Slenderness effects

### 4.9.1 Panel height to thickness ratio

Panel height to thickness ratios are specified in AS 3600. These ratios may be exceeded provided a detailed analysis is carried out taking into account the following factors:

- loading on the panel;
- moments due to the eccentricity of vertical loads;
- moments due to deflection of the panel and its supports; and
- long term effects, if any.

### 4.9.2 Dual lift slenderness design

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

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

The span/thickness ratio of the concrete element between lifting points should be limited to a maximum of 60 (see Figure 4.4) unless a detailed buckling analysis is undertaken.

## 4.10 Panel supports

Concrete panels should be designed to sit on only two localized shimming points when initially erected. The panel and the footings should be designed to carry the forces from the localized supports, taking into account normal construction tolerances.

By specifying the locations of only two shimming positions beneath a panel, the designer can control where the weight of the panel is supported. Construction tolerances are usually such that multiple shimming will not distribute the panel weight to its support in a predictable

manner, since any two of the shims are likely to support most of the load. After erecting the panel, grouting beneath the panel may serve to redistribute load following settlement beneath the original shimming points or additional loading of the panel.

Where two panels land on a discrete support, the load eccentricities that occur during construction, because one panel has to be erected before the other, can sometimes be a critical load case in design.

See section 9.3 of this code for further information on shims.

## 4.11 Fixing inserts

The design of fixing inserts for connecting panels to roof framing, and other structural members, should comply with AS 3850 and provide for the following:

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

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

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

Extreme heat, such as occurs during a fire, reduces the capacity of fixing inserts and other critical components. Drilled-in inserts may suffer a greater strength loss due to exposure to fire than cast-in inserts. Fixings may have to be protected against fire if heat will adversely affect their performance. Drilled-in inserts may be used for fire situations provided their performance can be substantiated.

Care should be taken to ensure that secondary effects, for example eccentricity of the steelwork framing cleat and semi-rigid rafter connections, are determined and considered in the selection of fixing inserts.

## 4.12 Joints

Joint widths (gaps) between adjacent 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 concrete elements should not be less than:

- 15 mm for joints with flexible sealant;
- 20 mm for mortar or grouted joints; and
- 150 mm for in-situ concrete infills.

Special care should be taken when specifying minimum joint width as the panel location tolerance, width dimension tolerance and squareness tolerance may significantly reduce joint widths and affect the choice of joint sealant and its performance.

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

- thermal and shrinkage movement of the concrete element;
- fire resistance level;
- weather resistance;
- structural movements to be accommodated;
- dimensional tolerances of panels; and
- panel location tolerance.



## 4.13 Brace footings

### 4.13.1 General

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

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

- construction loads; and
- wind loads for temporary structures in accordance with AS/NZS1170.2.

Combinations of applied loads should comply with AS/NZS 1170.0.

Requirements and details of brace footings for each type of concrete element should be clearly specified on the shop drawings. This should include the required concrete strength of the footing at the time of installation of the bracing.

### 4.13.2 Floor slabs

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

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

### 4.13.3 Concrete blocks (deadman)

Where floor slabs are not capable of resisting the bracing forces, or are not in place, concrete blocks (deadman) may be necessary to use as brace footings.

Unless specifically designated otherwise, the concrete strength of the brace footing at the time of installation of the bracing should be at least 25 MPa. Brace footings are frequently cast using low strength concrete and will need to be left for longer to ensure anchors do not pull out. The specification of early age strength concrete may be necessary.

A sketch of the brace footing should be provided to the erector by the builder before erection commences. The sketch should be signed by the erection design engineer.

In calculating the capacity of the brace footing, the direction of the applied brace loads, both in compression and in tension, needs to be taken into account to ensure stability under all conditions. Combined vertical and sliding mode failure needs to be considered.

Concrete block brace footings cast in the ground will need a larger mass in sandy soils compared to stiff clays which have better cohesive properties and are better able to resist pull out loads.

### 4.13.4 Other footings

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

## 4.14 Connections

### 4.14.1 General

Concrete elements should be incorporated into the structure in such a manner that the risk of progressive collapse is eliminated.

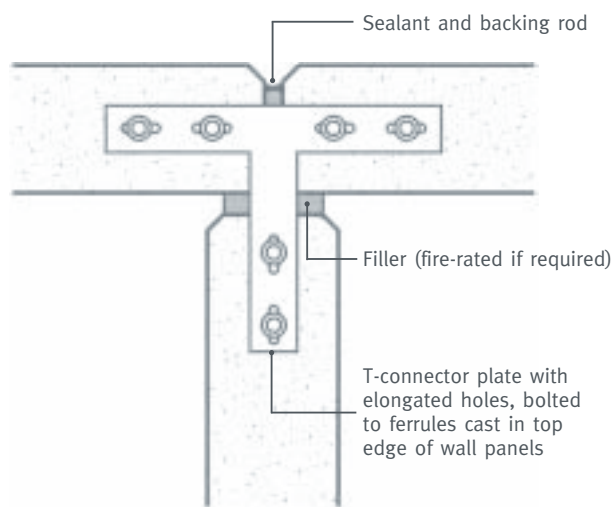
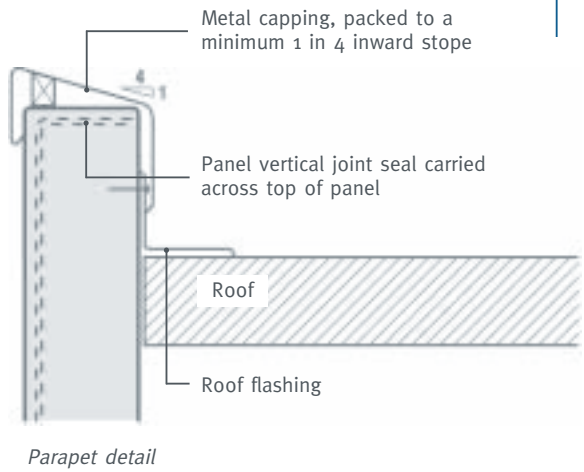
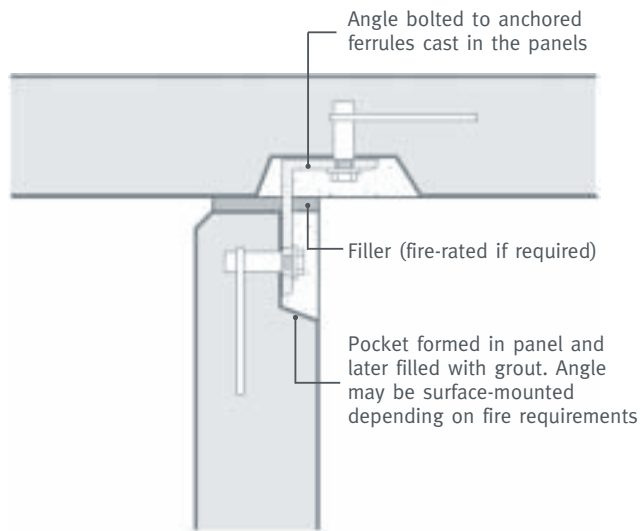
Connections should be specified and detailed on the shop drawings.

A selection of typical panel connections for various situations is shown at Figure 4.5.

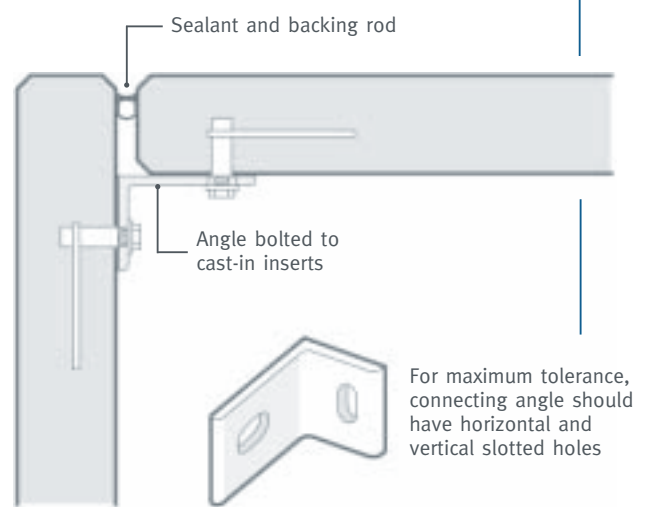
**Impact driven fixings, including explosive charge driven fixings, should not be used.**

### 4.14.2 Panel to panel

Connections between concrete panels should allow for independent shrinkage and thermal movement between panels and allow for construction tolerances in locating fixing ferrules and other cast-in components.

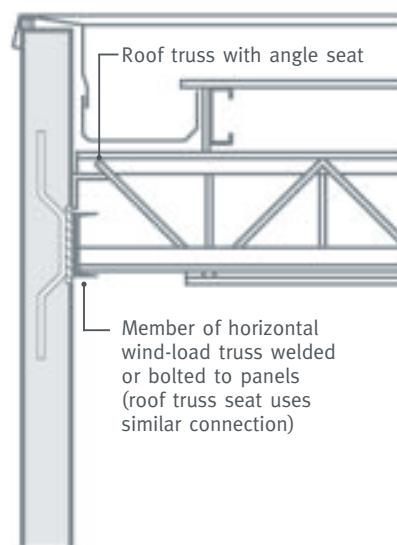


*Panel to panel at T-junction*

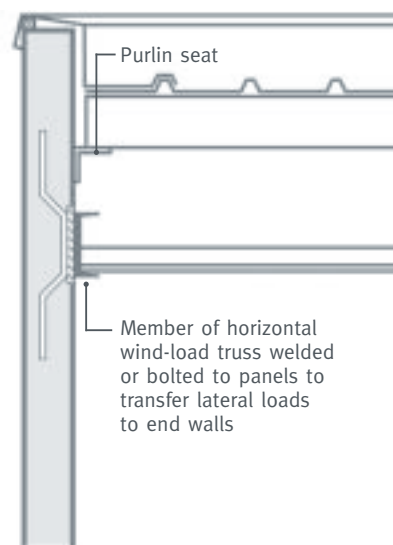


*Panel to panel at external corner*

*Parapet detail*



AT SIDE WALLS



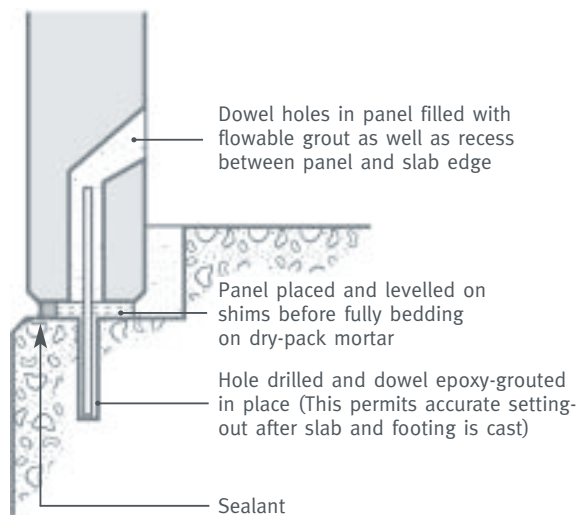
AT END WALLS

*Panel to roof truss*

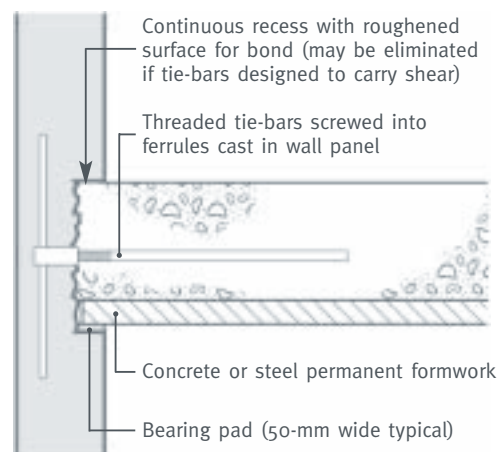
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**Figure 4.5: Various typical panel connections**

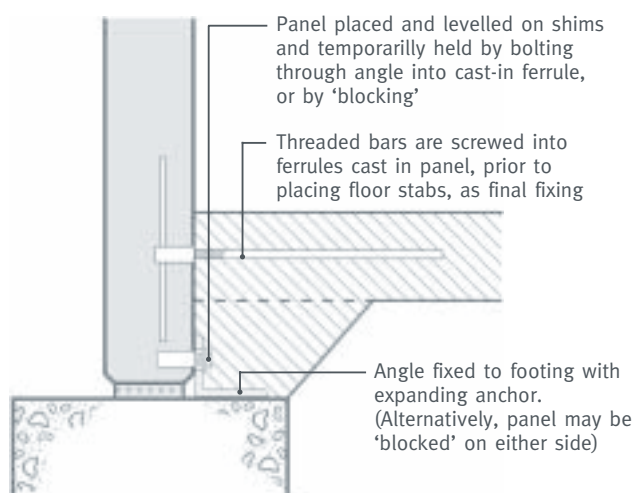




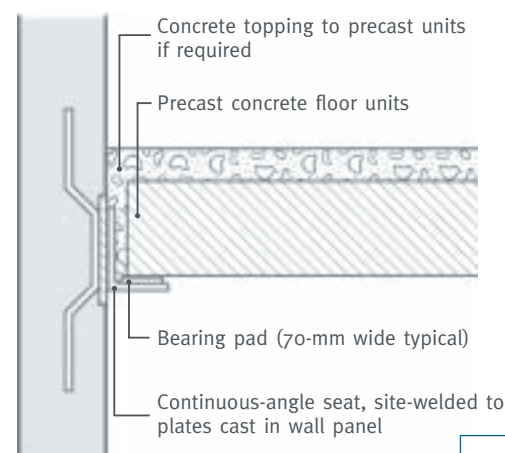
*Panel to footing slab*



*Panel to suspended insitu concrete floor*



*Panel to strip/pad footing*



*Panel to suspended precast concrete floor*

**Figure 4.5: Various typical panel connections (continued)**

In assessing the requirements for connections between panels, consideration needs to be given to the effects of abnormal loads on the building, such as vehicle impacts. For detailed information and recommendations on these issues, refer to the Precast Concrete Handbook referenced in Appendix C.

