

Approved Code of Practice for
**The Safe Handling,
Transportation and
Erection of
Precast Concrete**

ACKNOWLEDGEMENT

This approved code of practice has been developed in consultation with:

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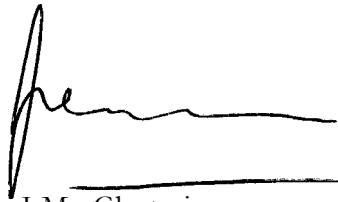
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NOTICE OF ISSUE

I have issued this *Approved Code of Practice for the Safe Handling, Transportation and Erection of Precast Concrete*, being a statement of preferred work practices or arrangements for the purpose of ensuring the health and safety of persons to which this code applies and persons who may be affected by the activities covered by this code.

A handwritten signature in black ink, appearing to read 'J.M. Chetwin', written over a horizontal line.

J.M. Chetwin
Secretary of Labour

FOREWORD

I have approved this statement of preferred work practices, which is an *Approved Code of Practice for Handling, Transportation and Erection of Precast Concrete*, under section 20 of the Health and Safety in Employment Act 1992.

When a code is approved, a Court may have regard to it in relation to compliance with the relevant sections of the Health and Safety in Employment Act 1992. This means that if an employer in an industry or using a process to which an approved code applies can show compliance with that code in all matters it covers, a Court may consider this to be compliance with the provisions of the Act to which the code relates.



Hon. Margaret Wilson
Minister of Labour

SUMMARY OF THE HEALTH AND SAFETY IN EMPLOYMENT ACT 1992

The principal object of the Health and Safety in Employment Act 1992 (HSE Act) is to prevent harm to employees at work. To do this, it imposes duties on employers, employees, principals and others, and promotes excellent health and safety management by employers. It also provides for the making of regulations and codes of practice.

APPROVED CODES OF PRACTICE

The HSE Act provides for the development and approval of statements of preferred work practice or arrangements that may be approved as “approved codes of practice”. These are recommended means of compliance with provisions of the Act, and may include procedures which could be taken into account when deciding on the practicable steps to be taken. Compliance with codes of practice is not mandatory. However, they may be used as evidence of good practice in Court.

EMPLOYERS’ DUTIES

Employers have the most duties to ensure the health and safety of employees.

Employers have a general duty to take all practicable steps to ensure the safety of employees while at work. (This is set out in section 6.) In particular, they are required to take all practicable steps to:

- Provide and maintain a safe working environment;
- Provide and maintain facilities for the safety and health of employees at work;
- Ensure that machinery and equipment is designed, made, set up, and maintained to be safe for employees;
- Ensure that employees are not exposed to hazards in the course of their work; and
- Provide procedures to deal with emergencies that may arise while employees are at work.

HAZARD MANAGEMENT

Employers shall have an effective method to identify hazards in the place of work (previously existing, new and potential) and regularly review them to determine whether they are significant hazards and require further action. Where there occurs any accident or harm in respect of which an employer is required to record particulars, the Act, section 7(2), requires the employers to take all practicable steps to ensure that the occurrence is so investigated as to determine whether it was caused by or arose from a significant hazard.

“Significant hazard” means a hazard that is an actual or potential cause or source of:

- Serious harm; or
- Harm (being more than trivial) where the severity of effects on any person depend (entirely or among other things) on the extent or frequency of the person’s exposure to the hazard; or
- Harm that does not usually occur, or usually is not easily detectable, until a significant time after exposure to the hazard.

Where the hazard is significant, the HSE Act sets out the steps employers must take:

- Where practicable, the hazard must be eliminated.
- If elimination is not practicable, the hazard must be isolated.
- If it is impracticable to eliminate or isolate the hazard completely, then the employer must minimise the hazard to employees.

In addition, the employer must, where appropriate:

- Ensure that protective clothing and equipment is provided, accessible and used;
- Monitor employees’ exposure to the hazard;
- Seek consent of employees to monitor their health; and
- With informed consent, monitor employees’ health.

INFORMATION FOR EMPLOYEES

Before employees begin work, they must be informed by their employer of:

- Emergency procedures;
- Hazards employees may be exposed to while at work;
- Hazards employees may create while at work which could harm other people;
- How to minimise the likelihood of these hazards becoming a source of harm to themselves and others; and

- The location and correct use of safety equipment.

Employers are also required to inform employees of the results of any health and safety monitoring. In doing so, the privacy of individual employees must be protected.

EMPLOYERS TO INVOLVE EMPLOYEES IN THE DEVELOPMENT OF HEALTH AND SAFETY PROCEDURES

Employers need to ensure that all employees have the opportunity to be fully involved in the development of procedures for the purpose of identifying hazards and dealing with significant hazards, or dealing with or reacting to emergencies and imminent dangers.

TRAINING OF EMPLOYEES

Employers must ensure employees are either sufficiently experienced to do their work safely or are supervised by an experienced person. In addition, employees must be adequately trained in the safe use of equipment in the place of work, including protective clothing and equipment.

SAFETY OF PEOPLE WHO ARE NOT EMPLOYEES

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

EMPLOYEES' DUTIES

If you are an employee, the Act gives you responsibility for your own safety and health while at work. You must also ensure that your actions do not harm anyone else.

ACCIDENTS AND SERIOUS HARM (RECORDS AND NOTIFICATION)

The Act defines:

“Accident” means an event that:

- (a) Causes any person to be harmed; or
- (b) In different circumstances, might have caused any person to be harmed.

This means that “accident” includes both near misses and accidents that result in harm to a person or might have caused any person to be harmed. Every employer is required to maintain a register of accidents and serious harm; and record particulars relating to:

- (a) Every accident that harmed (or, as the case may be, might have harmed)–
 - (i) Any employee at work; or
 - (ii) Any person in a place of work controlled by the employer; and
- (b) Every occurrence of serious harm to an employee at work, or as a result of any hazard to which the employee was exposed while at work, in the employment of the employer.

Where there occurs any serious harm or accident an employer must:

- (a) As soon as possible after its occurrence, notify the nearest OSH office of the occurrence; and
- (b) Within 7 days of the occurrence, give the Secretary of Labour written notice, in the prescribed form, of the circumstances of the occurrence.

The notification to the Secretary applies to:

- (a) Every occurrence of serious harm to an employee at work, or the occurrence of serious harm as a result of any hazard to which the employee was exposed while at work, in the employment of the employer; and
- (b) Accidents of a kind or description required by regulations.

PART 1. INTRODUCTION

1.1 PURPOSE

The purpose of this approved code of practice is to provide practical guidance and set minimum standards for the safe handling, transportation and erection of precast concrete elements.

1.2 APPLICATION OF THIS CODE

This code applies to all places of work at which an employee has to handle, transport or erect precast concrete components.

1.3 INTERPRETATION

1.3.1 “Shall” and “must” imply the instruction is mandatory for compliance with the code.

1.3.2 “Should” and “may” imply that the recommendation be adopted where practicable.

1.4 DEFINITIONS

Brace means a member placed diagonally with respect to the vertical plane of a precast component and rigidly fixed to provide stability.

Builder means a person who is engaged to do any building work using precast concrete components.

Competent means a person who has acquired, through a combination of qualifications, training or experience, the knowledge and skill to perform the task required.

Crane

- (a) Means a powered device:
 - (i) That is equipped with mechanical means for raising or lowering loads suspended by means of a hook or other load-handling device; and
 - (ii) That can, by movement of the whole device or of its boom, jib, trolley or other such part, reposition or move suspended loads both vertically and horizontally, and;
- (b) Includes all parts of the crane down to and including the hook or

load-handling device, and all chains, rails, ropes, wires, or other devices used to move the hook or load-handling device; but

- (c) Does not include lifting gear that is not an integral part of the crane.

Cyclic load means a reversing recurring load.

Designer means a person who, through training and experience, is qualified to design a device, system or element to serve a specific purpose.

Dogger/Rigger means a person who has been instructed in the proper selection of slings and the slinging of loads, and who understands the crane with which he is working. A dogger is competent to carry out elementary slinging or lifting tasks and the directing and positioning of loads.

Dunnage means timber (normally) material stowed under or between precast concrete elements to prevent damage or instability during storage and transportation.

Element means an individual precast concrete unit, e.g. column, stairs, beam and panel, etc.

Employee means a person employed by any other person to do any work (other than residential work) for hire or reward; and in relation to any employer, means an employee of the employer.

Employer means a person who employs any other person to do any work for hire or reward, and in relation to any employee, means an employer of the employee.

Levelling shim means a single or series of thin strips of suitable material that are used under elements to assist with final positioning.

