



## **INDUSTRY GUIDE**

---

---

# **Handling, Transportation and Erection of Precast Concrete**

---

---

**August 2015**

Available from Precast NZ Inc.

<http://www.precastnz.org.nz/precast-nz-publications/>



# CONTENTS

<b>FOREWORD .....</b>	<b>1</b>
<b>1. INTRODUCTION.....</b>	<b>2</b>
1.1 Purpose .....	2
1.2 Application of this guide .....	2
1.3 Interpretation .....	2
1.4 Definitions.....	2
<b>2. THE HEALTH AND SAFETY IN EMPLOYMENT ACT 1992.....</b>	<b>6</b>
<b>3. PRECAST CONCRETE DESIGN.....</b>	<b>7</b>
3.1 General.....	7
3.2 Precast element design loads.....	7
3.2.1 All loads to be considered.....	7
3.2.2 Buckling during handling, transport, lifting or erection .....	8
3.2.3 Lifting insert arrangement .....	8
3.2.4 Strongbacks.....	9
3.2.5 Lifting from casting beds .....	9
3.2.6 Precast element size .....	9
3.2.7 Reinforcement design .....	10
3.2.8 Panels.....	10
<b>4. LIFTING INSERTS AND LIFTING CLUTCHES .....</b>	<b>15</b>
4.1 Lifting inserts for lifting or handling .....	15
4.1.1 Lifting inserts.....	15
4.1.2 Lifting clutches.....	16
4.1.3 Lifting insert design loads.....	17
4.1.4 Reinforcing around lifting inserts .....	17
<b>5. MANUFACTURE .....</b>	<b>19</b>
5.1 Pre production .....	19
5.1.1 The builder's pre-production responsibilities.....	19
5.1.2 Manufacturing programme.....	20
5.1.3 Shop drawings and approvals.....	20
5.1.4 Concrete strengths .....	21
5.2 Production .....	21
5.2.1 Documentation and check sheets .....	21
5.2.2 Concrete strength requirements at different stages.....	21
5.2.3 Minimum strength for lifting.....	21
5.2.4 Maintain control while lifting .....	23
5.2.5 Manufacturing tolerances.....	23
5.2.6 Mould friction or suction .....	23
5.2.7 Tilting moulds and vertical moulds.....	23
5.3 Confirmation of compliance with this guide.....	23
5.4 Curing compounds and release agents .....	23

<b>6.</b>	<b>STORAGE RACKS AND FRAMES .....</b>	<b>25</b>
6.1	Stacking and storage .....	25
6.1.1	Dunnage .....	25
6.2	Racks and frames.....	25
6.2.1	Design of racks and frames.....	26
<b>7.</b>	<b>TRANSPORTING PRECAST ELEMENTS .....</b>	<b>27</b>
7.1	Key hazards when transporting precast concrete .....	27
7.2	Plant and equipment.....	28
7.3	Load restraints, lifting equipment and frames .....	28
7.3.1	Loading and unloading .....	28
7.3.2	Support frames .....	29
7.4	Inspection by competent person.....	29
7.5	Transporting .....	29
7.5.1	New Zealand Transport Agency (NZTA) compliance .....	30
<b>8.</b>	<b>BRACING AND PROPPING.....</b>	<b>31</b>
8.1	Braces and props .....	31
8.2	Removal of braces and props .....	31
8.3	Bracing design .....	32
8.3.1	Bracing loads .....	32
8.3.2	Brace configuration.....	33
8.3.3	Braces.....	33
8.3.4	Connections and braces.....	35
8.3.5	Bottom connections of braces .....	35
8.3.6	Inserts for bracing connections .....	36
8.3.7	Corner bracing .....	38
8.4	Propping of beams and floors.....	38
8.4.1	Propping requirements .....	38
8.4.2	Propping loads .....	39
8.4.3	Propping to be in place.....	39
8.5	Propping of beams.....	39
8.5.1	Post-tensioned beams .....	39
8.5.2	Precast shell beams .....	39
8.5.3	Support at the ends of precast beams .....	39
8.5.4	Beams that support floor units .....	39
8.6	Propping precast floor systems .....	40
8.6.1	Top bearer.....	40
8.6.2	Unpropped floor systems (hollowcore & tees).....	40
<b>9.</b>	<b>BUILDER'S RESPONSIBILITIES .....</b>	<b>41</b>
9.1	Scope .....	41
9.2	programme .....	41
9.3	Responsibilities relating to precast concrete.....	41
<b>10.</b>	<b>ERECTION OF PRECAST ELEMENTS .....</b>	<b>44</b>
10.1	Scope .....	44
10.2	Preparation .....	44