#### **4.14.3 Panel to footing or floor slab**

A fixing system should be used to resist horizontal load transmitted from concrete panels into footings or floor slabs. The fixings should be capable of resisting the forces set out in AS 3850. Friction forces should not be assumed to resist any part of this force.

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

#### **4.14.4 Panel to structural steel**

Connections between concrete panels and other structural members, need to be designed to resist the lateral and vertical forces imposed on the connections in accordance with the requirements of AS 3850 and AS 3600, as appropriate.

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

The project design engineer should make allowance in the design of connections between concrete panels and steelwork for unexpected loads. These loads may result from:

- erection problems due to panel tolerance or fabrication issues;

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- steelwork collapse due to erection problems or crane collision; and
- roof steelwork collapse due to fire.

The unexpected loads are generally additional tension loads, which tend to pull the panel and roof steelwork apart. The loads are generally not those loads identified as part of the structural analysis.

All concrete panel to steelwork connections should be designed to ensure a ductile failure.

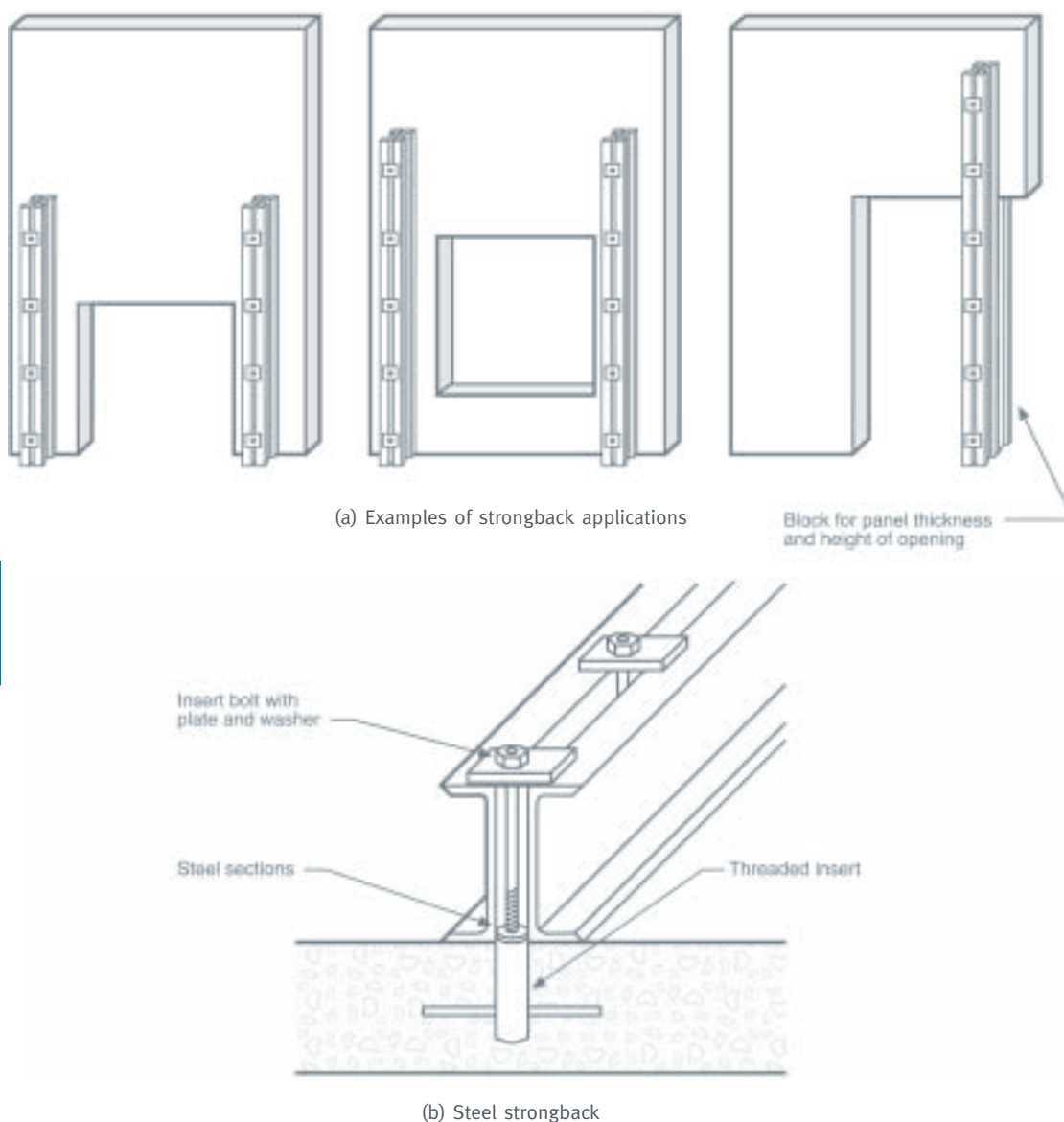
See section 9.2 of this code regarding loads resulting from erection of steelwork.

## 4.15 Strongbacks

When strongbacks are required they should be designed to ensure the strongback is sufficiently stiff to prevent cracking of the concrete panel due to differential deflection.

The location of the strongbacks should not interfere with the rigging at all angles of panel rotation. See Figure 4.6 for examples of strongback applications using steel channel section.

The erection design engineer should approve any changes to the specified strongback system prior to the changes being carried out and the shop drawings amended accordingly.



**Figure 4.6: Strongbacks**

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# 5

## Part Documentation

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# Documentation

## 5.1 Structural design drawings

Structural design drawings and details are the responsibility of the project design engineer and should provide sufficient information for the preparation of shop drawings by the shop detailer and erection documentation by the erection design engineer.

The information provided on structural drawings should include:

- date and issue number of the drawing;
- plans and elevations clearly indicating the structural framing and concrete element layout;
- structurally critical dimensions;
- reinforcement and concrete cover required for in-service loads and conditions;
- framing connection locations and required type (eg cast-in) and the capacity of the fixing inserts;
- levelling pad details;
- structural design criteria affecting construction, eg wind design loads, tolerances;
- 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 panel shop drawings;
- base connection details, eg grouting sequence of dowel connections; and
- location of services such as plumbing, electrical and cabling conduits.

## 5.2 Panel documentation

Concrete panel documentation consists of a marking plan, shop drawings and erection documentation for the concrete elements. Panel documentation should be available at the site whenever work is carried out.

### 5.2.1 Marking plan

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

### 5.2.2 Shop drawings

Shop drawings should provide all information and details required to manufacture the concrete element.

The builder should check the shop drawings for compliance with dimensions of structural drawings.

Standardised symbols should be used on the drawings in accordance with those used in AS 3850.

Shop drawings should include the following:

- date and issue number of the drawing;
- project location;
- concrete element number;
- the mass of each concrete element;
- concrete element dimensions and centre of gravity;
- structural reinforcement and concrete cover dimensions;
- the size, configuration and concrete cover of any additional reinforcement required for the transport and lifting of the concrete element;
- the location, orientation and depth of all inserts and the size, configuration and concrete cover of any component reinforcement that is required. All edge-lift inserts and some other inserts require component reinforcement and details should be obtained from the suppliers of these items;
- location of any conduits for plumbing, electrical or cabling;
- location of grouting ducts and, where required, lateral restraint details;

- the type, make, capacity and technical specifications of:
  - lifting inserts;
  - bracing inserts and fixings;
  - fixing inserts; and, if required
  - strongbacks, strong back fixing inserts and locations;
- the class and strength grade designation of the concrete as defined in AS 3600;
- the required concrete compressive strength of the element, bracing footings and prop footings (if required) as applicable at the time of lifting and erecting. 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;
- the surface finish of each concrete element;
- where appropriate, the tolerance limits on the concrete element (see section 4.5.3 of this code);
- the orientation (position relative to each other) of the concrete elements: and
- rigging details.

The shop drawings should be signed and dated by the project design engineer and the erection design engineer. A sample shop drawing, illustrating some detail, is shown at Appendix B.

Before being made available on site, shop drawings should be subject to an approval process whereby they are reviewed by the project design engineer, erection design engineer and building designer. Any necessary amendments should be marked up and returned to the shop detailer for incorporation into the shop drawings. These amended drawings are the approved shop drawings which should be available on site. See section 1.3.2 of this code.

### 5.2.3 Erection documentation

Documentation should be provided and signed by the erection design engineer which shows:

- rigging details, including sling lengths;
- configuration and size of erection braces and, where applicable, knee braces and cross-bracing;
- propping details if required;
- requirements for erection brace footings (and prop footings if required), brace fixings and concrete strength of the footings at time of erection; and
- levelling pad details.

In situations where the rigging differs from a configuration shown at Figure 4.3, the rigger should prepare a rigging diagram detailing the required configuration with sling lengths, spreader/lifting beam requirements and arrangement of sheaves.

## 5.3 Lodgement of shop drawings with local government

A copy of the approved shop drawings should be lodged with the relevant local government authority for filing with the relevant building licence.

Information contained in the shop drawings will assist in the consideration of any future modification work and the safety of any future demolition of the building. The Department of Local Government and Regional Development intends to make this lodgement a requirement of the Building Regulations 1989.

# 6

## Part Casting

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# Casting

## 6.1 General

Concrete elements should be manufactured in accordance with the approved shop drawings.

## 6.2 Preplanning and layout

Prior to manufacturing the concrete elements, the parties involved in the design, manufacture, transport and erection process should have planned the complete construction and erection sequences.

The casting and erection sequences of the concrete elements should be agreed between the builder and erector. The builder, in association with the erector, should prepare plans showing the erection sequence and bracing layout in accordance with the requirements of section 8.2 of this code.

For concrete panels cast on site, the floor slab is commonly used as the casting bed and crane standing area.

Prior to the casting bed being set out, consideration should be given to the following:

- the orientation of the panels on the casting bed;
- vehicular access to and around the site;
- location of overhead power lines, utility trenches and other services;
- panel storage locations, where required;
- crane type, size and lifting position; and
- erection sequence and bracing layout.

When assessing crane requirements, note that:

- a crane's maximum capacity refers to its capacity at minimum radius and often bears little relation to its actual capacity to lift large concrete panels into position;
- the selection of crane size needs to be made with consideration of the maximum working radius and load from pick up to final positioning;

- for face-lifted concrete panels, assessment of the true working radius of the crane should be made by adding at least 1.5 metres to the final panel position radius. (See section 8.6 and Figure 6.1); and
- usually the crane will be set up such that it does not need to slew greater than 180 degrees and the lifting radius is allowed for over that area. The slewing radius of the crane counterweights should not be overlooked in relation to any braces installed after crane set up.

For concrete panels, the casting sequence should reflect the erection sequence. To avoid multiple handling with stack-cast concrete panels, the top panel should be erected first.

## 6.3 Casting bed

Casting beds need to be capable of supporting formwork, panels and other loads, particularly where the casting bed is used as the crane standing area. The builder should obtain verification from the project design engineer that the casting bed can carry the construction loads.

The surface of the casting bed should be appropriate for the surface finish of the concrete element specified on the shop drawings.

Any cracks and defects in the casting bed may reflect in the cast panels. Where there is insufficient room to cast all panels on the casting bed, panels may be cast one on top of another, in reverse order of erection. Care is needed with this casting method to limit the tolerances of a panel, especially flatness, as the deviation may be cumulative as successive panels are cast one on top of another.

Additional casting beds may be constructed as required.