Lifting spreader means a device which spreads the lifting ropes, chains or slings and is in compression.

Lifting beam means a beam which carries loads from two or more points while being supported from one or more different points.

Non-standard lift means a lift that requires specific rigging or load equalisation procedures.

Precast concrete means a concrete element cast in other than its final position in the main structure.

Prop means a member, whether proprietary or of specific design, used to support a precast concrete element.

Registered Engineer means a qualified engineer who is registered by the Engineers' Registration Board and holds a current annual practising certificate.

Rigging means the use of mechanical load-shifting equipment and associated gear to move, place or secure a load including members of a building or structure and ensure the stability of those members.

Shop drawing means a line drawing of a precast element which is used in the manufacturing process to describe detail.

Standard lift means a lift that requires no special rigging or load equalisation procedures, i.e. not more than two anchors must be capable of carrying the applied load with the required factor of safety.

Strong back means a member connected to a precast concrete element to provide additional strength or support during handling.

Tag line means a rope attached to the load to be used to control the load during lifting or positioning.

Tilt slab means a concrete element, normally cast in a horizontal position at or near its final location. It is lifted to the vertical position with one edge remaining on the casting floor.

PART 2. DESIGN

2.1 GENERAL

This section is in five parts:

- 2.1 General
- 2.2 Precast element design
- 2.3 Bracing design
- 2.4 Construction methods
- 2.5 Lifting inserts and lifting clutches

The design and construction of all precast elements must be in accordance with the overall building design, and shall comply with the requirements of the *New Zealand Building Code*.

This code of practice refers to design issues specific to the safe handling, transportation and erection of precast concrete elements.

Design of precast concrete elements and construction systems shall only be undertaken by a competent person.

2.2 PRECAST ELEMENT DESIGN

2.2.1 Loads

Refer to the *New Zealand Building Code* for design loads. Loads during construction of precast concrete elements may include (but may not be limited to):

- (1) Variations in load distribution (with time) during construction. For example, variations in propping loads due to the effect of prestressing.
- (2) Loading on the bracing inserts, lifting inserts, lifting gear and precast elements from the dead load, the sling angles and any extraordinary dynamic load or impact load applied through handling.

2.2.2 Lifting from Casting Beds

When lifting precast elements from a casting bed, an allowance should be made for suction or demoulding forces. These allowances typically add 10% to 50% to the weight of the element.

2.2.3 Precast Element Size

In determining the size and shape of precast elements, consideration should be given to factors affecting safety including:

- (1) Size of crane available to undertake erection;
- (2) Access to and around the site;
- (3) Propping and/or bracing requirements, and
- (4) Transport restrictions.

Where elements are designed to be cast off-site, the designer should consider the effect of LTSA authority limits on length, width, height, and weight. Consideration also needs to be given to the availability of suitable and adequate transport equipment.

Joint widths between adjacent precast elements should be sufficient to allow safe alignment during erection and to accommodate tolerances.

2.2.4 Reinforcement Design

Additional reinforcement may be required in the following instances for safe handling and propping of elements:

- (1) At temporary support points.
- (2) Where temporary support conditions result in stresses greater than those the final structure was designed for.
- (3) For handling elements which do not achieve their full strength until being built in (e.g. partial-height precast beams).

2.2.5 Thin Panels

- (1) Thin panels are generally designed as unreinforced elements for handling and erection unless prestressed.

The designer shall consider the consequence of inadvertent overloading and cracking of such elements during handling, and shall provide reinforcement where necessary to limit sudden catastrophic collapse.

- (2) Where panels are being handled flat off a casting bed or truck, the centre of the lifting inserts should coincide with the centre of gravity of the precast element.
- (3) Where a panel is to be lifted flat and then tilted to a vertical position in one operation, the panel may only be lifted using two crane hooks. The panel and the lifting inserts must be designed for that purpose.

The rigging configuration intended by the panel designer shall be clearly shown with the construction documents.

- (4) For tilt-up panels the centre of the lifting inserts should normally be at least 300 mm closer to the top of the panel than the centre of gravity of the panel so that the suspended panel will hang near vertical. Running rigging is commonly used with tilt panels. The

bottom edge must stay on the ground or platform to maintain control. (See figure 1.)

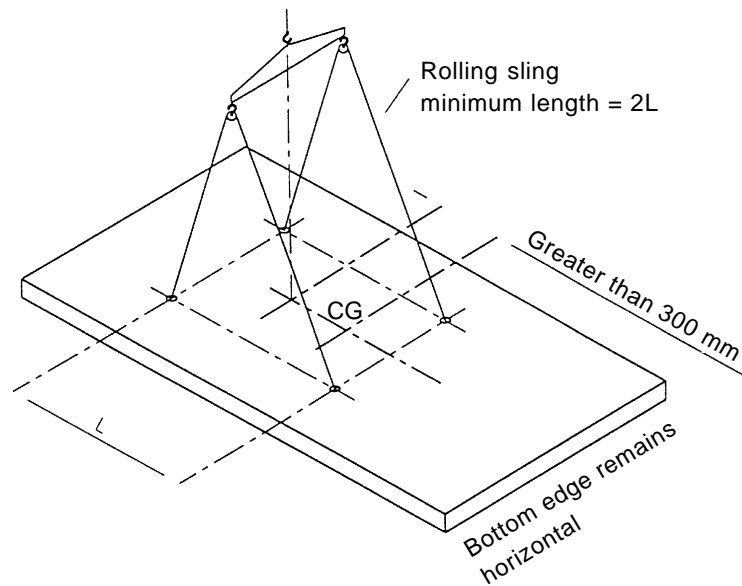


Figure 1. Arrangement for positioning panel

- (5) The lifting inserts and the rigging for tilt up panels should be so arranged that when the panel is lifted it remains stable and the bottom edge remains horizontal.
- (6) Designers should attempt, whenever possible, to design inserts to suit the common rigging configurations shown in figure 2.
- (7) The loads on anchors and stresses within panels vary with the length of rigging slings. The minimum length of a rigging sling should allow for a maximum angle of 60 degrees at the hook or pulley block.

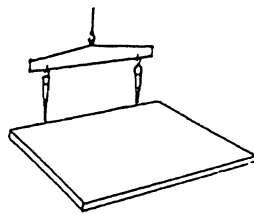
The designer may nominate a strop length, or range of lengths, required for the design, and must do so when the design requires a particular strop length.

- (8) The loads on anchors and stresses within panels vary with the angle of tilt. The designer should allow for the loads and stress at all angles of tilt.
- (9) The design chart on page 18 shows design handling stresses for some simple tilt up panels. This chart must not be used for panels with openings, irregularities, or recesses.
- (10) If elements are large or awkwardly shaped, it may be necessary for the designer to allow for the use of strong-backs to limit concrete stresses to acceptable levels.

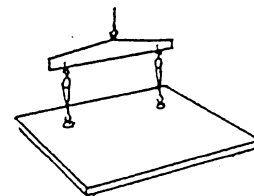
The designer should take into account the size, shape and weight of the panel when designing the strong-back and the connection details. If the strong-back is to have lifting gear fixed to it, it must be designed for that purpose.

The weight of the strong-back must be taken into account in determining the centre of gravity of the panel. Failure to do this could result in the panel hanging out of plumb and making erection difficult.

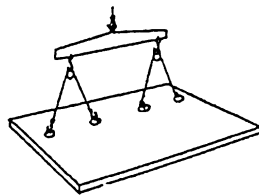
Strong-back connections to the panel should be by way of cast-in insert or structural expansion anchor. If structural expansion anchors are used the working load should be less than the clamping force provided by the anchor. (See 2.3.4)



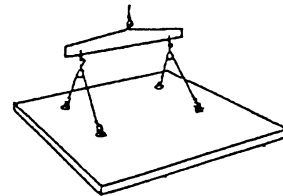
Edge lift



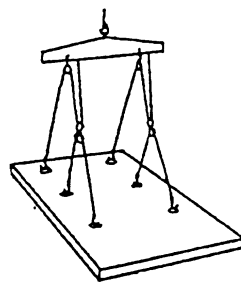
Single row (2 point)



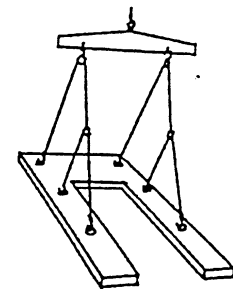
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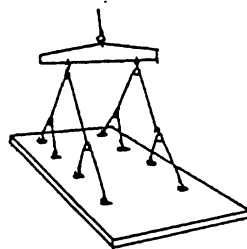
Double row



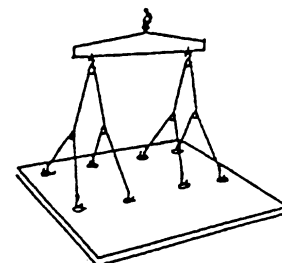
3 high equal load



3 high double load (top anchors)



4 high 2 wide



2 high 4 wide

Figure 2. Common rigging configurations

TILT-UP PANEL DESIGN CHART

Stress Tables — Solid Panels Only

The tables below show the maximum vertical flexural stresses induced when tilt up panels are being lifted with the three most commonly used rigging arrangements.