10.3	Lifting .....	45
10.3.1	Missing or unusable lifting inserts .....	46
10.3.2	Units with no lifting inserts .....	46
10.3.3	Braces attached to wall panels .....	47
10.3.4	Attaching bracing after positioning.....	47
10.3.5	Safe removal of braces.....	47
10.4	Levelling shims .....	47
10.4.1	Material for levelling shims .....	47
10.4.2	Levelling shims to be on solid foundations .....	47
10.4.3	Height of shims .....	47
10.4.4	Location of shims .....	47

## APPENDICES

APPENDIX A: Manufacturer’s Statement of Compliance for Precast Concrete Elements . 48

APPENDIX B: Publications and References .....

## TABLES

Table 1:	Table of Concrete Stresses.....	13
Table 2:	Edge Lift – Flexural stresses (MPa) .....	14
Table 3:	Single row face lift – Flexural stresses (MPa).....	14
Table 4:	Double row face lift – Flexural stresses (MPa).....	14
Table 5:	Maximum safe working loads for short foot anchors (tonnes) .....	18
Table 6:	Recommended minimum concrete strengths for lifting and handling. Higher strengths may be required.....	22
Table 7:	Recommended location tolerances for lifting inserts .....	22

## FIGURES

Figure 1:	Rigging arrangement for tilt panel .....	11
Figure 2:	Common rigging configurations .....	12
Figure 3:	Typical anchor types .....	18
Figure 4:	Typical bracing configuration.....	34
Figure 5:	Examples of expansion anchors.....	36
Figure 6:	Examples of deformation controlled anchors. ....	37
Figure 7:	Corner panel bracing without skewing .....	38
Figure 8:	Top bearer.....	40

# FOREWORD

The Approved Code of Practice for The Safe Handling, Transportation and Erection of Precast Concrete was published by the Department of Labour in May 2002.

An up-to-date version of this ACOP is being developed by WorkSafe New Zealand, to align with the new impending health and safety legislation (the Health and Safety at Work Act).

This Industry Guide is based on a document developed by a 22 member working group in 2008. Precast New Zealand Inc. believes information from that should be available to assist those involved in this field. It will be subject to revision when the new ACOP is issued and relevant legislation changes.

Comments are welcome. Please send to [precast@precastnz.org.nz](mailto:precast@precastnz.org.nz).

This document will be revised and updated. Check for updates at <http://www.precastnz.org.nz/precast-nz-publications/>.

## ACKNOWLEDGEMENT

Precast New Zealand Inc. thanks the following people and organisations for assisting with the development of this industry guide:

- The many individuals who contributed time, expertise and informed comment.
- WorkSafe New Zealand.
- The working group involved in the 2008 draft to update the 2002 Approved Code of Practice.

- Cement & Concrete Association of New Zealand (CCANZ).
- Derek Lawley.
- Rod Fulford.

WorkSafe New Zealand is currently developing a draft Code of Practice for the Handling, Transportation and Erection of Precast Concrete. Content from this draft work has been used in this industry guide. The WorkSafe New Zealand content has not been publically consulted on and may change as WorkSafe continues to develop its Code of Practice, particularly during the consultation process. WorkSafe New Zealand takes no responsibility for the legal or technical content of this industry guide.