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

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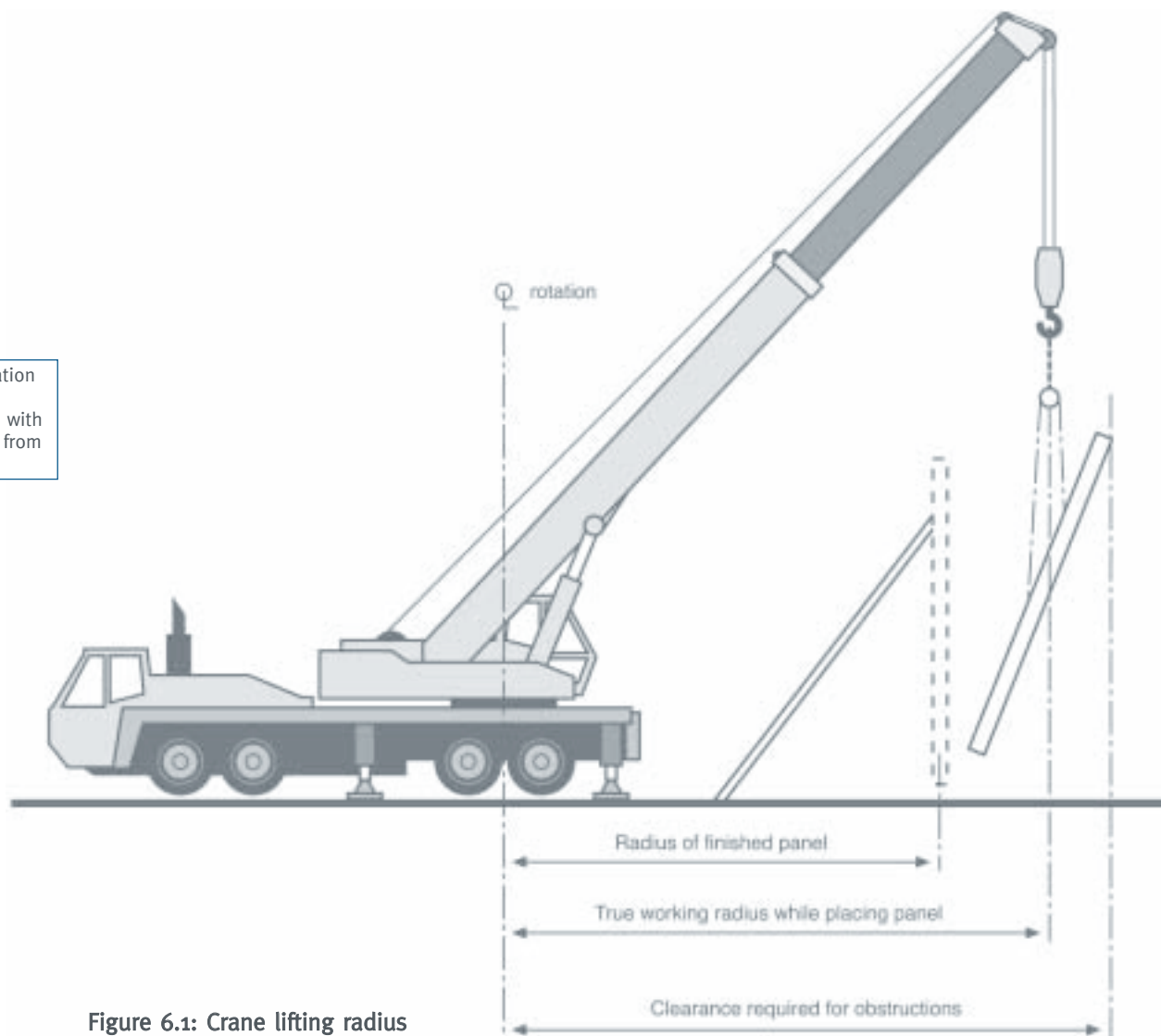


Figure 6.1: Crane lifting radius

## 6.4 Formwork

Formwork should be designed and constructed in accordance with AS 3610 and the requirements of section 6.5 of this code.

See section 6.7 regarding the written inspection report required before casting of concrete panels is carried out.

Tilt-up and precast concrete construction usually requires multiple use and early stripping of formwork. These requirements should be taken into account in the design of the formwork.

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

- 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 concrete element; and
- both suction and friction can be reduced by the use of good quality mould release compounds.

These matters were discussed in section 4.3.2 of this code.

## 6.5 Tolerances

The tolerance on deviation from flatness of the casting bed should be such that the as-cast element meets the requirements of section 4.5.3 of this code.

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



## 6.6 Reinforcement

Reinforcement needs to comply with the requirements of AS 3600 and the approved shop drawings.

Reinforcement should be securely fixed 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 casting.

## 6.7 Manufacturer's statement and inspection

Prior to placing concrete, the form arrangement and set up should be inspected for compliance with the shop drawings. In particular, this should include checks on:

- formwork dimensions;
- formwork stability;
- panel edge details and penetrations;
- connection details;
- insert locations, types and fixing to reinforcement;
- reinforcement size, location, concrete cover and fixing; and
- bond-breaker effectiveness.

The inspection should be carried out by a competent person who was not directly involved in the original assembly of the formwork, reinforcement and hardware components. For stack casting, an inspection should be done prior to the casting of each panel.

For concrete panels cast on or off-site, regulation 3.88G requires a written report of this inspection to be kept at the site whenever tilt-up work is being carried out.

Prior to the transportation or erection of concrete elements, the builder should provide to the erector a statement signed by the manufacturer stating that the manufacture of the elements was carried out in accordance with the engineer approved shop drawings. For site casting this statement should be signed by a competent person.

The manufacturer's signed statement should be available on site at the time of lifting the elements listed on the statement. See section 6.11 of this code for element identification.

No lifting should take place until the signed statement covering the particular element is available on site.

The statement should contain as a minimum the information contained in the form at Appendix B.

Records should be kept to substantiate the manufacturer's statement.

## 6.8 Placement and compaction of concrete

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

The concrete supplier should be advised of:

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

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

## 6.9 Curing and release agents

The curing compound and release agent should be applied in accordance with the manufacturer's specification and the requirements of section 3.3 of this code.

### **6.10 Lifting, bracing and fixing inserts**

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

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

Inserts should not be welded to reinforcement.

### **6.11 Element identification**

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

### **6.12 Stripping and repair**

Formwork should be carefully stripped and stored to prevent damage.

If the concrete element suffers damage greater than minor spalling, the proposed repair system should be approved in writing by the project design engineer before being carried out.

# 7

## Part Handling, storage and transport

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# Handling, storage and transport

## 7.1 General

Methods for handling and storage of concrete elements will vary depending on the type of element and whether the concrete element is cast on-site or off-site.

Concrete panels cast on site should only be stored in a designated area and in such a manner as to minimise multiple handling.

There is always a risk to safety of persons involved and a risk of damage to a concrete panel every time it is moved. Careful planning and scheduling will minimise the need to relocate panels. A panel should not be relocated without first discussing the need with an engineer.

Factory manufactured concrete panels and other concrete elements should be retained in the precast yard and delivered to site for installation as required.

The rigging system to be used for each concrete element must be as set out in the erection documentation detailed in section 5.2.3 of this code.

Concrete elements should not be lifted without the appropriate methods being documented.

## 7.2 Handling and storage of site-cast concrete panels

Where storage of site-cast concrete panels is required the storage area should be:

- well drained and consolidated;
- located where there is little chance of damage to the panels to be stored;
- adequate to support the weight of the panels and any necessary stacking frames; and
- unlikely to settle unevenly.

The storage area needs to provide adequate room for lifting equipment and for manoeuvring trucks (if required) and cranes.

Racking systems, frames and supports for panels should be constructed in accordance with a design prepared by an engineer.

The general requirements for handling and storage of concrete panels on site are as follows:

- panels should only be stored in a position approved by the erection design engineer. Panels should preferably be stored in the vertical position;
- ground conditions need to be checked by an engineer to ensure that the mass of the element and any necessary stacking frames can be supported; and
- where a panel is to be stored horizontally or on a suspended floor slab, approval and written instructions should be obtained from the project design engineer before proceeding.

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 oriented for re-lifting.

Where panels are stored in areas of vehicular movement, protection by way of bollards or other physical barriers and appropriate warning signs should be considered.

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

## 7.3 Handling and storage of factory manufactured concrete elements

Recommended practices and procedures for handling and storage of precast concrete elements can be found in the *Precast Concrete Handbook* referenced in Appendix C.

With proper preplanning and discussion of delivery arrangements between the builder and precaster, handling of factory manufactured concrete elements can be minimised.

Precast concrete elements are usually stored horizontally, however wall cladding panels are usually stored vertically by using A frames or a racking system.

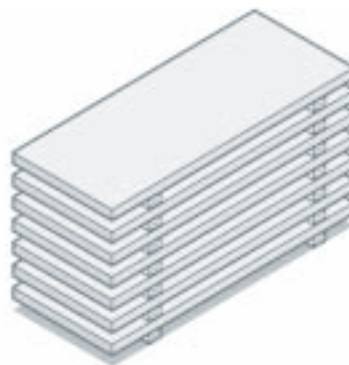
For horizontally stored concrete elements, only two points of support should be used if possible, located to minimise stresses on the element. If more than two supports are necessary, care should be taken to ensure the concrete element does not bridge over one of the supports.

General guidelines for handling and storing precast concrete elements are as follows:

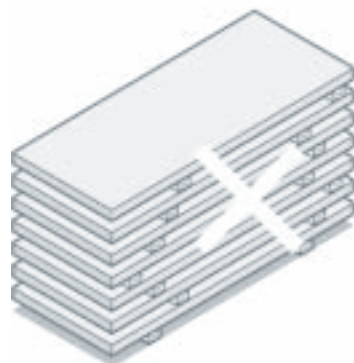
- wherever possible, elements should be stacked at only two support positions, one fifth of the length of the element from each end for wall units;

- support points should be directly above each other, not misaligned;
- stacked elements should be of equal length;
- softwood supports should be used to reduce edge chipping and minimise staining. Hardwood supports may cause staining of concrete which may be difficult to remove; and
- storage should be planned to minimise handling before delivery.

See Figure 7.1 for correct horizontal stacking of concrete panels.



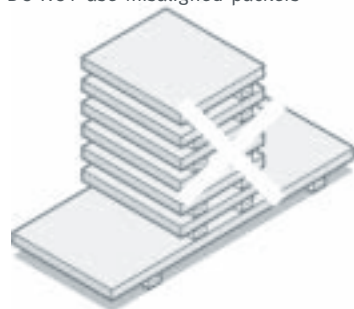
Units should be stacked with suitable packings, near ends for beam and slab units and at  $L/5$  from ends for wall units



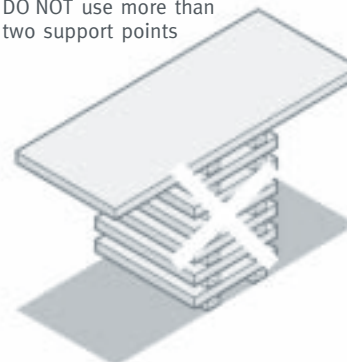
DO NOT use misaligned packers



DO NOT use more than two support points



DO NOT place shorter units on longer ones



DO NOT place longer units on shorter ones

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**Figure 7.1: Horizontal stacking of factory manufactured concrete panels**

## 7.4 Transport

### 7.4.1 General

To reduce hazards, the transport of concrete panels should be avoided wherever possible. Preplanning will reduce the need to transport concrete panels around the site.

### 7.4.2 Preplanning

The following points should be taken into account when transporting concrete elements and whenever it is necessary for concrete panels to be transported to or around the site:

- the shape, size and mass of the concrete elements;
- specific design requirements, including the concrete strength required for transportation and the stability of long or unusually shaped panels during transportation. The precaster needs to ensure the concrete element has reached the design concrete strength prior to transportation;
- traffic regulations governing maximum weight, length, width and height of the laden vehicle;
- all-weather access for the delivery vehicle and the traffic management plan referred to in section 7.4.6 of this code;
- capacity of any permanent structures to carry transport loads; and
- temporary storage, where required.

### 7.4.3 Loading

The concrete elements should be loaded in a sequence compatible with the required unloading sequence on site.

Secure restraint of loads on vehicles is important in preventing accidents and injuries. Load restraints may be chains or webbing straps.

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

The precaster should advise the transporter of any special requirements for support and restraint of the concrete elements.

Special restraints may be required for long concrete elements, especially when transporting over long distances.

The equipment should be inspected before use to ensure it is serviceable.

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

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

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

- power lines;
- recognised truck routes for over-dimensional loads; and
- roundabouts and reverse camber in the roads.

Differential road cambers may induce torsional loads in long panels. Slender concrete panels may require temporary stiffening against lateral buckling.