These tables assume that the vertical flexural stresses induced exceed those being induced in a horizontal direction.

In cases where the horizontal length of the panel is significantly greater than the height of a panel, a four point single row face or edge lift should be adopted to ensure that the horizontal flexural stress induced does not become excessive. Panels can be safely lifted when the actual calculated flexural tensile stress from the appropriate table is less than or equal to the allowable flexural stress given in table 1.

Under normal circumstances only the minimum, centrally placed, shrinkage control steel (Cl.5.3.36 of NZS 3101) will be required for tilt-up panels. Additional reinforcing steel does not reduce the flexural stresses induced in panels during lifting.

TABLE 1

f'_c	10	15	20	25	30	35	40
$0.75\sqrt{f'_c}$	2.37	2.91	3.35	3.75	4.10	4.44	4.74
$0.41\sqrt{f'_c}$	1.30	1.59	1.83	2.05	2.25	2.43	2.61

f'_c = Concrete compressive strength at time of lift. (MPa)

$0.75\sqrt{f'_c}$ = modulus of rupture as recommended by A.C.I. This is a value which usually produces the first crack in the concrete. (MPa)

$0.41\sqrt{f'_c}$ = the allowable flexural tensile stress in MPa for the given compressive strength at time of lift.

f_b = actual calculated flexural tensile stress during erection as shown in stress tables (MPa)

ACTUAL CALCULATED FLEXURAL TENSILE STRESS (MPa)

Panel Thickness	EDGE LIFT				
	Panel Height (m) = H				
100mm	2.5	3.0	3.5	4.0	4.5
120mm	1.58	2.27			
150mm	1.31	1.89	2.57		
175mm	1.05	1.51	2.06	2.69	
200mm	0.90	1.30	1.76	2.30	2.91
	0.79	1.13	1.54	2.01	2.55

Panel Thickness	SINGLE ROW FACE LIFT (2pt or 4pt)							
	Panel Height (m) = H							
100mm	4.0	4.5	5.0	5.5	6.0	6.6	7.0	6.0
120mm	1.36	1.72	2.12	2.56				
150mm	1.13	1.43	1.77	2.14	2.54			
175mm	0.90	1.14	1.41	1.71	2.03	2.39	2.77	
200mm	0.78	0.98	1.21	1.46	1.74	2.05	2.37	2.72
	0.68	0.86	1.06	1.28	1.53	1.79	2.08	2.39

Panel Thickness	DOUBLE ROW FACE LIFT											
	Panel Height (m) = H											
100mm	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0		
120mm	1.60	1.86	2.13	2.42								
150mm	1.33	1.55	1.78	2.02	2.28	2.56						
175mm	1.07	1.24	1.42	1.62	1.83	2.05	2.28	2.53				
200mm	0.91	1.06	1.22	1.39	1.56	1.75	1.95	2.16	2.39			
	0.80	0.93	1.07	1.21	1.37	1.53	1.71	1.90	2.09	2.30		

2.2.6 Lifting Inserts

- (1) When choosing the number of lifting inserts to be used in elements, consideration should be given to the lifting insert capacity, the total weight of the elements, their length and height, the position of any cut-outs and openings, and rigging arrangements. Additional lifting inserts are often added for multiple lifts, for demoulding from the bed, handling, transportation, and erection.
- (2) Lifting inserts shall be designed with a minimum factor of safety of 3 unless they are to be used for multiple lift applications (e.g. reusable manhole covers, concrete counterweights) in which case they should be designed with a factor of safety of 5.
- (3) 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 lifting devices that are loaded concurrently.
 - Concrete thickness.
 - Concrete strength at lifting.
 - Embedment depth.
 - The presence of cracks.
 - The proximity of reinforcement or prestressing tendons.
 - Tension stresses in the concrete around the anchorage.

Note: Horizontal bars placed around the foot of a lifting insert should be used where recommended by the manufacturer, but may provide very little, if any, additional lifting capacity.

- (4) Refer to the manufacturers data sheets for design loads on inserts, taking account of the factors given in (3) above.
- (5) Some types of lifting inserts require reinforcing to develop their required load capacity. This additional reinforcing shall be placed in accordance with the requirements of this code, the New Zealand Standards and the suppliers recommendations.

Note 1: Lifting inserts are referred to by their maximum load capacity. Their actual safe load may be considerably less depending on conditions.

Note 2: This part of section 2.2 covers the use of inserts in elements. Inserts on their own are also covered by section 2.5 and some information is repeated in both sections.

2.3 BRACING DESIGN

2.3.1 Loads

- (1) Bracing shall be designed for wind and construction loads.
 - (a) It is common practice to adopt a design wind load of 0.5 kPa for temporary conditions during erection.
 - (b) Where the temporary bracing is expected to provide support for extended periods (more than 2 weeks) consideration must be given to a more accurate determination of wind loads in accordance with NZS 4203.
 - (c) Consideration shall be given to the risk and consequence of failure.
 - (d) Allowance shall be made for higher loads due to local effects such as wind funnelling.

2.3.2 Configuration

- (1) Generally, a minimum of two braces should be used for each panel or element. Where one brace is used an additional means of support should be incorporated to safeguard against collapse. For narrow wall panels or columns, it is common to use two braces at right angles.
- (2) The designer should note that the recommended support angle for a brace from a floor to a wall panel is when the brace forms a 3/4/5 triangle (i.e. a 5-metre prop with its base 3 metres from the panel and extending 4 metres up the panel). In practice, 50 to 60 degrees from the horizontal is acceptable.
- (3) In the case of wall panels, bracing points in the wall should ideally be not less than 67% of the height of the panel from its base. Under no circumstances should wall panels be braced below mid-panel height unless this is being carried out under strictly controlled conditions with special provisions having been made to prevent base “kick-out” or panel failure due to bending at the bracing point. See figure 3.

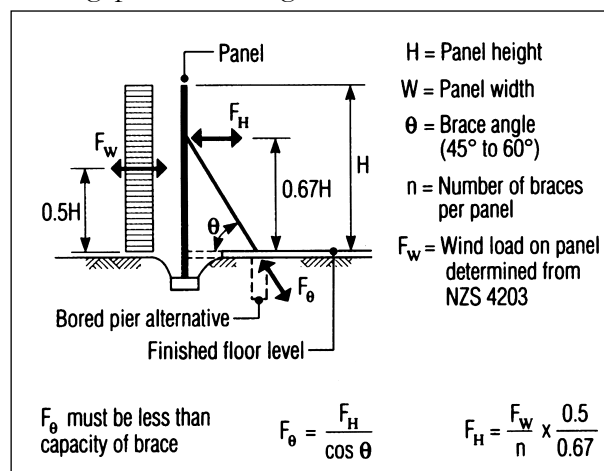


Figure 3: Panel configuration

2.3.3 Braces

- (1) All braces should have a known safe working load available. In the case of adjustable braces, the safe working load, at zero extension and maximum extension, should be available.
- (2) Adjustable braces should have stops on the threads to prevent over extension.
- (3) **Braces should have a factor of safety of 2 against ultimate failure.**

2.3.4 Anchoring Braces

- (1) It is important that braces are fixed to solid, flat concrete or other surfaces that are capable of resisting the applied loads.
- (2) Bracing connections should be designed with a factor of safety of 2.5 against ultimate failure.

Bracing anchors must be capable of providing a clamping force to each end of the brace that is higher than the maximum design load that fixing has been designed to resist. This will ensure that creep of the fitting will not occur under cyclic loads. The working load should normally be limited to 65% of the load at which the anchor exhibits first slip.

- (3) Expansion anchors for brace-fixing anchors shall be load controlled, i.e. an anchor where an increase in load will result in an increasing wedging force. The permissible load shall be limited to 65% of the load at which the anchor exhibits first slip.
- (4) Chemical anchors relying solely on chemical adhesion shall not be used for brace fixings unless each fixing is individually proof tested to the working load limit.
- (5) Deformation controlled anchors are not to be used for anchoring braces, because:
 - (a) They have no additional expansion (and hence load capacity) after the initial setting process; and
 - (b) They fail without warning and are highly sensitive to installation procedures.