## DISCLAIMER

Precast New Zealand Inc. has made every effort to ensure the information in this guide is reliable. We make no guarantee of its accuracy or completeness and do not accept responsibility for any errors. This document has no legal status and does not take precedence over legislation or design standards. It is simply a guide to provide information and assistance to competent people and those working within the industry.

# 1. INTRODUCTION

## 1.1 PURPOSE

This industry guide aims to give practical guidance for the handling, transportation and erection of precast concrete elements. It covers the steps from manufacture through to final placement. It does not cover every situation or component.

## 1.2 APPLICATION OF THIS GUIDE

This guide is primarily considering precast concrete as used in buildings but it may be referred to for handling, transportation and erection all precast concrete elements where appropriate. It does not take priority over the Building Code, New Zealand Standards, approved Codes of Practice, etc.

The Building Code and the various design standards cover requirements for structures in service. This guide is to assist with the processes prior to incorporation of precast concrete elements into the structure. It covers matters from manufacture through handling, transportation and erection. The range of precast concrete products is large, and they are used in a myriad of ways. This brief guide cannot cover all circumstances.

Design of concrete structures to NZS 1170 uses a strength based approach. This requires a level of knowledge required of professional engineers and is not readily applied without appropriate academic training.

Lifting equipment is tested on a working load basis applying factors of safety. Working load design with

factors of safety applied is more readily understood and applied without academic training. As each step of the process from manufacture through handling, transport and erection is seldom under control of an engineer, this guide uses the working load design basis with factors of safety applied.

Either strength based design should be used by an engineer, or working load design with factors of safety by a competent person. The systems should not be mixed just as imperial and metric units should not be mixed in the design process.

This guide refers to 0.5 kPa as a commonly adopted load for panels temporarily propped and exposed for up to two weeks. A load of 0.5 kPa applied to an insert using a factor of safety of 3, gives an almost identical result to a 1.0 kPa load using a strength based approach with a wind load factor of 1.0 and a strength reduction factor of 0.65 for the insert.

All procedures should be under control of a competent person with appropriate training.

## 1.3 INTERPRETATION

'Shall' and 'must' means that the recommendation is considered necessary.

'Should' and 'may' means that the recommendation should be considered where appropriate.

## 1.4 DEFINITIONS

**Anchor** as used in this guide refers to a cast in or drilled in fixing for

temporary use in the handling transportation or erection process. Drilled in anchors for connecting braces should be of a type known as heavy duty high load slip expansion anchors or 'load controlled' where an increase in load results in increased wedging force.

**Brace** is a member normally placed diagonally and firmly attached to resist horizontal movement and provide stability. Braces are commonly used as temporary members to resist wind loads on panels. For the purpose of this document, vertical temporary supports are referred to as props.

**Builder** is the person in control of a place of work, and can be the employer, self-employed and/or principal or lead contractor.

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

**Crane** means a powered device:

- that is equipped with mechanical means for raising or lowering loads suspended by means of a hook or other load-handling device; and that can, by the 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
- 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

- does not include lifting gear that is not an integral part of the crane.

**Crush zone** is an area where a person could be crushed between a transported precast element and a solid object.

**Cyclic load** means a recurring load, or a recurring reversing load.

**Dead men** Dead men are concrete elements that are solely for the attachment of the bottom end of temporary precast braces. They may be either precast blocks placed on the ground that may be re-used, but more commonly they are specifically designed bored and cast into the ground at predetermined locations.

**Designer** is someone who is qualified because of their training and experience to design a device, system or element to serve a specific purpose.

**Dogger/Rigger** is someone who knows how to use the correct sling for a load and who understands the crane they are working with. A dogger is competent to do elementary slinging or lifting tasks and direct and position loads. See also Rigger/Dogger.

**Drop zone** is the area where a precast element would land following an uncontrolled fall. For example, during lifting or placing by a crane.

**Dunnage** is timber or other material put under or between precast concrete elements to prevent damage or instability during storage and transportation.