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

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

### 7.4.4 Support frames

Frames used to support concrete elements during transport need to 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 transport vehicle or trailer should be adequately secured and capable of withstanding any forces applied during loading, transportation and unloading.

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

#### **7.4.5 Element protection**

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

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

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

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

Particular attention needs to be given to prestressed concrete elements to ensure they are only supported at designated bearing points and that restraint systems do not impose excessive loads. Prestressed concrete elements should not be supported, even temporarily, at any other points and they should not be tipped sideways.

#### **7.4.6 Delivery**

Delivery of concrete elements onto the site requires co-operation between the builder, precaster, transporter and erector.

The builder should provide a documented traffic control management plan that includes, where necessary, traffic controller, barricades and road closure permits to allow unimpeded access to the site. This traffic management plan should form part of the work plan which must be available on site at all times when work is carried out.

The precaster needs to ensure that the transporter has detailed instructions on how to enter the site.

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

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

The builder needs to ensure that the area where the crane is to be set up is stable, compacted if on the ground, and able to support the crane when loaded and positioning concrete elements in their storage or erection positions. The crane operator should check these factors with the builder prior to handling any concrete elements. See section 8.5 of this code.

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

# 8

## Part

## Erection to temporary braced condition

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# Erection to temporary braced condition

## 8.1 General

Safe erection of concrete panels and precast concrete elements depends on the preplanning process. All personnel should be aware that erection of these elements is potentially hazardous and the purpose of the pre-planning process is to identify hazards and control any risk in the erection process.

**The actual lifting of concrete panels is the time when potential for serious accident is highest.**

Due to their large surface area and mass a great deal of care needs to be taken when lifting, moving and securing concrete panels into position. The likelihood of fatalities if a panel falls over is considerable. Increasing the risk is the fact that the crane may fall over and other panels that are struck by the crane or falling panel are also likely to collapse. With these factors in mind it is extremely important that both the panel erection crew and crane operator are highly skilled and experienced in the erection of concrete panels.

Requirements for training and supervision are set out in section 2.2 of this code.

## 8.2 Planning the construction and erection sequence

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

The planning process should take into account:

- site limitations and local street access;
- concrete element sizes;
- crane size configuration, mobility and access;
- compaction of site surface areas;
- casting sequence;
- overhead obstructions, particularly overhead power lines and construction site overhead power;

- underground power lines and other services; and
- underground tanks and soakwells.

A crane layout drawing should be prepared showing the working radius of the crane.

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

- supervision;
- induction training;
- adequate first aid facilities, workplace amenities and personal protective clothing and equipment in accordance with the Commission for Occupational Safety and Health code of practice on the provision of these services and equipment as appropriate;
- perimeter fencing around the site to prevent access by members of the public. Link mesh fencing 1.8 metres high will generally be required to provide sufficient public protection. Other forms of protection may be suitable in some situations;
- adequate 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 and transport equipment;
- height access equipment appropriate to the construction methods;
- access to approved shop drawings; and
- risk assessment giving particular attention to overhead power lines at or adjacent to the site.

The rigging system needs to be designed to suit the spacing and layout of the lifting inserts. See Figure 4.3 for preferred rigging configurations.

**Sling lengths are critical where the rigging system includes the use of spreader beams or lifting beams with slings running through sheaves.**

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, including appropriate exclusion zones; (see section 8.4 of this code)
- make sure that crane and truck access is inspected and confirmed as safe;
- inspect the crane standing area and confirm that it is safe. Obtain verification from an engineer that the crane standing area can safely support the erection loads; (see section 8.5 of this code)
- make sure the crane operating area has been cleared to provide adequate room for crane outriggers, counterweight tail swing, boom swing and under-hook and overhead obstructions, including overhead power lines. Refer to section 8.6 of this code for points to be considered in planning craneage requirements;
- ensure that provision has been made for safe working at heights, if necessary; (see section 8.9 of this code)
- confirm the erection crew members are properly certificated and trained and available in adequate number; (see section 8.11 of this code)
- verify that the element concrete (and brace footing concrete) has attained the specified strength for lifting and nominated brace fixing bolts are available on site. If the element concrete does not achieve the specified strength for lifting in accordance with the requirements of section 3.2 of this code, the erection design engineer should be notified before lifting occurs;
- check that strongbacks, if required, are available and are correctly installed;
- make sure that locating dowels or other horizontal restraints are fitted prior to lowering concrete elements and levelling shims are correctly located;
- confirm that the means of support, including falsework, is adequate for the intended purpose and is correctly located;
- check that sufficient clear space is available for the safe propping of precast concrete elements or bracing of concrete

panels and ensure that nominated braces are fitted to the panels;

- in consultation with the rigger:
  - determine if load distribution on lifting points is satisfactory;
  - ensure that the appropriate rigging equipment is available and is serviceable;
  - ensure that braces do not interfere with the rigging;
  - check that lifting inserts are compatible with lifting clutches and are in their correct location and that recesses are cleaned out in preparation for lifting;
  - determine an appropriate interval for checking the condition of braces, and torque on brace bolts, to ensure they have not become loose; and
- determine if weather conditions are adequate for erection.

### 8.3 Work method statement

A work method statement should be prepared, usually by the erector, in consultation with the builder and the Safety and Health Representative (if any) of the workers. In the absence of a Safety and Health Representative, the work method statement should be prepared in consultation with the erection crew and reviewed by the Safety and Health Representative (if any) following their election.

The work method statement needs to be specific to the project and based on the documentation detailed in Part 5 of this code. It should be signed off by the builder and erector. The work method statement should provide a general description of the erection process, identifying the objectives of the erection process and broadly describing how these objectives are to be realised. Most importantly it should set out the safe working procedures to be used during the erection process.

Sample documents for erection of concrete elements are provided at Appendix B. Sample documents for casting of concrete elements and incorporation of structural steel into the final structure are also provided at Appendix B. These documents include schedules for the concrete elements.

## 8.4 Exclusion zones

Regulation 4.53

Regulation 4.53 requires, as far as practicable, that loads are not suspended over, or travel over, a person.

Only persons directly involved with the lifting of concrete elements should be located in an area where the lifting is taking place. Such persons should avoid being in a position where they could be struck in the event of a concrete element falling or a crane or panel falling over.

The Act, section 21(1)(b)

Under section 21(1)(b) of the Act, employers and self-employed persons must, as far as is practicable, ensure that the safety and health of non-employees, including members of the public, is not adversely affected by their work or the work of their employees.

The Act, section 22(1)

In addition, persons having control of a workplace have a responsibility under the Act (section 22(1)) to take all practicable measures to ensure that people who are not employees who are at the workplace, or likely to be at the workplace in the course of their work, or enter or leave the workplace, are not exposed to hazards.

To satisfy these legislative responsibilities exclusion zones should be set up to prevent, as far as practicable, unauthorised persons gaining access to areas where lifting of concrete elements or other items is taking place.

This may necessitate the erection of para-webbing, signage and/or fencing depending on the ease of access and the likely presence of workers or members of the public. All members of the public and workers not involved in the lifting of concrete elements or other items should be prevented, as far as practicable, from accessing an exclusion zone while lifting is taking place. The provision of perimeter fencing around the site will assist the operation of exclusion zones.

Where a common boundary between two properties is located in an exclusion zone, an effective means of communication with occupiers is essential to keep members of the public away from the exclusion zone while lifting is taking place. This issue should be addressed in the planning stage (see section 8.2 of this code).

Where a footpath, road or other access way is located in an exclusion zone, members of

the public and traffic should be prevented, as far as practicable, from passing through the zone while concrete elements or other items are being lifted and prior to securing concrete panels with braces.

## 8.5 Crane standing area

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

The project design engineer should provide this verification where the crane standing area forms part of the structure.

If the crane is to be set up on the ground, compaction tests should be taken of the area to ensure the loads imposed by the crane can be supported.

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

## 8.6 Planning crane requirements

Cranage planning should commence as early as possible in development of the project.

The requirements for cranes should be in accordance with section 3.8 of this code.

It is essential to ensure all lifts can be carried out while keeping a safe distance from power lines and obstructions, never operating over any person, road traffic, unprotected public space, unprotected site offices or amenities sheds.

In accordance with the requirements of regulation 4.54, cranes and elevating work platforms (EWP) must be maintained, inspected and operated in accordance with the written instructions of the designer or manufacturer of the crane. If it is not practicable to obtain these instructions the WorkSafe Western Australia Commissioner may approve written instructions. If it is not practicable for the person in charge of the workplace to get either of these forms of

Regulation 4.54



instruction then the requirements of AS 2550.1 and AS 1418.1 should be followed, together with the requirements of any other part of AS/NZS 2550 and AS/NZS 1418 that are relevant.

The selection of an appropriate mobile crane, preparation of the site and correct location of the crane are crucial in ensuring the safe erection of concrete elements. Mobile cranes used for this type of construction are often required to work close to their maximum capacity with high luff angles due to the large size and mass of concrete panels. These factors increase the likelihood of the crane overturning, particularly if the ground is not level. All cranes used for the lifting and erection of concrete elements should be fitted with load indicators as described in regulation 3.23.

The crane should be located with consideration given to the erection sequence of the concrete elements to avoid any possibility of the rear of the crane slewing into braces supporting previously erected concrete panels.

Where two or more cranes are operating they should be sited so as to prevent them operating in each other's airspace.

At appropriate stages, the planning process needs to consider:

- crane selection, access and siting in accordance with AS 2550;
- ground support conditions and the location of any excavations or underground services likely to be adversely affected by imposed crane loads;
- proximity of overhead power lines;
- written procedures for setting up and dismantling the crane and the lifting method as well as a risk assessment of these procedures;
- the make-up of the crane crew appropriate to the particular circumstances of the job;
- the communication system;
- selection of lifting gear including appropriate snatch block for rotation of panels while suspended if rotation is to be carried out (see section 3.8 of this code);
- personal protective equipment for the rigging crew;

- emergency procedures; and
- protection of the public.

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

As a general "rule of thumb", cranes used on tilt-up work should have a maximum capacity of at least three times the weight of the heaviest concrete panel to be lifted. In some situations a smaller crane will be acceptable and in some situations a larger crane may be required where large irregularly shaped elements are to be lifted or where the crane cannot be positioned close to the casting bed or final position of the panels.

Larger cranes are generally more difficult to manoeuvre around the site. However site movements may be minimised with large cranes. Of utmost importance is the need to ensure the crane does not damage the structure or braces when operating, especially slewing.

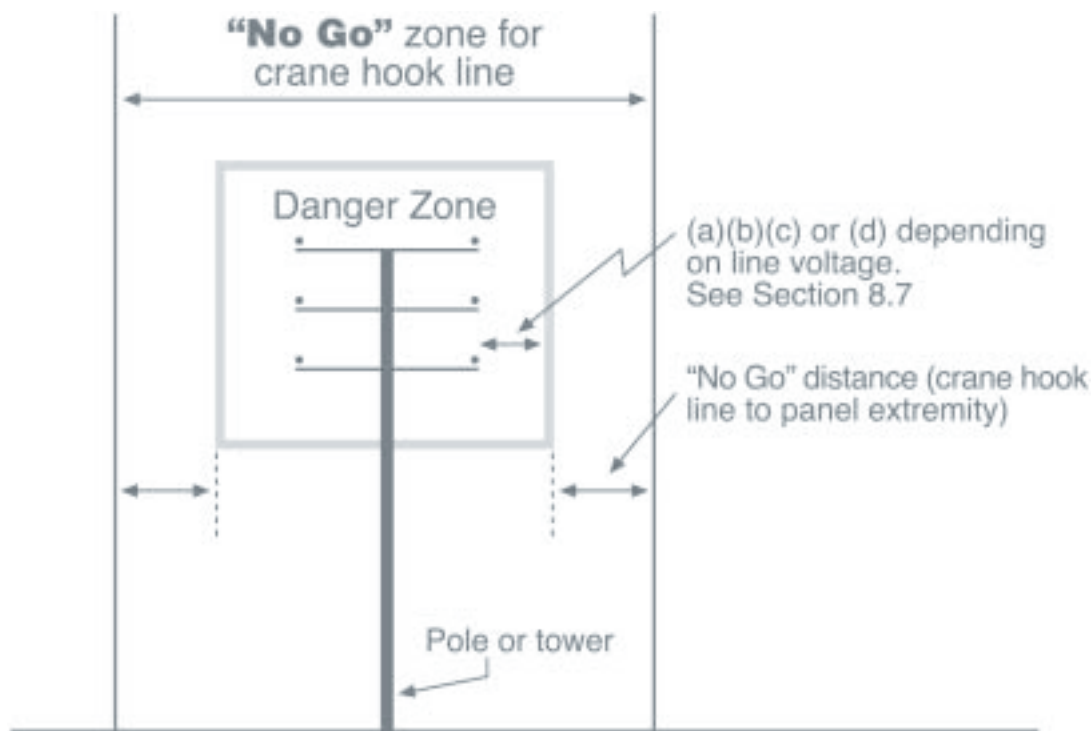
The extra cost of a large crane may be justified by a shorter overall erection time.