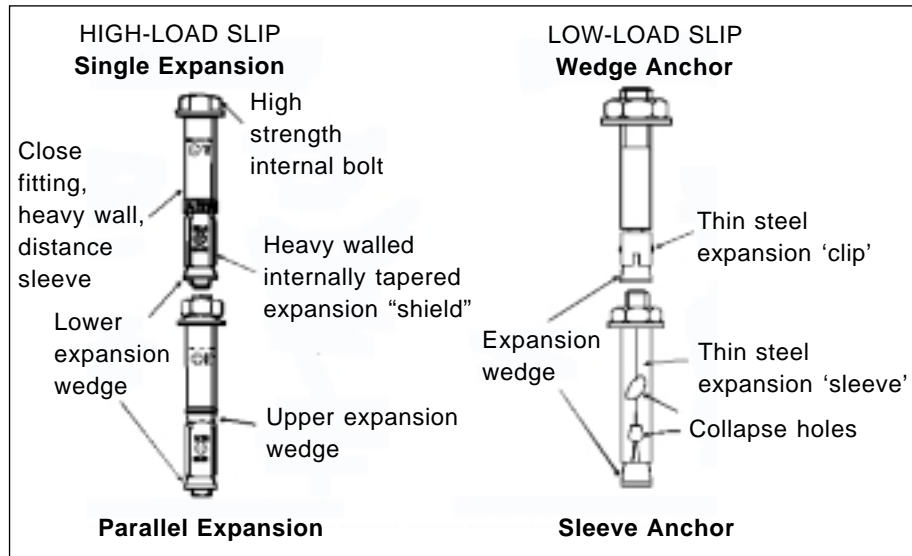


Figure 4: Examples of load-controlled anchors - acceptable for anchoring braces.

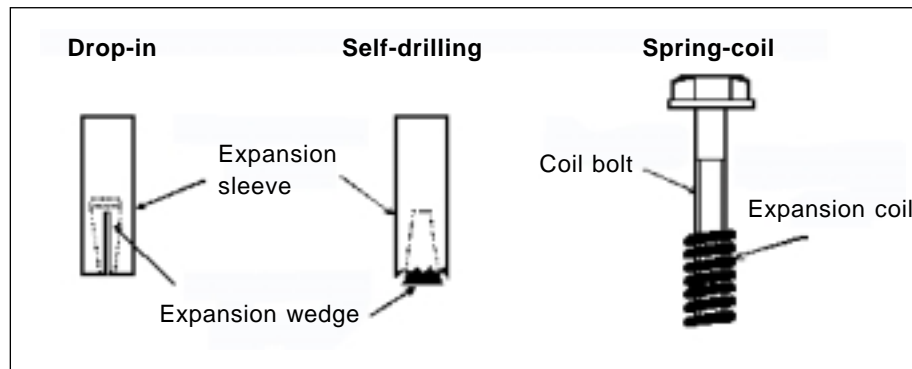


Figure 5: Examples of deformation-controlled anchors - not acceptable for anchoring braces.

2.4 CONSTRUCTION METHODS

2.4.1 Building Stability

The builder should ensure the stability of the whole of the building or part of the building being constructed is checked by a registered engineer to limit the possibility of collapse at any stage during erection or construction.

2.4.2 Erection Platform

The builder must determine that the erection platform (floor slab, suspended slab or surrounding ground, etc.) can carry the construction and erection loads and provide verification to the crane owner/operator prior to the commencement of the work. Suspended slabs are not normally designed to support cranes or transporters.

If a suspended slab is used to support the crane or transporter, the slab shall be designed for the point loads applied by the crane's outriggers, wheel loads, or any other construction loads. A temporary propping system may be required for a suspended slab.

2.4.3 Transportation

Where elements are to be cast off-site, transportation arrangements must comply with the Land Transport Safety Authority (LTSA) requirements.

2.4.4 Temporary Base Restraint

The builder must ensure that adequate temporary base restraint is provided for any precast element to prevent a sliding failure (kick-out) at the base or support of the element.

2.4.5 Fixing Inserts

- (1) Where permanent fixings or connections are to be utilised for temporary use during construction the builder should verify that the fixings are suitable for the temporary use and will not compromise their long-term performance.
- (2) To ensure correct fitting, each component of the complete lifting system, anchor, lifting eye or clutch and recess former shall be compatible with each other.
- (3) Additional lifting inserts are often added: for multiple lifts, for demoulding from the bed, handling, transportation and erection. Ensure that where multiple inserts are used, the correct inserts are used for each operation.
- (4) Suction can cause overloading of inserts if:
 - (a) The element is lifted off its bed too quickly;
 - (b) Release agents are inadequate; or
 - (c) Formwork restricts separation of the form.

Where elements do not release readily, verify safe lifting loads with the designer before increasing the lifting force.

- (5) The strength of lifting inserts is affected by:
 - Proximity to edges;
 - Proximity to holes, recesses or edge rebates;
 - Proximity to other lifting devices that are loaded concurrently;
 - Concrete thickness;
 - Concrete strength at lifting;
 - Embedment depth;
 - The presence of cracks;
 - The proximity of reinforcement or prestressing tendons; and
 - Tension stresses in the concrete around the anchorage.

2.4.6 Lifting Precast Elements

- (1) Where elements are being handled flat off a casting bed or truck the centre of the lifting inserts should coincide with the centre of gravity of the precast element. The lifting hook should be directly above the centre of gravity of the element. Running rigging must not be used if it would permit the element to tilt in an uncontrolled manner.

Where a panel is to be lifted flat and then tilted to a vertical position in one operation, it should be lifted using two crane hooks with suitable lifting eyes, as positioned by the designer.

- (2) Whenever possible, inserts for tilt panels should be designed to suit the common rigging configuration shown in figure 2 on page 17. The builder shall check that the configuration proposed suits the panel design.
- (3) Running rigging is commonly used with tilt panels. The bottom edge must remain on the ground or platform to maintain control of the element.
- (4) The lifting inserts and the rigging should be so arranged that when the element is lifted it remains stable and the bottom edge remains horizontal.
- (5) Hoops of reinforcing steel shall not be used for lifting. However, lengths of prestressing strand are used in some circumstances for handling precast elements. They may need to be used with a special lifting mandrel to ensure that the strand is not bent around a tight radius. Lifting loops must not be used when complex tilting manoeuvres are being carried out.

Strand lifting eyes should be free of nicks, arc strikes or wedge grip marks within the exposed eye or less than 300 mm from the concrete surface. Multiple strand eyes must project from the concrete surface at least 600 mm, and should be contained in a tight plastic tube, over their exposed portion, to ensure that each strand eye carries an equal share of the load.

Welded steel sections used for lifting should be designed by a competent person to accommodate standard commercially available hooks, shackles, chains or sling eyes.

- (6) If precast elements are large or awkwardly shaped, it may be necessary to use strongbacks to limit concrete stresses to acceptable levels.
- (7) If the strong-back itself is to be used for lifting, it must be specifically designed for this purpose.
- (8) Strong-back connections to the panel should be by way of cast-in insert or structural expansion anchor. If structural expansion anchors are used, the working load should be less than the clamping force provided by the anchor.

2.4.7 Braces and Bracing Inserts

- (1) Adjustable braces shall have stops on the threads to prevent over extension.
- (2) Expansion anchors for brace-fixing inserts shall be load controlled, i.e. an anchor where an increase in load will result in an increasing wedging force.
- (3) The recommended support angle for a brace supporting a wall panel is when the brace forms a 3/4/5 triangle (i.e.: a 5-metre prop with its base 3 metres from the panel and extending 4 metres up the panel). In practice, 50 to 60 degrees from the horizontal is acceptable.
- (4) Generally, a minimum of two braces should be used for each panel or element. Where one brace is used an additional means of support should be incorporated to safeguard against collapse. For narrow wall panels or columns, it is common to use two braces at right angles.
- (5) In the case of wall panels, bracing points in the wall should ideally be not less than 67% of the height of the panel from its base. Under no circumstances should wall panels be braced below mid-panel height unless this is being carried out under strictly controlled conditions with special provisions having been made to prevent base “kick-out” or panel failure due to bending at the bracing point.
- (6) It is important that braces are fixed to solid, flat concrete or other surfaces that are capable of resisting the applied loads.
- (7) Precast elements should remain temporarily braced until they are adequately restrained or incorporated into the final structure.
- (8) Chemical anchors relying solely on chemical adhesion shall not be used for brace fixings unless each fixing is individually proof tested to the working load limit.

2.5 LIFTING INSERTS AND LIFTING CLUTCHES

(Note: Ductile materials to be used.)

2.5.1 Lifting Inserts

- (1) Lifting inserts should be manufactured from materials which meet a minimum of 27J impact energy at -15°C, this being the average of three tests in which the test pieces were prepared and tested in accordance with the standard V-notch Charpy test, ASTM:E23:1996.

- (2) All lifting inserts embedded in concrete shall be clearly marked to enable their length and type to be identified after they have been cast into the element.
- (3) Lifting inserts shall be designed with a minimum factor of safety of 3 unless they are to be used for multiple lift applications (e.g. reusable manhole covers, concrete counterweights) in which case they should be designed with a factor of safety of 5.
- (4) Where proprietary cast-in lifting systems are specified, the suppliers of these proprietary cast-in lifting systems should have batch test certificates issued by an independent testing authority or an “in house” certified quality assurance programme. To ensure correct fitting of each component of the complete lifting system, anchor, lifting eye or clutch, and recess former shall be compatible with each other.
- (5) All lifting device information shall state the effect on safe working loads of:
 - Proximity to edges;
 - Proximity to holes, recesses or edge rebates;
 - Proximity to other lifting devices that are loaded concurrently;
 - Concrete thickness;
 - Concrete strength at lifting;
 - Embedment depth;
 - The presence of cracks;
 - The proximity of reinforcement or prestressing tendons, and
 - Any other factor which could effect its strength.

Note that lifting inserts are referred to by their maximum load capacity. Their actual safe load may be considerably less.

2.5.2 Lifting Clutches

- (1) Lifting clutches shall have a factor of safety of 5 and shall be initially proof loaded to twice the safe working load.
- (2) Lifting clutches shall be checked by a competent person on a regular basis and a record kept of those checks.

Table 1: Safe Working Loads for Short Foot Anchors (Tonnes)

Anchor Depth (D) (mm)	Concrete Strength (f'c)				
	10MPa	15MPa	20MPa	25MPa	30MPa
50	0.63	0.78	0.90	1.00	1.10
60	0.83	1.02	1.18	1.32	1.44
70	1.07	1.31	1.52	1.70	1.86
80	1.33	1.63	1.88	2.10	2.30
90	1.53	1.94	2.24	2.50	2.74
100	1.71	2.10	2.42	2.71	3.00
130	2.61	3.43	4.16	4.83	5.46
160	3.96	5.20	6.30	7.31	8.27
180	5.01	6.57	7.97	9.26	10.46

Notes:

1. The applied load should never exceed the nominal rating load of the anchor.
2. Safe working loads given in the above table should be reduced where anchors are closer than three anchor lengths from a panel edge or opening, or closer than six anchor lengths from another loaded anchor.

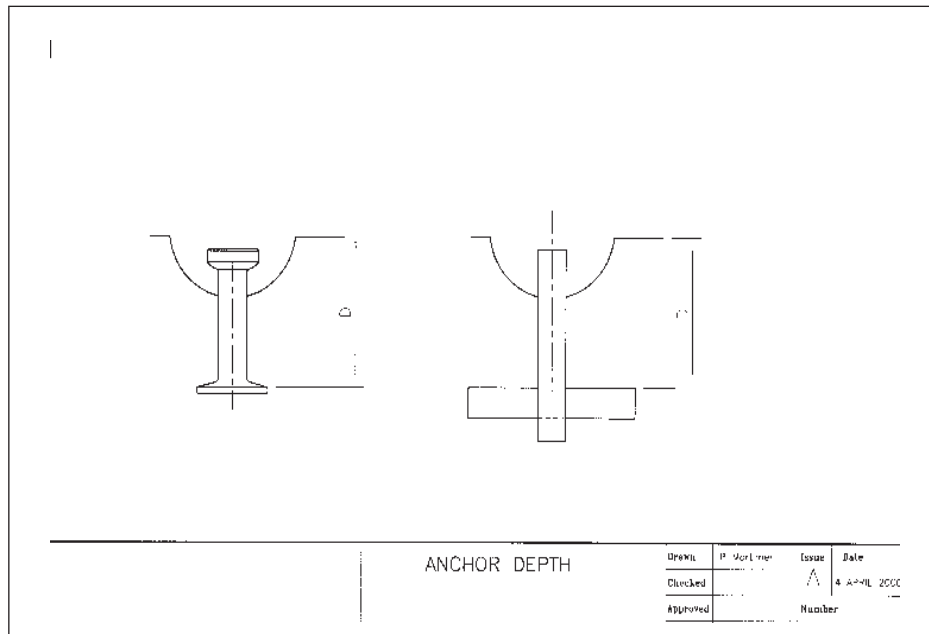


Figure 6: Typical Anchor Types

Dimension D indicates the embedment depth for these anchor types.

PART 3. MANUFACTURE

Manufacturing requirements can have a direct bearing on the safe handling, transportation and erection of precast concrete elements.

3.1 PRE-PRODUCTION

3.1.1 Contract Information

The precast concrete manufacturer must be aware of the client's requirements as set out in the contract drawings, the specification and the schedule. This information must include any current amendments, notices to tenderers and agreed variations.

3.1.2 Programme

The manufacturing programme and resources must be matched against the project programme.

Special transport requirements or site access limitations may require deliveries outside normal working hours or on special transporters.

3.1.3 Builder's Preferred Handling Systems

The builder may have a preferred system for lifting and handling, to suit available hardware, and may have special requirements for propping and bracing to ensure stability during construction.

3.1.4 Draughting and Approvals

Shop drawings are an essential part of the manufacturing process. They should be submitted to the builder for checking and approval prior to casting any concrete. The builder may be required to or prefer to submit shop drawings to the designer for approval or review.

The standard convention for precast shop drawings is that each element is drawn the way the production workers will view the mould. Non-standard finishes and special lifting and handling procedures must be clearly noted on the drawings.

Shop drawings may include an erection layout drawing and should note the requirements for special handling and propping where this is part of the precast concrete design, but will not necessarily detail the temporary propping and bracing.

The builder must co-ordinate between the precast manufacturer and the erection subcontractor to determine the requirements for propping, bracing and special lifting procedures.

3.1.5 Concrete Strengths at 28 Days

The required concrete strength at 28 days will be stated in the contract specifications. This will be based on strength or durability requirements as determined by the designer.

Concrete of a higher strength may be used for some precast components to enable early removal from moulds or to enable construction loads to be carried at an early age. The expected 28-day strength of this concrete must be noted on the shop drawings as overstrength precast concrete beams may alter the performance of concrete columns under earthquake loads.

3.1.6 Propping and Support Details

Props are required for a variety of reasons to:

- Reduce the self-weight deflection of precast flooring systems while the cast-in-place topping concrete is placed and cured;
- Provide temporary gravity load support during construction. For example, where seating lengths are less than the specified minimum, or where the connection requires cast-in-place concrete or welding to provide permanent support;
- Resist wind loads and accidental side loads during erection;
- Prevent torsional instability or rotation of beams loaded along one edge;
- Provide fine adjustment of the precast element to the correct level while freeing the crane quickly for the next lift; and
- Support temporary construction loads that exceed the design capacity of any part of the structure.

Where the element requires propping, that requirement should be noted on the shop drawings.

Support details for precast elements include temporary shims, rubber or plastic bearing pads, levelling bolts or mortar pads.

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

Precast floors exposed to the sun (for example the top levels of carparking buildings) require special consideration as the long term effects of thermally induced movements can cause severe spalling at the support.

Permanent grouting or mortar packing of precast concrete support points requires care and supervision to ensure that the requirements for strength and durability are met.

3.1.7 Weight of Units

Calculating the weight, the balance point or centre of gravity, and the handling procedures (such as the use of strongbacks or load equalising beams) is a key part of erecting precast concrete elements. The required crane capacity will depend on this information.

The precast manufacturer and the design engineer may assist in reducing the weight of individual elements by altering the size, varying the concrete density, or by other appropriate design procedures.

3.1.8 Lifting and Handling Stresses

Allowable lifting and handling stresses will be determined by the degree to which cracking can be tolerated. Units will either be designed to be handled with no visible cracks, or to be handled in a manner that restricts the crack widths to acceptable limits for the environment that the unit will be exposed to in service.

Lifting and handling concrete flexural stress calculations may assume an impact allowance of 50% for transport and handling. For precast units that must be transported over rough terrain, an additional impact factor should be allowed.