For all face-lifted concrete panels, the true working radius of the crane needs to include an allowance of at least 1.5 metres 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 6.1). This may need to be increased for tall panels. An assessment of the true working radius should be made according to individual panel details.

Where lifting is not possible with one crane and it is necessary to use two cranes to "dual lift" concrete elements, the required crane capacities should be carefully assessed. In accordance with regulation 4.54 the rated capacity of each crane must exceed the crane's share of the load by at least 20%.

Dual lifting is a potentially dangerous operation requiring a great deal of skill by operators. Regulation 4.54 requires that dual lifting only be carried out where the physical dimensions and mass of the load prevent the load from being handled by a single crane that is readily available. The regulation also requires direct supervision





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**Figure 8.1: Clearance for cranes from overhead power lines**

by a competent person not otherwise involved in the operation.

Dual lifting should never be carried out where wind speeds exceed those specified by the crane manufacturer.

“Blind” lifting, where the rigging is on the side of the concrete panel opposite to the crane, should be avoided because the crane operator and rigger will be unable to visually check the rigging during lifting. Very importantly, if failure should occur, the panel will fall towards the crane. “Blind” lifting may be unavoidable in some situations such as when placing a closure panel in a building.

## 8.7 Operating near overhead power lines

Wherever plant is required to work near overhead power lines a severe hazard is created. This occurs in many types of construction activity.

In the case of precast and tilt-up construction, cranes often operate in close proximity to overhead power lines and the risk of injury can be very high.

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

Where overhead power lines 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, all power lines must be treated as being live and without written confirmation of the line voltage from the supply authority, the highest line voltage must be assumed and a 6 metre “danger zone” used.

Regulation 3.64 of the *Occupational Safety and Health Regulations* specifies a “danger zone” around overhead power lines of different voltages, which must not be entered by employees, plant or material.

This “danger zone” is within:

- (a) 0.5 metres for insulated overhead line or aerial bundled conductor line not more than 1000 volts;
- (b) 1.0 metre for uninsulated overhead line not more than 1000 volts;

Regulation 3.64

(c) 3.0 metres for overhead line exceeding 1000 volts but not more than 33000 volts; and

(d) 6.0 metres for overhead line exceeding 33000 volts.

WorkSafe Western Australia's *Guidelines for Work in the Vicinity of Overhead Power Lines* provides guidance on the operation of cranes and the use of other plant and equipment in the vicinity of overhead power lines. The Guidelines promote a "no go" distance beyond the "danger zone" which should not be entered by the crane lifting hook. This "no go" distance is the horizontal distance from the centreline of the crane hook to the perimeter of the load which for concrete panels is half the length of the lifted edge.

The "no go" distance may need to be increased if panels are laid down away from the crane, particularly for high panels where the risk of making contact with overhead power lines is increased.

Figure 8.1 shows required clearances for cranes from overhead power lines in accordance with WorkSafe Western Australia's Guidelines.

If, for any reason, it is necessary for a person or any plant, material or equipment to enter the "danger zone", the prior authorisation of the supply authority must be obtained before entry is made.

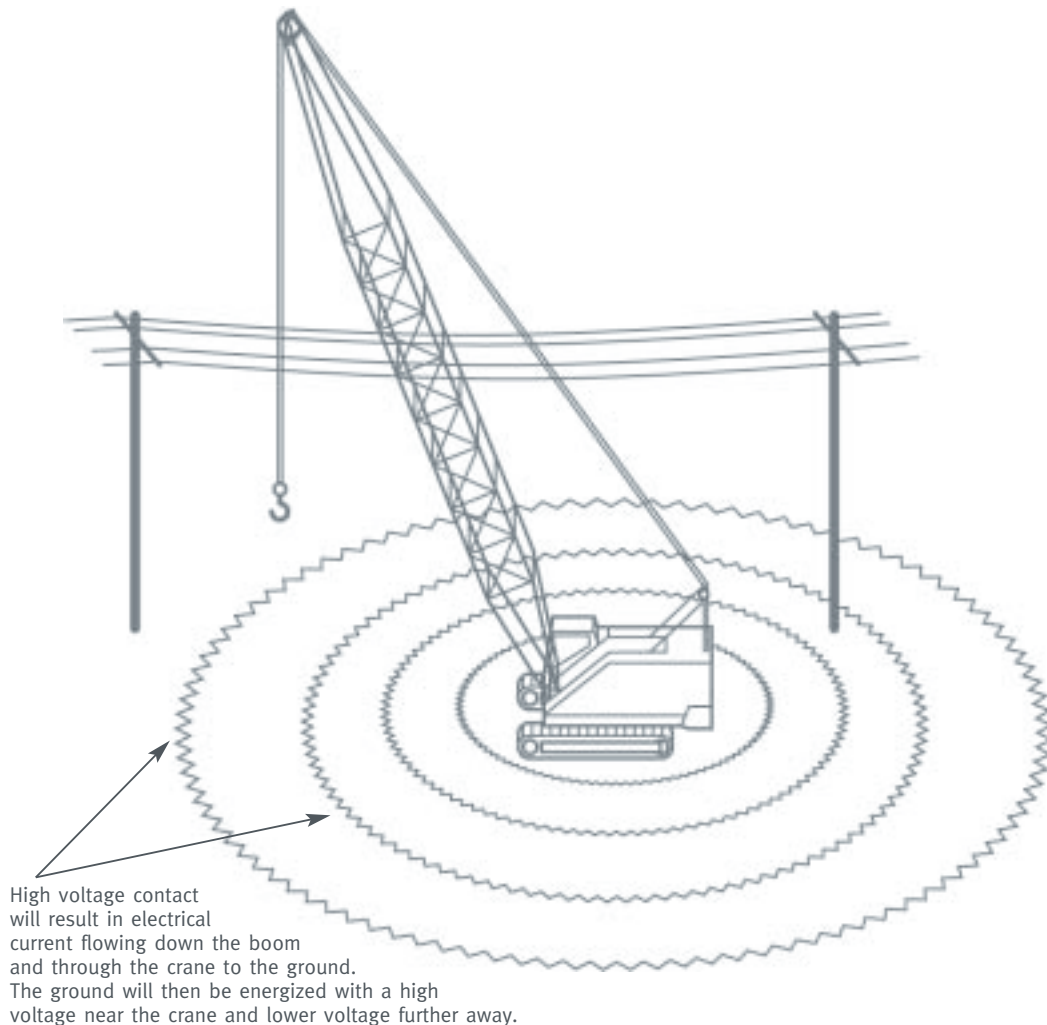
In instances where it is necessary to operate the crane within the "no go" zone (but still outside the "danger zone"), a dedicated spotter should be used throughout these phases of the erection sequence. In these circumstances, the erector should also implement the following measures:

- increase the visibility of the power lines by arranging with the supply authority the installation of "tiger tail" wrapping around the lines;
- 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 personnel to stand clear of the crane and load at all times;
- install warning notices in a prominent position in the crane cabin to alert operators to check for the presence of power lines;
- dry taglines (tail ropes) made of non-conductive material such as natural fibre, hemp or sisal should be used to control the load. Due to their conductive properties, synthetic ropes should not be used. The tagline should be prevented from approaching or being blown into contact with any power line; and
- mobile cranes should be provided with a steel earthing chain. 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. Earthing chain should not be used when the crane is operating near the rails of an electric train system.

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

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

- remain inside the cabin;
- warn all other personnel to keep away from the crane and not to touch any part of the crane, rigging, tail ropes or load;
- try, unaided, and without anyone approaching the machine, to move the crane until clear of the power line;
- if the machine cannot be moved away, remain inside the cab. If possible, by using a safe means of communication, get someone to inform the electricity distribution authority at once. Take no action until the distribution authority confirms that the conditions are safe;
- if it is essential to leave the cabin because electrical contact or arcing has caused a fire or other life-threatening emergency, jump clear as far away from the crane as possible. Do not touch the crane and the ground at the same time;



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**Figure 8.2: High voltage contact**

- 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); and
- ensure someone remains near the crane, at a safe distance, to warn others of the danger of approaching.

Following any contact with live power lines or arcing, 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.

In the case of wheeled machinery it is important that this inspection consider the

possible degradation of rubber tyres caused by high temperatures.

All tyres suspected of being subjected to heat from any source should be replaced.

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

## 8.8 Operating near braces and panels

The use of mobile plant such as cranes, backhoes, excavators and EWPs, close to concrete panel braces can be extremely hazardous due to the risk of panels and braces being struck and panels collapsing. Braces are designed to resist wind loads applied to panels and not to resist impact loadings with moving plant.

Braces that are struck by mobile plant may collapse in a very rapid and uncontrolled fashion causing panels to fall. A falling panel is likely to strike other panels and progressive collapse of other panels can occur.

The hazard can be minimised by giving careful consideration to siting of the crane and the erection sequence as discussed at section 8.2 of this code.

The builder should be notified of any instance where braces are struck by plant.

**Particular care needs to be taken when a crane is being used to erect structural steelwork to prevent parts of the crane and the suspended load from hitting braces and panels. Erection of steelwork in accordance with the requirements of AS 3828 will minimise the risk of contact occurring.**

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

Where it is necessary to operate plant in close proximity to braces and panels, control measures should be implemented. Control measures include the following:

- use of a spotter to signal the plant operator to stop the plant in the event of any part of the plant approaching a brace or panel. Such a system would need to ensure the communication method between the spotter and operator was effective and take into account factors such as noise on site and the spotter possibly being out of view of the operator;
- use of barricading to ensure separation of plant and braces; and
- use of hazard tape, 'para-webbing' and/or signage to make the brace position obvious, particularly where braces are close to access areas.

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

## 8.9 Working at height

All work at height should be carried out in accordance with regulations 3.48 to 3.57 and the Commission for Occupational Safety and Health *Code of Practice Prevention of Falls at Workplaces*.

The above regulations and code of practice contain requirements and advice on edge protection, fall prevention systems, scaffolding and ladders for safe working at heights.

Useful information may also be found in AS 3828.

Regulation 3.55 specifies that where there is a risk that persons could fall 2 metres or more from the edge of a scaffold, fixed stair, landing, suspended slab, formwork or falsework, guard railing comprising a top rail, mid rail and toeboard, or top rail, toeboard and meshing must be provided.

Regulation 3.55 also requires that where there is a risk that persons could fall 3 metres or more from any other edge, edge protection in the form of guard railing mentioned above, or alternatively a fall injury prevention system, must be provided.

To reduce the need for working at height, as many sections of the structure as possible should be assembled on the ground before being lifted into their final position. However, personnel are generally required to work at height to perform the following activities:

- removal of braces from concrete panels;
- attaching the panels to one another or to structural steelwork prior to removal of the braces; and
- application of caulking to vertical joints between panels.

Work at height should either be performed from platforms with guardrails, including EWP, or mobile scaffolding. Portable ladders should only be used where other methods are impracticable. Their use must comply with regulation 3.26.

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

Regulations  
3.48 to 3.57

Regulation 3.55

Regulation 3.26

The use of EWP on site must be in accordance with regulation 4.54. The requirements for maintenance, inspection and operation were mentioned in section 8.6 of this code.

Before specifying or using an EWP, a check should be made as to its suitability for the site conditions.

## 8.10 Strongbacks

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

Strongbacks should be bolted so they are hard up against the panel, otherwise they may not adequately prevent damage to the panel.

## 8.11 Erection crew

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

The crane operator must hold a certificate of competency appropriate for the type and capacity of crane in use.

The size and make-up of the remainder of the erection crew is specified in regulation 4.54 and is dependent on the maximum rated capacity of the crane used.

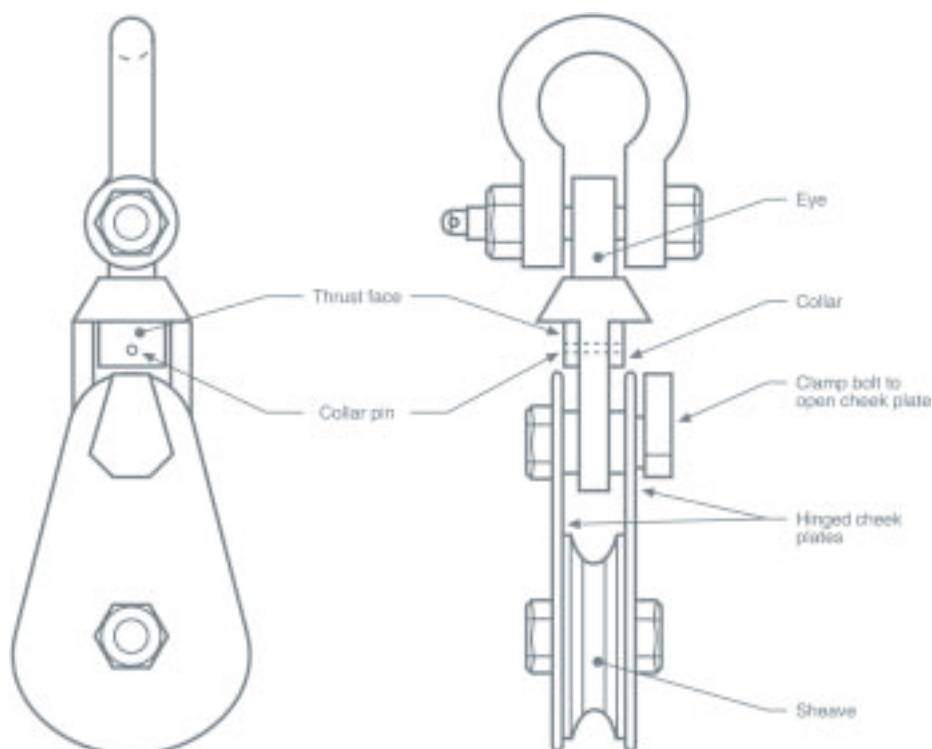
All members of the erection crew should have been trained in this code of practice, and at least one of the erection crew or another person who remains on site throughout the erection should hold a current first aid qualification.

## 8.12 Rigging

Setting up a rigging system requires careful and thorough preplanning. The selection of the rigging system connecting the concrete element to the crane should be agreed between the erector and the rigger.

The preferred configurations for concrete panel lifting are described in section 4.7.3 of this code and shown in Figure 4.3. Refer to section 5.2.3 for documentation required for rigging.

The rigging system should distribute equal loads to all lifting points.



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**Figure 8.3: Snatch block**



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

Lifts desirably should be planned so that rotation of the snatch-block under load is not required. Where the snatch block is required to rotate it needs to have thrust races or separate swivel bearings as mentioned in section 3.8 of this code.

An inspection and check of the rigging should be performed prior to lifting by the rigger in charge, especially where steel wire rope is being used in the rigging system. This inspection should include a visual check to ensure the snatch block collar pin is intact and the collar has not become loose.

Where blocks with lockable clamp bolts are not available, care needs to be taken to ensure that the cheek plate clamp bolt is fully tightened and that rubbing and abrasion under load does not occur. See Figure 8.3.

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

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

Lifting clutches should be inspected, prior to each use, for wear and deformation. If any deterioration is seen or safety concerns identified, a proof test should be conducted as mentioned in section 3.5.2 of this code.

### 8.13 Erection of concrete panels

Concrete panels should be erected in accordance with AS 3850 and the work method statement referred to in section 8.3 of this code. Before erection commences the checklist at section 8.2 should be carried out.

Concrete panels should not be lifted or erected before attaining the minimum concrete strength on the shop drawings for lifting or erection.

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

It is essential that the order in which the various components and members of the structure are assembled will maintain stability at all stages, allowing for the effects of high winds on partially completed structures. Overnight it may be necessary to stabilise incomplete structures using measures considered as part of the initial design and forming part of the designed erection sequence. They should not be an ad hoc means of stabilisation.

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

For site-cast panels, the adhesion of the panel to the casting bed has to be broken. At all times panels should be lifted smoothly to avoid shock loading which can induce cracking in the panel.

For face-lifted panels, load on the crane should not be increased if the panel does not come free when the crane's load indicator registers the combined weight of the panel, rigging and any attachments such as strongbacks.

For edge-lifted panels, load on the crane should not be increased if the panel does not come free when the crane's load indicator registers 65% of the weight of the panel plus 100% of the weight of the rigging and any attachments such as strongbacks.

In all circumstances where a lift has been stopped, procedures such as wedging or jacking should be as determined by the builder. Such procedures need to be undertaken or directly supervised by the rigger in charge of the erection. Where used, wedges should be aligned with the line of lifting inserts unless written instructions state otherwise.



Each concrete panel should be lifted so that, while suspended, it leans away from the crane. The situation when the panel tilts towards the crane is extremely dangerous. If part of the lifting system fails, in this situation, the panel will fall against the crane and may cause the crane to overturn. The requirement to lift panels in this manner can exist when panels are cast on the outside of the building to be constructed.

Bracing inserts are usually located on the same face of the panel as the lifting inserts.

Good practice dictates that whenever possible, the braces should be fixed to the concrete panel before lifting.

During the lifting process, the braces should not hang below the level of the base of the panel. This may be achieved by the use of adjustable length braces or by the use of taglines.

Where, under unusual circumstances, it is necessary to attach braces to the panel after it has been positioned, the panel should be held firmly, just past vertical by the crane while the braces are attached. Where bracing inserts are located on the opposite side of the panel to the lifting inserts, the panel should be tilted slightly back on to the rigging and the braces attached.

**No person should ever work on a concrete panel that is leaning towards them or be placed between a panel being lifted and another panel, wall or object, where movement of the panel could cause crushing. This applies until the release of the crane from the panel.**

The following practices should be followed during the lifting and placing of concrete panels:

- lifting gear and sheaves to be in good condition and lifting clutches fully engaged prior to lift occurring;
- lifting clutch release lines are fitted to enable clutches to be disengaged without the need for workers to climb on top of the panel;
- whenever possible, panels should be lifted with the rigging equipment in view of the crane operator as the crane hook is hoisted;

- all personnel should be clear of the area where the panel may fall when lifting, tilting or rotating the panel from horizontal to vertical;
- when taglines are used to control the swing of the panel, personnel should position themselves clear of the panel edges as the panel may slew sideways. Clutch release ropes should never be used as taglines;
- no attempt should be made to lift and erect panels in strong winds where wind speeds exceed those specified by the crane manufacturer;
- crane support should be maintained until all braces have been installed and secured to the panel and footings;
- the crane operator should never leave the crane while the panel is connected; and
- no brace should be connected to another panel for support unless clearly specified on the shop drawings.

After erection of a panel it is the builder's responsibility to check braces, brace bolts and pins at regular intervals to ensure they maintain the required capacity. These intervals should be determined by the builder and erector at the preplanning stage (see section 8.2 of this code). See also section 9.1, Installation and inspection of temporary bracing.

## 8.14 Modifications

Modifications to concrete panels and other precast concrete elements and their associated supporting components and connections, may only be carried out with the approval of the project design engineer. The need for modification may be due to relocation or changes to sizes of windows and doorways.

It is a requirement of the Building Regulations 1989 that the relevant local government authority be notified to obtain the consent of the building surveyor prior to proceeding with any variation from, or alteration of, approved plans, drawings and specifications. This requirement, of course, applies throughout the life of the building.

# 9

## Part

## Temporary braced condition

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# Temporary braced condition

## 9.1 Installation and inspection of temporary bracing

Bracing should be installed in accordance with AS 3850 and the approved shop drawings unless prior written approval is obtained from the erection design engineer. The capacity of a brace varies with the installation angle of the brace.

Where a single brace is used eg on narrow panels, to brace a panel, particular care is required on site to prevent impact or damage to the brace. Panels supported by a single brace only are very susceptible to failure by panel rotation about the brace.

Where single braces are used, they should have a minimum of two fixings at each end. Care needs to be taken in the installation of these two fixings as their closeness may reduce the effective anchorage of each.

Usually two braces are used to support each panel. Three braces may be necessary on large panels and in situations where load controlled expansion anchors are used in brace footings since the capacity of these anchors may be less than the capacity of the brace itself.

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

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

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

The angle of installation of braces should be shown on the shop drawings. Braces are usually installed at an angle of  $45^\circ$  to  $60^\circ$  and square to the line of the panel (see Figure 9.1) unless the erection design engineer has considered another arrangement and it is shown on the shop drawings. If site conditions prevent the braces from being installed in the positions shown on the shop drawings, the erection design engineer should be consulted and approve an alternate location and any associated changes necessary such as larger braces and higher capacity base fixing.

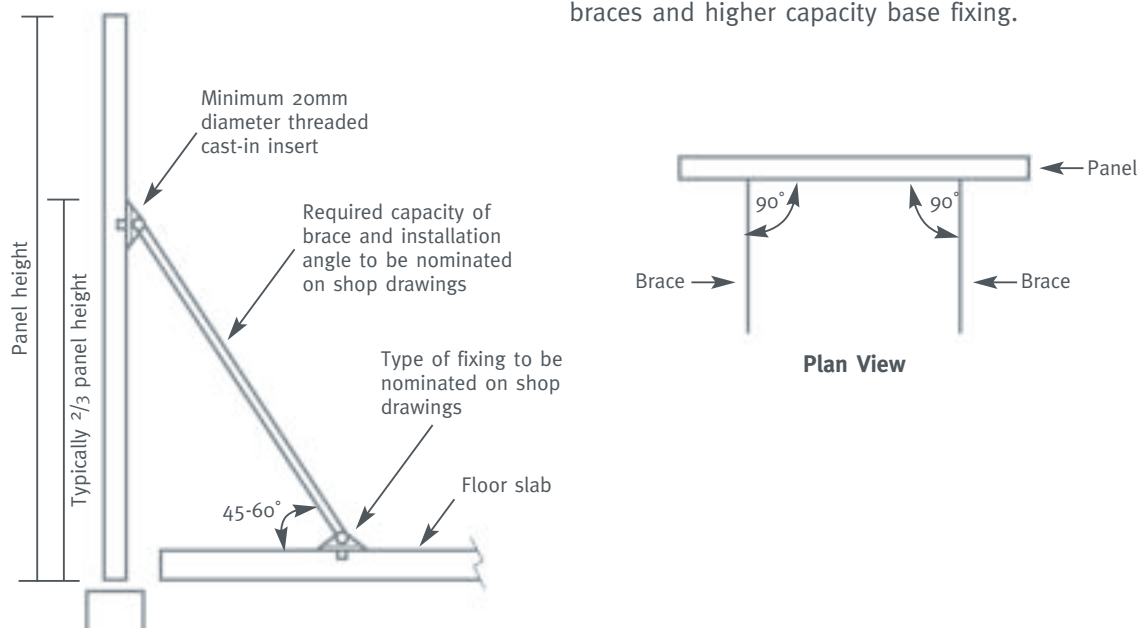


Figure 9.1: Concrete panel bracing, preferred arrangement

Figure 9.2 shows the proper method of bracing corner panels without having to skew the braces for attachment to the floor slab. Attachment of braces to concrete blocks (deadman) in the “leave-out area” between the floor slab and the panels allows the braces to be properly located without skew. Panel stability is reduced when braces are skewed.

Bracing feet (or shoes) need to be designed to prevent lateral displacement of the shoe from the fixing insert after installation.

The preferred location of bracing points in a concrete panel is at two-thirds of the height, measured from the base of the panel and at least 600mm above the centre of gravity. Where it is necessary to locate bracing points below the panel’s centre of gravity, this needs to be specifically designed and detailed on the shop drawings. Special provisions should be made to prevent “kick-out” of the base of the panel in these situations.

Regular visual inspection of panels in the braced condition needs to be carried out to check that the braces and bracing insert connections have not been loosened by wind action.

A check of the torque of the bolts should be carried out 24 hours after erection and at appropriate intervals after installation determined in the erection planning stage (see section 8.2 of this code), particularly after high winds, to ensure the bolts are correctly torqued and the braces have not moved.

## 9.2 Superimposed loads

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

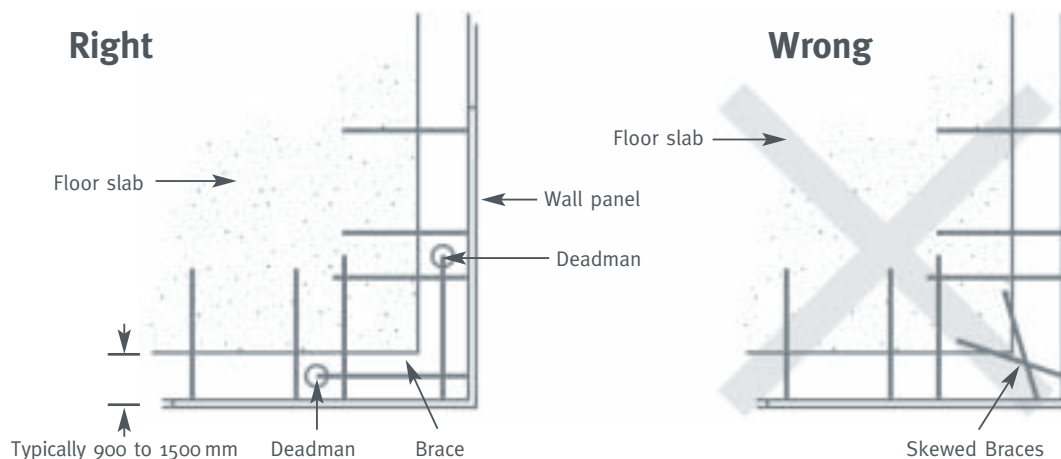
The erection of roof steelwork can exert significant outward loads onto braced panels. In some cases these forces may be sufficient to overload the temporary bracing and cause failure of the bracing inserts/bolts.