3.1.9 Capacity of Lifting Inserts

Lifting inserts may often be required to carry more load than is apparent. Increased loads can result from:

- The angle of lifting chains or slings;
- Impact or inertia forces;
- Unequal sling lengths, where there are more than two slings (even relatively minor variations in length can be significant);
- Suction or mould friction; and
- Mispositioning of anchors.

Unless special means are taken to equalise loads it is safer to assume that only two lifting inserts will be carrying the load.

3.1.10 Location of Lifting Inserts and Tolerances

The position of lifting inserts are calculated to limit lifting stresses and to ensure that the precast element hangs in the correct orientation during lifting from the mould and while it is lifted into its final position.

Tolerances on the location of lifting inserts for typical precast elements are given in Table 3.2.14.

3.1.11 Stability and Buckling

Some precast elements, such as long slender bridge beams and thin wall panels, may buckle if handled or transported incorrectly. Where the designer is aware of this possibility, it should be clearly noted on the contract drawings.

The manufacturer should also check the potential for lateral instability taking into account tilting due to road camber, additional axial loads due to lifting sling angles, and wind forces on the element during erection.

3.2 PRODUCTION

3.2.1 Moulds

While the design of moulds for precast concrete production is outside the scope of this code, there are aspects of mould design that have a direct bearing on how precast elements are handled, and on the loads imposed during production.

3.2.2 Surface Finishes

Surface finish requirements will often dictate the preferred orientation of a precast element in the mould. The quality of the finish of vertical mould faces may be inferior to that cast against a horizontal surface. Two-stage casting is often used to avoid this problem.

3.2.3 Assembly and Release Details

Removable sections of moulds are normally attached with bolts, clamps or wedges. Major items of embedded hardware, threaded inserts and dowel connectors are often bolted to the mould. The production methods should ensure an error proof system for checking that all bolts have been removed before the element is lifted from the mould. Failure to remove bolts is a common cause of lifting insert failures.

3.2.4 Suction and/or Friction

Both suction and friction can be reduced by the use of high quality mould release compounds.

Suction on flat mould surfaces is increased by the presence of water. Suction pressure can be relieved by lifting gently at one end or edge of the element.

Friction forces are increased by vertical or near vertical sides on a mould. To reduce friction, mould sides should be detailed with adequate draw, or should be released to allow them to spring back. To avoid overloading lifting inserts, the mould can be vibrated while gently lifting one end of the precast element.

3.2.5 Tilting Moulds and Vertical Moulds

Thin, lightly reinforced panels are often cast in vertical moulds, or in horizontal moulds that are tilted to vertical before the panel is lifted out. Panels cast in this manner should be stored, transported and handled in a near vertical position at all times. These panels may not have sufficient strength to resist gravity loads if laid flat.

3.2.6 Concrete Strengths

Production requirements may result in concrete strengths greater than the specified 28-day strength. While this may not be a problem for most precast elements, the designer should check that overstrength precast beams will not affect the seismic performance of a ductile moment resisting frame by causing unplanned column hinging.

3.2.7 Minimum Strength for Lifting

The minimum concrete strength at which precast elements can be lifted from the mould will be based on the calculated concrete stresses at the lifting points, or on calculated stresses caused by the transfer of prestressing forces or handling.

For vertically cast panels, or elements cast on tilting moulds the flexural stresses may not determine minimum concrete strengths.

The minimum strength of the concrete at initial lift must be sufficient to develop the required capacity of the lifting inserts.

The following table provides minimum concrete strengths for lifting and handling.

Higher strengths may be required to develop the capacity of some lifting inserts or for safe handling of the elements.

The capacity of the lifting inserts may be less than their rated capacity due to short embedment lengths and/or low concrete strengths at the time of lifting.

Table 2: Recommended Minimum Concrete Strengths for Lifting and Handling

Application	Minimum Concrete Strength f'c
None specified, fine controlled crane, non-prestressed.	10 MPa*
Lifting which involves significant impact or high acceleration.	15 MPa*
All units where concrete strength for lifting is specified in the contract documents.	As specified
Concentrically prestressed elements (piles, wall panels or thin floor slabs).	20 MPa
Eccentrically prestressed elements (tees, deep flooring units).	25 MPa
Bridge beams and similar highly stressed prestressed elements.	30 MPa or as specified
*Dependent on anchor length or as recommended by insert manufacturer.	

Note: Special care should be taken with prestressed elements to ensure lifting devices are anchored in compression zones, unless covered by specific design.

3.2.8 Minimum Strength for Transport and Erection

Transporting and erection will generally impose less stress on precast elements than those caused during lifting from the mould. This may not be the case for panels cast in vertical or tilting moulds. In the case of elements subjected to high stresses due to support conditions on trucks, or elements required to carry significant construction loads, the minimum

strength required for transport and erection should be clearly stated on the shop drawings, and on the precast layout drawing. This would normally be the responsibility of the designer of the element.

The erector should ask for confirmation of concrete strength from match cast concrete test cylinders, impact hammer tests, or other means.

Manufacturers should be aware that allowing the concrete to dry out or prolonged cold weather can slow the strength gain of concrete.

3.2.9 Reinforcement

The grade of reinforcing steel should be clearly noted on the shop drawings. Mixed grades should be avoided if possible or, if unavoidable, they should be clearly highlighted.

3.2.10 Additional Reinforcement for Lifting and Handling

The manufacturer may decide to provide additional reinforcement to improve safety during transport and handling. Examples may be top reinforcing bars in precast half beams, or crack control steel at transport support points and lifting points. The number of additional reinforcing bars should be calculated in accordance with sound design principles and these should be clearly shown on the shop drawings. Details of additional reinforcing should be submitted to the building designer for approval.

3.2.11 Lifting Inserts

Proprietary lifting inserts should comply with the requirements of section 2.5.

Reinforcing bars must not be used for lifting eyes.

3.2.12 Type of Lifting Insert

The type of lifting eyes or inserts to be used on a project should be mutually agreed between the manufacturer and the builder or erector.

3.2.13 Setting up Lifting Anchors in Moulds

Lifting insert supports should be firmly fixed to the mould in a manner that prevents them moving out of position as the concrete is placed. Puddling in face lift anchors after pouring is a common and accepted technique. In all cases anchors must be held at the correct height to accommodate the lifting clutch, hook or shackle that will be used to handle and erect the precast element.

Recess formers should be well maintained and must be compatible with the type of insert that is being used.

3.2.14 Lifting Position Tolerances

Table 3: Recommended Location Tolerances of Lifting Devices

Type of Unit	Tolerance
Piles	150 mm
Flooring Units	150 mm
Beams	Along the length 300 mm Across the width 25 mm
Columns	Along the length 300 mm On the end 25 mm
Wall Panels	Face 25 mm in any direction Edge 5 mm across the thickness and/or 25 mm longitudinally.

3.2.15 Type of Lift

The manufacturer must clearly identify elements requiring a non-standard lift.

Standard Lift A lift that does not require special rigging or equalisation procedures, i.e. no more than two anchors must be capable of carrying the load with the required safety factor.

Non-Standard Lift A lift that does require special rigging or equalisation procedures. This must be noted on the shop drawings.

3.2.16 Regular Inspection of Lifting Equipment

A visual inspection of lifting equipment is required prior to and after use. Refer to clause 2.5.2 and the relevant codes (*Approved Code of Practice for Cranes* and the *Approved Code of Practice for Load-Lifting Rigging*).

3.2.17 Units With No Lifting Inserts

Some precast elements such as prestressed hollow core floor slabs may have no lifting inserts. These units must be handled by means of lifting clamps designed by a suitably qualified person, or by lifting strops or slings. Lifting equipment of this type wears rapidly, and must be regularly inspected by a suitably qualified person in accordance with the *Approved Code of Practice for Load-Lifting Rigging*. Inspections must be recorded. On construction sites, elements handled by means of lifting clamps or forks should have the load secured by safety slings or other securing devices. The location of lifting points should be indicated by the designer or other competent person.

3.2.18 Stacking and Storage

Incorrect stacking and storage can damage precast elements. For those units where support points are critical, for stacking, transport or long term storage, the locations for dunnage or support should be noted on the shop drawings or on the precast layout drawing.

3.2.19 Dunnage

Dunnage performs the important function of supporting the bottom unit of a stack clear of the ground, allowing access between units to fit lifting forks or strops, and preventing damage resulting from concrete-to-concrete contact.

The bottom level of dunnage must be adequate to transfer the load to the ground without excess settlement. Settlement of dunnage can result in cracking of some types of elements.

Dunnage must be arranged to avoid twisting or distorting the precast elements. Dunnage for the next level in a stockpile should be directly over the dunnage below.