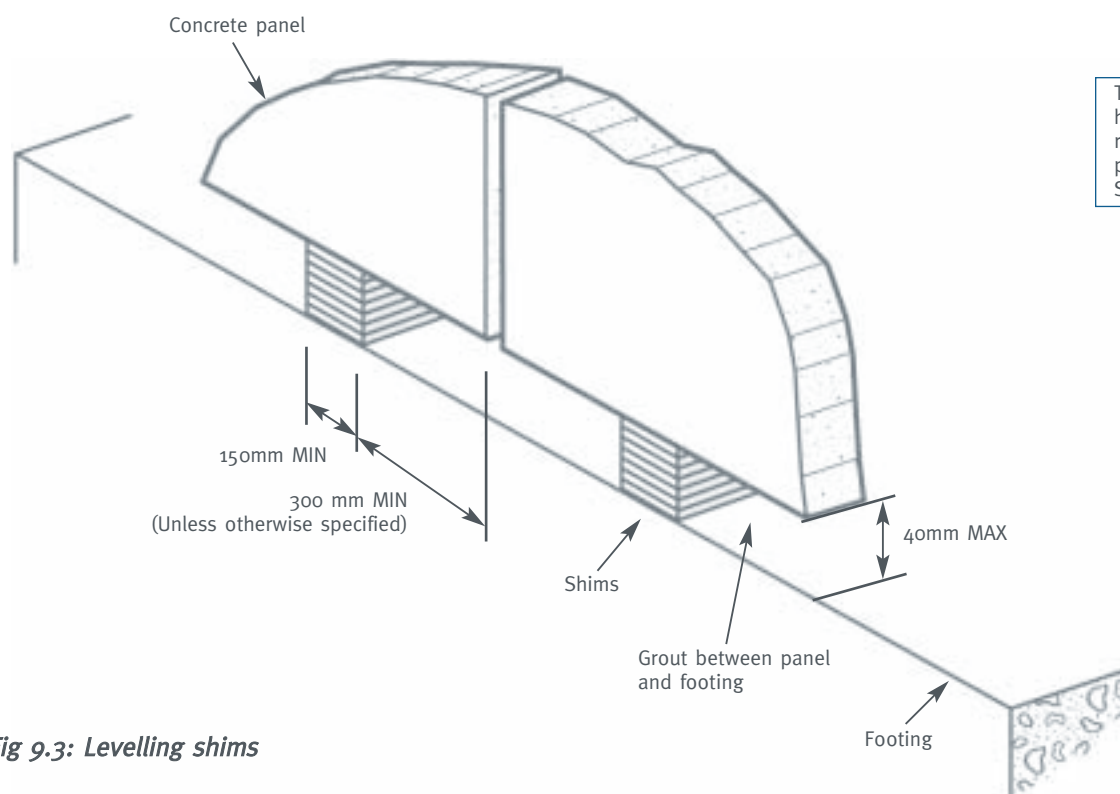
During release of a rafter’s weight from the crane, the braces adjacent to the rafter being erected should be monitored and adjusted accordingly.

As well, substantial inward forces may be imposed on braced panels and fixings to steelwork as a result of temporarily unrestrained steel rafters rotating and moving sideways under self-weight and erection loads. The resulting forces may overload bracing and fixing inserts.

To ensure safe work methods during the erection of steelwork, the project design engineer should consider the effect of the erection sequence on stability in accordance with AS 3828. Clear instructions should be provided to the steel erector for the requirement of any temporary bracing for steelwork. Where such bracing is required it should be detailed on the shop drawings so the steel erector can make provision for such bracing and riggers do not have to access an unstable structure.

**Figure 9.2: Corner bracing**





**Fig 9.3: Levelling shims**

### 9.3 Levelling pads and shims

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

See section 4.14.3 regarding horizontal restraints of concrete panels.

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

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

Shims should be located at least 300 mm in from the ends of the element and bearing support, unless otherwise specified. This is particularly relevant for thin concrete panels where edge breakout can occur if shims are placed too close to bottom corners. See Figure 9.3.

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

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

### 9.4 Grouting of the base

After concrete panels have been finally plumbed, the base of the panel and any grout pockets need to be fully grouted unless otherwise stated on the drawings. Grouting and appropriate strength gain should take place before any formwork is removed from beams or slabs supported by a panel.

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

# 10

## Part Incorporation into final structure

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# Incorporation into final structure

## 10.1 Fixing to final structure

The fixing of concrete panels should be in accordance with the structural drawings and the shop drawings including any changes made to specifications or instructions issued by the project design engineer or the erection design engineer.

All steelwork forming part of the structure should be erected in accordance with AS 3828 which sets out recommended safe working provisions and practices supported by training, for those involved in erection of the steelwork including associated trades.

The recommendations also relate to other workers on the site who may be at risk from the erection of the steelwork.

A key requirement of AS 3828 is the preparation of a work method statement by the contractor which clearly identifies the method used to erect the steelwork and how it will be fitted into the overall workplan for the project.

## 10.2 Inspection prior to and removal of braces

Panel braces should not be removed until the concrete panel is incorporated into the structure and the structure is capable of supporting the panel for the applied loads.

Prior to the removal of braces, the structure should be inspected to ensure that all structural elements affecting stability are securely fixed to the panels. This inspection should be carried out by the project design engineer and written approval to remove the braces given to the builder.

The removal of braces from a panel should be planned and carried out in a controlled manner to prevent risk of injury and damage to equipment.

Braces to be removed from site should be loaded onto transport in such a manner as to allow safe transport and avoid damage to them.

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

# Appendix A

## Definitions of terms used in this code

### A1: General definitions

#### **BUILDER**

The company or person responsible for the construction of the completed building and who has control of the building site.

#### **BUILDING DESIGNER**

The person responsible for the overall 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.

#### **CONCRETE ELEMENT**

Either a concrete panel or other precast concrete element.

#### **CONCRETE PANEL**

A concrete panel that is manufactured as a separate and movable panel for the purpose of being incorporated as a wall (including a retaining wall) once the process by which the panel is manufactured is complete, but does not include a column, beam or paving slab or a panel that is for decorative purposes only.

The panel may be precast on-site, or off-site in a factory or casting yard.

#### **ENGINEER**

Means a qualified practising engineer. A qualified practising engineer should possess an undergraduate qualification in engineering and have at least three years work experience in an engineering field.

#### **ERECTOR**

The company or person responsible for erecting the concrete elements.

#### **ERECTION DESIGN ENGINEER**

The engineer responsible for the design for the erection of the concrete elements of the building and the stability of the concrete elements during construction. The erection design engineer should be a qualified practising engineer and be competent to practice in the structural engineering field. The erection design engineer may also be the project design engineer.

#### **EXCLUSION ZONE**

An area over which concrete elements or other items, while being lifted, are suspended or pass over or may fall or drop into. Workers and members of the public should, as far as practicable, be prevented from accessing this area while lifting is taking place.

#### **PRECASTER**

The company or person responsible for manufacturing the concrete elements.

#### **PRECAST CONCRETE ELEMENT**

A concrete element usually, but not necessarily, manufactured under controlled conditions in a factory or casting yard and subsequently transported to and erected on a building site.

#### **PROJECT DESIGN ENGINEER**

The engineer responsible for the engineering design of the building. The project design engineer should be a qualified practising engineer and be competent to practice in the structural engineering field. The project design engineer may also be the erection design engineer.

#### **SHOP DETAILER**

The person responsible for preparing the shop drawings of the concrete elements. The shop detailer should be a person who, through training or experience, is able to undertake the work as described in this document.

#### **TILT-UP CONCRETE PANEL**

An essentially flat concrete panel designed in accordance with AS 3850 and AS 3600; cast in a horizontal position, usually on-site; initially lifted by rotation about one edge until in a vertical or near-vertical position; transported and lifted into position if necessary; and then stabilized by bracing members until incorporated into the final structure.

## **TILT-UP WORK**

Means any of the following:

- (a) the manufacture, transport, crange, temporary storage, erection or temporary bracing of a concrete panel;
- (b) the fixing of a concrete panel for the incorporation of the panel as a wall (including a retaining wall);
- (c) the removal of temporary bracing of a concrete panel.

## **TRANSPORTER**

The company or person responsible for transporting the concrete element.

## **A2: Technical definitions**

### **BRACES**

Certified temporary components providing stability in preventing a tilt-up concrete panel 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. Braces should not be used as props.

### **BRACING FEET OR SHOES**

The components that connect braces onto a panel or onto the bracing support or footing via pinned connections and inserts.

### **BRACING INSERT**

A component cast into a concrete panel or cast into or fixed to a brace footing, for later attachment of a brace.

## **CONNECTIONS**

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

### **CRANE RATED CAPACITY**

The maximum load which may be applied to the crane while in a particular working configuration and under a particular condition of use.

### **CRANE STANDING AREA**

The base on which the crane is supported during erection of the concrete elements. Referred to as the erection platform in AS 3850.

### **EDGE LIFTING**

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

### **EXPANSION ANCHORS**

Anchors placed in holes drilled in hardened concrete which rely on expansion devices within the hole to prevent pullout under load. The two types of expansion anchors are:

#### ***Load controlled***

Anchors that have a wedge and expansion-shield system where the wedge is directly connected to the applied load. Increases in load above the retained preload from the initial torque will increase the expansion force.

This type of expansion anchor is the only type permitted in tilt-up and precast construction.

### ***Deformation controlled***

Anchors that are expanded only during installation. Application of further load to the anchor does not increase the expansion force.

This type of anchor is not permitted in tilt-up and precast construction.

### **FACE LIFTING**

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

### **FIXING INSERT**

A component cast into or fixed to the concrete element and used to tie it into the structure.

### **FIXINGS**

The hardware components of all connections including bolts, washers, weld plates, anchors etc.

### **JOINTS**

The gap between adjoining concrete elements or between a concrete element and some other portion of the structure.

### **LEVELLING SHIMS**

Proprietary material used under concrete elements to support them in their correct position until the final connection is made.

### **LIFTING BEAM**

A certified component of the rigging system that transfers the load from the concrete element to the crane.

**LIFTING CLUTCH**

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

**LIFTING INSERT**

A component cast into the concrete element for lifting it during erection.

**LIFTING SPREADER**

A certified device that spreads the lifting ropes and distributes the lifting load.

**LIMIT STATE FACTOR (LSF)**

The number by which the failure load is divided to give the working load limit (WLL) as referenced in AS 3850.

**PROPRIETARY COMPONENTS**

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

**PROGRESSIVE COLLAPSE**

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

**PROPS**

Certified temporary components supporting loads. Both ends of the prop are fitted with rigid foot plates that provide support between two parallel surfaces. Props should not be used as braces.

**REINFORCEMENT*****Structural reinforcement***

Reinforcement, including reinforcing steel and prestressing tendons, provided for the integrity of the completed structure.

***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.

**RIGGING SYSTEM**

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

**SHEAR CONE FAILURE**

The type of failure reached 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 concrete element.

**SHOP DRAWING**

A detailed drawing of a concrete element used in the manufacturing and erection processes.

**STRONGBACK**

A specified temporary steel member fixed to a concrete element to provide localised strengthening during lifting, transport or erection.

**TAGLINE OR TAIL ROPE**

A non-conductive line (eg fibre rope) attached to the element being erected to help control the element during lifting and placement.

**WLL (WORKING LOAD LIMIT)**

The maximum load that may be applied to an item, component or system. Formerly referred to as the safe working load (SWL).

**WORK METHOD STATEMENT**

A document setting out safe working procedures.

# Appendix B

## Sample documents, schedules and shop drawing

PROJECT

SITE ADDRESS

### CONCRETE PANEL SCHEDULE: PLANNING

Sheet 1

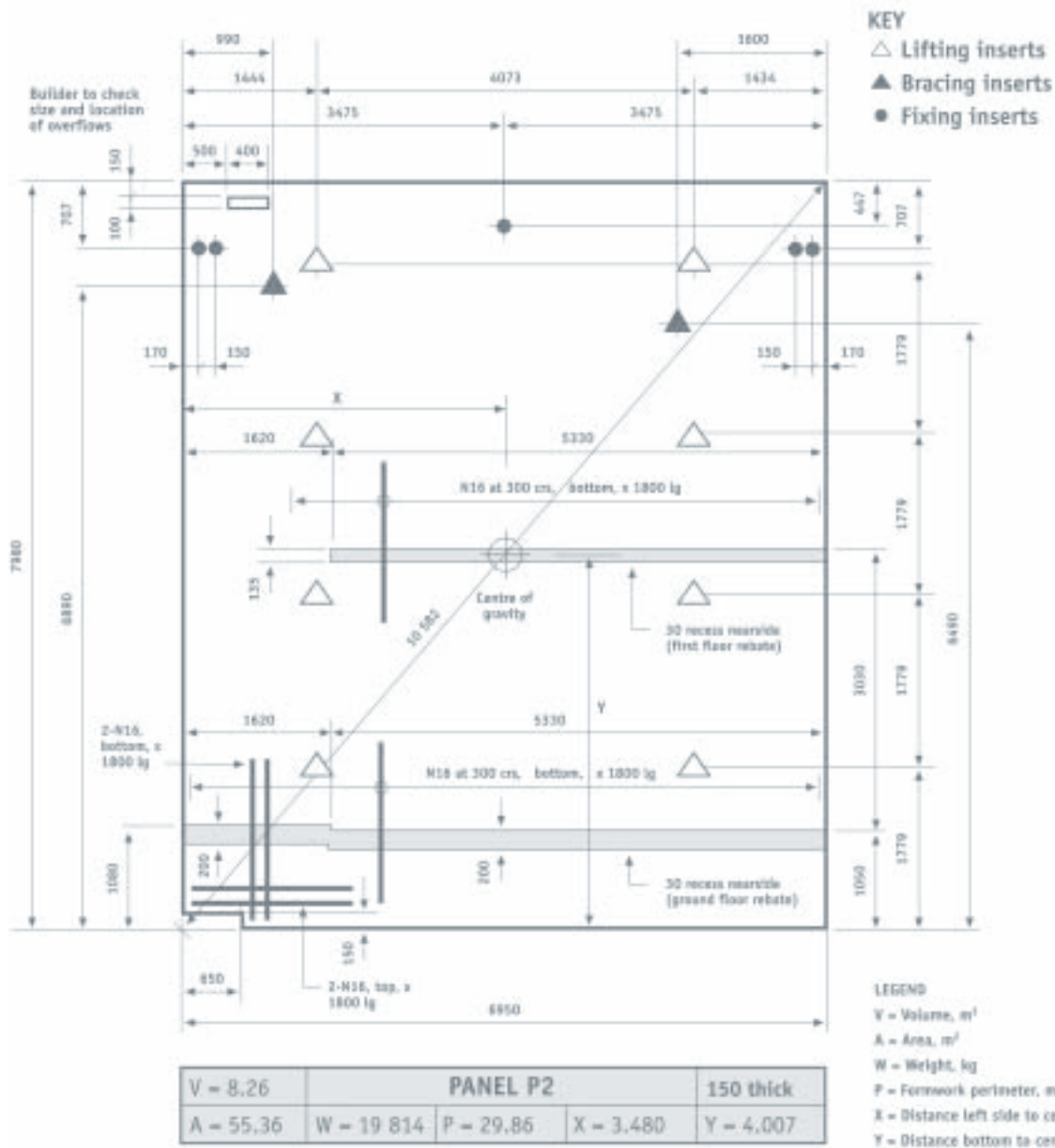
Planning Task	Action	Name	Initiation Date	Receipt Date
Notification to WorkSafe Western Australia Commissioner of intention to cast concrete panels in accordance with AS 3850	Builder			
Construction programme prepared	Builder			
Shop drawings prepared	Shop Detailer			
C.P.S. PROPERTIES completed	Builder			
Concrete element layout plan showing site constraints, stacking sequence, crane position/s, erection sequence and temporary brace position	Builder/ Site Manager/ Erector			
Shop drawings and layout plan marked up and signed by engineer	Erection Design Engineer			
Approved shop drawings checked for structural intent by engineer	Project Design Engineer			
Work Method Statement: SITE ESTABLISHMENT/SERVICES	Site Manager			
Work Method Statement: CONCRETE ELEMENT PRODUCTION	Site Manager			
Work Method Statement: CONCRETE ELEMENT ERECTION	Erector			
Work Method Statement: STEEL INCORPORATION INTO FINAL STRUCTURE	Erector			
Local Government Authority Building Licence	Builder			
Reinforcement scheduled from approved shop drawings	Builder			
C.P.S. HARDWARE completed	Builder			
Panel casting sequence programmed from construction programme and layout plan	Site Manager			
Workplan Master File: PLANNING/PRODUCTION/ERECTION	Builder			

### HOLD POINT

Concrete element production must not commence until all planning requirements are satisfied

# Sheet 2

Typical shop drawing of panel details



This illustration has been reproduced from the Concrete Panel Buildings Briefing 08 January 2003 with permission of Cement Concrete & Aggregates Australia





<b>PROJECT</b>
<b>SITE ADDRESS</b>

## CONCRETE PANEL SCHEDULE: PROPERTIES

## Sheet 4

### HOLD POINT

Concrete element production must not commence until all the planning requirements are satisfied

Production Task	Action	Name	Completion Date
<b>Audit all panel components against C.P.S. HARDWARE are on site</b>	Site Manager		
Audit scheduled reinforcement and “shake out” into individual panels	Site Manager		
Set out casting beds in accordance with concrete element layout plan	Site Manager		
Provide compacted limestone (or alternative) access ramps and slab edge protection for concrete agitator trucks	Site Manager		
<b>KEEP ELECTRIC LEADS CLEAR OF ALL VEHICLE ACCESSWAYS</b>			
START concrete element production in accordance with panel casting programme and C.P.S. QUALITY CONTROL	Site Manager		
Maintain daily concrete delivery and test records for C.P.S. QUALITY CONTROL (test as per AS 1379)	Site Manager		
Set out and permanently mark panel positions on footings. Verify dimensions “close-out” with layout plan	Site Manager		
Clearly mark panel level pad positions on footings and record pad thicknesses on concrete element layout plan	Site Manager		
<b>MAINTAIN STRICT HOUSEKEEPING AND CLEANLINESS POLICY</b>			
C.P.S. QUALITY CONTROL completed, test results recorded and completed	Site Manager		
Strip formwork, cleanup, remove from erection area. Clearly mark panel number on panel base	Site Manager		
Audit temporary strongbacks and falsework delivered in accordance with shop drawings and layout plan	Site Manager		
Audit temporary brace insert bolts with 20mm galv. structural and spring washer assembly	Site Manager		
Audit temporary brace torque controlled floor anchors with 20mm galv. structural washer assembly	Site Manager		

### HOLD POINT

Concrete element erection must not commence until all the production requirements are satisfied



<b>SITE ADDRESS</b>
<b>DATE</b>

## CONCRETE PANEL SCHEDULE: ERECTION

## Sheet 6

### HOLD POINT

**Concrete element erection must not commence until all the production requirements are satisfied**

Erection Task	Action	Name	Completion Date
Provide compacted limestone (or alternative) access ramps and slab edge protection for crane	Site Manager		
Identify and clearly mark any U/ground services in “angle of repose” vicinity of crane standing area	Site Manager/ Erector		
Traffic management plan approved with valid permits and/or personnel deployed in accordance with Work Method Statement: CONCRETE ELEMENT ERECTION	Site Manager/ Erector		
Erection and fall zones are warning barricaded from unauthorised entry and from public safety	Site Manager/ Erector		
Crane supplied is of capacity planned in layout plan and in approved service condition	Site Manager/ Erector		
Rigging equipment and hardware of capacity as approved on shop drawings, layout plan and Work Method Statement	Erector		
Crane and rigging personnel demonstrate technical competencies and complete site induction	Site Manager/ Erector		
All erection personnel have participated and “signed off” the JOB SAFETY ANALYSIS	Erector		
Correct diameter drill-bits/adequate sized rotary hammer drills, at least 3 suitable panel bars, rotary socket wrenches and manual torque socket wrench	Erector		
<b>KEEP ELECTRIC LEADS CLEAR OF ALL CONCRETE ELEMENTS BEING ERECTED</b>			
Temporary bracing anchors to be torque “preloaded” on installation ONLY and recorded on C.P.S. TORQUE REGISTER	Erector		
All concrete elements to be aligned, base restrained, in plumb and temporary bracing anchors to be checked for “slip-load” (70%) preload	Erector		

### HOLD POINT

**Incorporation of structural steel into final structure must not commence until all the concrete element erection requirements are satisfied**

<b>PROJECT</b>
<b>SITE ADDRESS</b>
<b>DATE</b>

## STRUCTURAL STEEL INCORPORATION INTO FINAL STRUCTURE

## Sheet 7

### HOLD POINT

**Incorporation of structural steel into final structure must not commence until all the concrete element erection requirements are satisfied**

Structural Steel Erection Task	Action	Name	Completion Date
Provide compacted limestone (or alternative) access ramps and slab edge protection for crane and EWP	Site Manager		
Identify and clearly mark any U/Ground services in "angle of repose" vicinity of crane standing area	Site Manager/ Erector		
Identify and clearly mark any slab penetrations and concrete element temporary bracing obstructions affecting EWP and crane mobility	Site Manager/ Erector		
Traffic management plan approved with valid permits and/or personnel deployed in accordance with Work Method Statement: STRUCTURAL STEEL INCORPORATION INTO FINAL STRUCTURE	Site Manager/ Erector		
Erection and fall zones are warning barricaded from unauthorised entry and for public safety	Site Manager/ Erector		
Structural steel fabricated and delivered to site is in accordance with shop drawings, structural steel layout plan and Work Method Statement	Site Manager/ Erector		
Crane, EWP and rigging personnel demonstrate technical competencies and complete site induction	Site Manager/ Erector		
All erection personnel have participated and "signed off" the JOB SAFETY ANALYSIS	Erector		
Fall prevention systems are recognised, maintained and monitored throughout structural steel erection	Erector		
On completion of erection of structural steel the entire structure inspected for structural compliance	Project Design Engineer		

### HOLD POINT

**Concrete element temporary bracing removal and loading of roofing material and/or plant onto structural steel must not commence until structure is inspected and written approval of compliance by project design engineer.**

Record concrete element temporary bracing removal on C.P.S.TORQUE REGISTER	Site Manager		
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# Appendix C

## Referenced documents and further reading

### Legislation referenced

- *Occupational Safety and Health Act 1984*
- Occupational Safety and Health Regulations 1996
- Building Regulations 1989

### Publications referenced

#### ***Commission for Occupational Safety and Health***

- Guidance Note: General Duty of Care in Western Australian Workplaces
- Codes of Practice: First Aid Facilities and Services, Workplace Amenities and Facilities, Personal Protective Clothing and Equipment
- Code of Practice: Prevention of Falls at Workplaces

#### ***WorkSafe***

- Guidelines for Work in the Vicinity of Overhead Power Lines

#### ***Australian Standards***

- AS 1012 *Methods of testing concrete*
- AS/NZS 1170.0 *Structural design actions – General principles*
- AS/NZS 1170.1 *Structural design actions – Permanent, imposed and other actions*
- AS/NZS 1170.2 *Structural design actions – Wind actions*
- AS/NZS 1170.4 *Minimum design loads on structures – Earthquake loads*
- AS 1379 *Specification and supply of concrete*
- AS 1418 *Cranes (including hoists and winches)*
- AS 2550 *Cranes- Safe use*
- AS 3600 *Concrete structures*
- AS 3610 *Formwork for concrete*
- AS 3799 *Liquid membrane-forming curing compounds for concrete*
- AS 3828 *Guidelines for the erection of building steelwork*
- AS 3850 *Tilt-up concrete construction*
- AS 4100 *Steel structures*

## Other documents referenced

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

The Building Code of Australia 96 (BCA96) is a uniform set of technical provisions for the design and construction of buildings and other structures throughout Australia. It allows for variations in climate and geological or geographic conditions. The BCA is produced and maintained by the Australian Building Codes Board (ABCB) on behalf of the Commonwealth Government and each State and Territory Government. The BCA96 is available as a stand-alone product or with value-added products included. The stand-alone versions are available from the ABCB's Principal Publishers, Standards and CanPrint, in electronic and hard copy formats.

- Z48: Precast Concrete Handbook, produced by the National Precast Concrete Association of Australia and published by the Concrete Institute of Australia.
- Z10: Recommended Practice, Design of Tilt-up Concrete Wall Panels, published by the Concrete Institute of Australia.

## Further reading, advice and information

Additional and more detailed information can be obtained from the above organisations and their websites and some of these documents are listed below.

### *Cement & Concrete Association of Australia*

- Tilt-up Construction Notes
- Briefing Notes (monthly publication)

### *National Precast Concrete Association of Australia*

- National Precaster (Newsletter)

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