Materials used for dunnage on surfaces that will be exposed in the finished structure should be non-staining.

Note: Variations in concrete curing under dunnage may result in colour variations that could take some time to fade.

3.2.20 Creep (Long-Term Permanent Deformation)

Incorrect stacking can cause long-term creep that is difficult to remove from precast elements. The younger the age at which precast elements deflect or twist under incorrect storage, the greater the creep.

3.2.21 Quality Assurance and Certificate of Compliance

The precast concrete manufacturer may be required to certify that the elements have been manufactured to the contract documents. Refer to Appendix 1 for a suggested format.

PART 4. TRANSPORTATION, HANDLING AND ERECTION

4.1 ERECTION PLATFORM

- 4.1.1 The builder must determine that the erection platform (floor slab, footing, suspended slab or surrounding ground, etc.) can support the construction and erection loads and provide verification to the crane owner/operator prior to the commencement of the work.
- 4.1.2 If a suspended slab is used to support the crane, or transporter, the slab should be designed for the crane point loads, wheel loads, or any other construction loads, by a registered engineer. A temporary propping system may be required.

4.2 ERECTION PREPARATION

- 4.2.1 Prior to commencing the handling and/or erection of precast concrete elements, the following items should be considered by the manufacturer or builder as appropriate.
- (1) Check crane access to the site and erection platform to prevent cranes or trucks damaging the concrete floor during access. A compacted hard-fill ramp at a suitable gradient should be provided to a level slightly above the concrete floor.
 - (2) Obtain verification that the erection platform can support the erection loads.
 - (3) Ensure the locating dowels and levelling shims are correctly located. Dowels rather than blocks should be used to restrain the base of face-lifted panels when they are being positioned.
 - (4) Clear the site for truck and crane access ensuring room for crane outriggers, counterweight tail swing, boom swing and under hook and overhead obstructions.
 - (5) Ensure that sufficient space is available for precast propping or panel bracing.
 - (6) The builder must ensure that adequate temporary base restraint is provided for any precast element to prevent a sliding failure (kick-out) at the base or support of the element.
 - (7) Check that the means of temporary support, including falsework is adequate for the intended purpose and located correctly prior to the precast elements being placed.

- (8) Verify that the concrete has obtained the specified strength for lifting. This may already have been done if the element was manufactured off-site.
- (9) Check that the lifting inserts are in their correct location and that recesses are cleaned out in preparation for lifting.

Note: If incorrectly located, faulty or missing lifting inserts are identified, immediate contact should be made with the designer who will rectify the problem and/or provide an appropriate solution.

Check that the strongbacks, if required, are available and correctly installed.

- (10) Determine if it is necessary to equalise loads on lifting points.
- (11) Ensure that the appropriate rigging equipment is available. This includes lifting beams and correct attachments for cast-in anchors or inserts.
- (12) Wherever possible the lifting of tilt-slab panels should be undertaken from within the building envelope. In this way, the crane operator is able to keep the rigging and lifting eyes in view at all times.
- (13) Erection should be possible without the need for any worker to be positioned underneath a precast element or on the underside of a tilt-up panel during erection.

4.2.2 Where possible, braces should be fixed to wall panels and precast elements prior to lifting.

4.3 RIGGING

4.3.1 Setting up a rigging system for erecting tilt-up panels and precast elements requires careful and thorough pre-planning. In the case of tilt-up panels, it is normal for a competent person to supply an insert layout and rigging plan which has been based upon the design of the panels for lifting. This must be available to a competent operator or supervisor on site to ensure that the rigging adopted conforms with the lifting design. Special care must be taken with rigging arrangements where unequal insert loadings have been used for the panel design.

For general precast elements, such as beams or flat slabs, care should be taken to determine if it is necessary to equalise loads between lifting points on any element.

4.4 CRANES

4.4.1 The normal rated capacity of a crane refers to its load capacity at a minimum radius and often this bears little relation to its actual capacity at a working radius when lifting precast elements.

- 4.4.2 The required crane capacity is affected by factors including the distance from the centre of rotation of the crane to the centre of gravity of the precast element being lifted. The rated capacity of a crane decreases as distance of lift from the centre of rotation of the crane increases. The operating radius for tower cranes and large mobile cranes will generally be much greater, and a methodology should be developed between the builder, crane owner and handling and erection personnel.
- 4.4.3 For all face-lifted tilt-up panels the true working radius of the crane may be up to 1.5 m more than the final position radius of the panel.

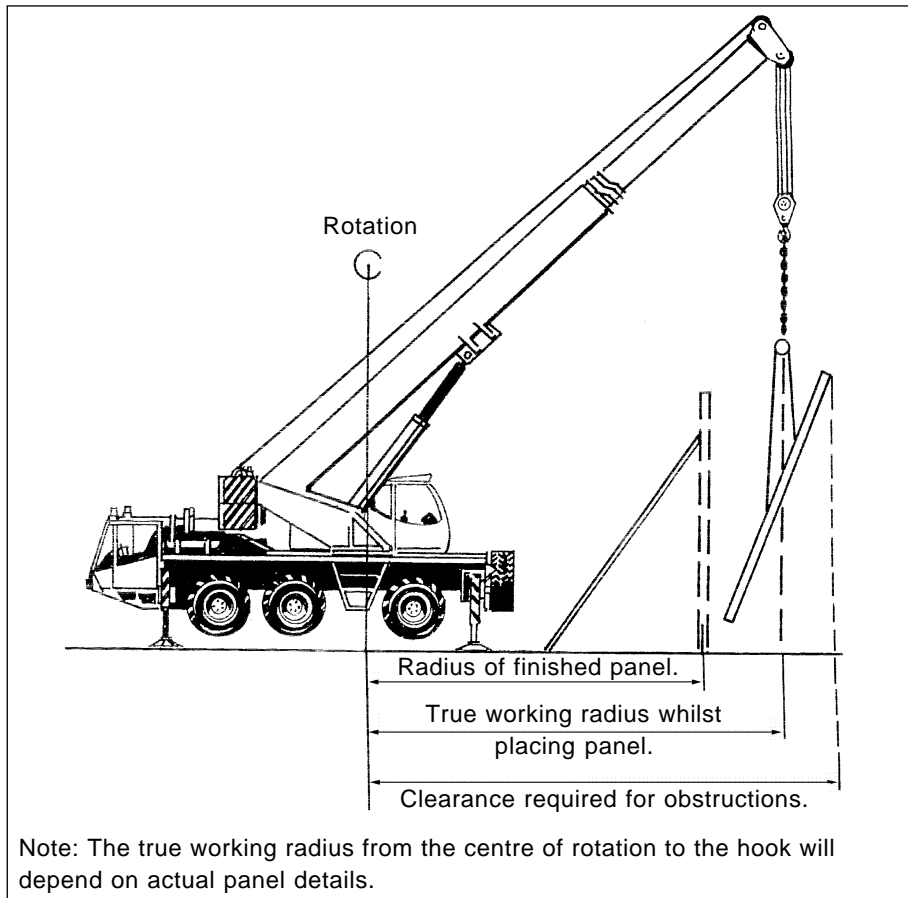


Figure 7: Crane Working Radius

4.5 ERECTION CREW

The erection crew for handling and erection of precast elements should consist of:

- (1) A competent crane operator who holds a national certificate, or one who is competent in the work that is to be performed;
- (2) A dogger/rigger who holds a national certificate or one who is competent in the work that is to be performed; and
- (3) Additional competent labour as required to assist with erection or placement of elements.

Note: A person with dual qualifications may function as both a rigger and dogger.

4.6 ERECTION SEQUENCE

Precast elements should be erected in accordance with a pre-planned sequence.

4.7 ERECTION OF TILT-UP PANELS

- (1) The crane operator should be competent in the scope of the work to be undertaken.
- (2) Where large panels have been cast on a bed, the adhesion between the panel and bed needs to be relieved. If the panel does not come free when the crane safe load indicator registers a maximum of 110% of the panel weight, procedures such as wedging or jacking should be undertaken by or under the direction of a competent person.
- (3) All personnel should be outside the drop zone when lifting/tilting the panel and rotating it from the horizontal to the vertical.
- (4) Care should be taken when taglines are used to control the swing of a panel. Personnel should also ensure that they always position themselves a safe distance from the panel.
- (5) Whenever possible, panels should be lifted with the rigging equipment in view of the crane operator.
- (6) At no time should any worker position themselves underneath a precast element or on the underside of a tilt-up panel during erection.
- (7) No attempt should be made to lift and erect panels in strong winds where control of the panel may be lost.
- (8) Braces at both ends should be connected before releasing the lifting equipment, unless designed otherwise.

4.8 ERECTION OF GENERAL ELEMENTS

- (1) The dead weight of all elements should be calculated or weighed prior to the commencement of erection, and this information made available to the erection crew.
- (2) The lifting equipment should be attached to the precast elements by a competent person and the immediate area cleared in preparation for lifting.
- (3) Taglines may be required in some circumstances.
- (4) Under no circumstances should personnel pass or stand beneath a suspended element.
- (5) Consideration must be given to the effect of wind upon the safe handling and erection of elements.

4.9 LEVELLING SHIMS

4.9.1 Levelling shims are to be manufactured from a suitable durable material and shall have adequate strength to carry the full imposed loads.

Note: Direct concrete to concrete, or concrete to steel bearing should be avoided unless some edge spalling and cracking is acceptable.

4.9.2 Levelling shims must be used on solid foundations and it is not recommended that levelling shims be placed on thin layers of site concrete. It should be remembered that levelling shims carry the full construction load of the pre-cast element which must be supported adequately to prevent movement before it is incorporated in the main structure.

4.9.3 Shimming should be limited to a height of 30 mm unless steps are taken to ensure stability of the temporary support.

4.9.4 Where practical, shims for levelling pre-cast elements should be located at least 300 mm in from the ends of the element. This is particularly relevant for thin wall panels where edge break-out can occur if shims are placed close to bottom corners.

4.10 FIXING INSERTS

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

4.11 MISSING/UNUSABLE LIFTING POINTS

If incorrectly located, faulty or missing lifting inserts are identified, immediate contact should be made with the designer who will rectify the problem and identify an alternative solution.

Solutions could include:

- (1) Fixing a plate with undercut anchors.
- (2) Fixing a plate with expansion anchors. If using expansion anchors, refer to clause 2.3.4 (but with a factor of safety of 3:1).
- (3) Fixing a plate with chemical anchors. Anchors must be individually proof tested.
- (4) Drilling through the element and attaching lifting plate(s) by bolting.

All of the above solutions must have a factor of safety greater than 3 on the first slip load.

4.12 TEMPORARY BRACING

- 4.12.1 The design of temporary bracing should comply with section 2.4.7.
- 4.12.2 Wherever possible bracing should be fixed to the element before lifting.
- 4.12.3 When it is necessary to attach the braces after the element has been positioned, the element should be held safely by the crane whilst the braces are installed on the upper face by the use of a ladder or alternative access system.
- 4.12.4 Generally, a minimum of two braces should be used for all elements. Where elements can be effectively coupled together one central brace to resist rotation or toppling may be sufficient subject to design by a registered engineer.
- 4.12.5 Braces shall be attached to a flat surface which is capable of withstanding the applied load.
- 4.12.6 Bracing bolts should be checked at regular intervals and immediately after any occurrence such as an earthquake or storm.

Note: All equipment used in conjunction with the handling, transportation and erection of a precast element must be maintained to a high standard and be suitable for its intended use.

4.13 STORAGE AND MULTIPLE HANDLING

- 4.13.1 The sequence of erection should be such that the multiple handling of elements is minimised. A specific procedure should be developed and the operation supervised by a competent person if multiple handling is required.
- 4.13.2 Elements should only be stored in a manner approved by the designer or other competent person.

4.14 CERTIFICATION OF COMPLIANCE

- 4.14.1 Prior to the lifting of any precast element the crane owner or their representative should receive from the builder or precast manufacturer a statement confirming that the manufacture of the elements is in compliance with this code of practice.

An example of a manufacturer's certificate of compliance is provided as Appendix 1.

Note: It is not intended that a certificate of compliance should be provided or requested for each manufactured element. Where a number of elements of similar design are manufactured under the same or similar conditions one certificate would be acceptable assurance of compliance with this code.

PART 5. PROPPING

5.1 PROPPING OF BEAMS

- 5.1.1 Propping for beams should allow for possible changes to the distribution of loads during the construction process.
- 5.1.2 Where beams are post tensioned, the stressing process can change the shape of the member thereby reducing the load on some props and increasing the load to others. This particularly applies where the stressing induces a camber into the beam which can lift the beam off props at mid-span transferring all the load to the props at the ends.
- 5.1.3 Precast shell beams are normally prestressed which induces a natural camber into the units. In some cases propping is lowered slightly at mid-span to allow the beams to deflect to a more level shape during placing of the concrete core and topping to the floors. This will result in a much higher than anticipated load being carried through the temporary props at the ends.
- 5.1.4 The seating for precast beams may not be suitable to transfer high loads during construction and the beams will normally require full propping at each end.
- 5.1.5 If the designer of the structure requires the beams to be supported without the use of mid-span props (to reduce the end support dead load bending moments), then the requirement must be clearly noted on the contract drawings and on the precast layout drawings.
- 5.1.6 Where beams are to have floor systems placed on them prior to the beams being fully built into the structure, allowance should be made for the fact that the beam may not be evenly loaded by the floor units during construction. Long-span floor units placed on one side only of a beam may cause the beam to roll on the props. For this reason each edge of the beam may require temporary propping.
- 5.1.7 Where beams are to support floor units, allowance must be made for the beams to carry an appropriate proportion of the construction load from the floor. Propping for the floor may in some cases be intended to only even out the levels of the underside of the floor units and not to take any significant floor load during construction. This can lead to a higher than anticipated load being carried through the beam propping.
- 5.1.8 Unless specifically noted otherwise, all temporary propping should be in place, adjusted to the correct levels allowing for any required cambers, and fully braced prior to commencement of erection of any precast beams.

5.2 PROPPING OF PRECAST FLOOR SYSTEMS

- 5.2.1 Refer to the floor system designers for the number and position of temporary support points, if any, required for each unit during erection and construction of the floor. Loads to the propping should be calculated by a competent person.
- 5.2.2 Unless specifically noted otherwise, temporary propping should provide full support of all construction loads including the full self-weight of the completed floor system and possible local concentrations of load during construction. Construction loads may include pallets of infills stacked on the partially constructed floor, reinforcing steel or mesh, excess concrete before being spread and levelled and other loads.
- 5.2.3 Unless specifically noted otherwise, all temporary propping should be in place, adjusted to the correct levels allowing for any required cambers, and fully braced prior to commencement of erection of any floor units.
- 5.2.4 Floor units such as the various hollow-core systems which are normally erected without temporary props, may require some amount of temporary propping at mid-span principally to even out the natural variations in cambers of the units, or for other structural or cosmetic reasons. With the specific approval of the floor system supplier in each particular instance, it may be satisfactory to erect the temporary props after the precast floor units are in place, and for the props to take only a portion of the full construction load.
- 5.2.5 Propping to floor units should have a stable top bearer. This top bearer should be located in the header of the props in such a way as to prevent rolling of the bearer and to ensure that the load from the bearer is transferred concentrically into the prop. The top bearer should be over the centre line of the prop otherwise it may cause the prop to bend leading to failure.
- 5.2.6 Props should be adequately seated, levelled and capable of transferring the full load through whatever structure they are bearing on and into the ground without unacceptable settlement.
- 5.2.7 Props, if required, should be vertical. They should also be braced to prevent side-sway of the whole assembly and the buckling of individual props.

PART 6. RIGGING

It was not intended that this document should cover load lifting and rigging.

For this type of information, refer to the *Approved Code of Practice for Load-Lifting Rigging*, revised 2001, published by the Occupational Safety and Health Service of the Department of Labour.

APPENDIX: MANUFACTURER'S CERTIFICATION OF COMPLIANCE FOR PRECAST CONCRETE ELEMENTS

Project Name: _____
Site Address: _____
Manufacturer's Name: _____
Designer's Name: _____
Date of Lift or Erection: _____

Element Schedule

Component Identification Numbers:

I, on behalf of the manufacturer, hereby certify that the elements scheduled above, have been manufactured in accordance with section of the *Approved Code of Practice for the Safe Handling, Transportation and Erection of Precast Concrete* and the relevant shop drawings.

Manufacturing Details

Concrete design strength as recorded on delivery docket: _____
Date elements cast: _____
Concrete strength test result and age of test: _____

Element Details

Calculated element weight (tonnes): _____
Lifting inserts positioned correctly: _____
Reinforcement located correctly: _____
Lifting insert manufacturer/type/safe working load: _____
Lifting insert length: _____
Release agent used (for tilt-up panels only): _____
Type of lift: _____

Signature: _____ Position: _____

Date: ___ / ___ / ___

Note: A manual for proprietary inserts is to be available on the site of work. A separate certificate is required for each element type.