**Element** refer precast element.

**Engineer** is a chartered professional engineer registered under the Chartered Professional Engineers of New Zealand Act 2002 and holding a current registration certificate.

**Expansion anchors** in this guide refers to drilled in anchors of a type known as heavy duty high load slip expansion anchors or 'load controlled' where an increase in load results in increased wedging force.

**Factor of safety** see safety factor.

**Levelling shims** are either a single or series of thin strips of a suitable material that are put under elements to help with final positioning.

**Lifting beam** means a beam that carries loads using two or more lifting points while being supported from one or more different points.

**Lifting clutch** is the device that connects directly to the cast in lifting insert to enable attachment to and transfer of load to a crane or other lifting or handling piece of equipment. Typically a proprietary item for use with foot anchors but the requirements of this guide may also apply to other non-proprietary items.

**Lifting equipment** means all equipment that connects a precast concrete component to a crane or other lifting device. It does not include anything that is an integral part of a crane or other lifting device or is cast into the precast concrete element.

**Lifting insert** means a component

cast into the precast concrete element for the purpose of providing a point of attachment for the lifting equipment. It may or may not be a proprietary item.

**Lifting spreader** is a compression member that spreads lifting ropes, chains or slings while an element is being lifted to change the angle of the force applied to the lifting inserts.

**Load restraint** is all the lashing and tying equipment as per *the official New Zealand truck loading code*, New Zealand Transport Agency (NZTA).

**Non-standard lift** means a lift that requires specific rigging or load equalisation procedures, to ensure the load is distributed appropriately to the lifting points. Any lift requiring attachment to more than two lifting points in a beam or three lifting points for a face lifted panel will normally be a non-standard lift.

**Precast concrete** means a concrete element cast in other than its final position.

**Precast element** means any item of precast concrete and may refer to a precast beam, column, floor slab, wall panel, cladding panel, pile, pile cap, cruciform or any other item of precast concrete.

**Prop** is a member, whether proprietary or of specific design, used as temporary support for a precast concrete element. Props are commonly used to support floors and beams. For the purpose of this document, prop refers to vertical members resisting vertical loads and brace refers to diagonal or non-vertical members.

**Rigger/Dogman** means a person qualified to sling loads and direct the lifting and placing operations of a crane. *Reference: Approved Code of Practice for Cranes – Includes the Design, Manufacture, Supply, Safe Operation, Maintenance, and Inspection of Cranes.* (Department of Labour 2009).

**Rigging** means the use of mechanical load-shifting equipment and associated gear to move, place or secure a load including plant, equipment, or members of a building or structure and to ensure the stability of those members, and for the setting up and dismantling of cranes and hoists, other than the setting up of a crane or hoist which only requires the positioning of external outriggers or stabilisers. *Reference: Approved code of practice for load-lifting rigging.* Published by MBIE 2002.

**Safety factor** is the theoretical reserve capability, calculated by dividing the reliable ultimate load capacity of the product by its rated load. This may be expressed as a number, or as a ratio such as 2:1. Also referred to as factor of safety.

**Safe working load** is the maximum load that the designer or user is permitted to intentionally apply in the design process to an anchor, insert, coil bolt, brace or other component when using working load design. It is also known as safe load carrying capacity, SWL, rated load, working load or working load limit (WLL). It is normally set by the supplier or designer and incorporates appropriate factors of safety.

**Shop drawing** means a line drawing

to describe detail of a precast element for the manufacturing process.

**Significant hazard** is defined in the Health and Safety in Employment Act 1992 (the Act). This Act is expected to be superseded during 2015.

**Spalling** in this guide refers to the unintentional shearing off of a part of the precast concrete element. Normally due to a concentration of load or due to sliding.

**Spreader** or spreader bar – see Lifting spreader.

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

**Strong back** is a beam or girder connected to a precast concrete element to give it extra strength or support during handling.

**Tag line** means a rope of suitable strength, construction and length attached with an appropriate recognised bend or hitch to the load, which is used to control the load during lifting or positioning. *Reference: Approved code of practice for load-lifting rigging.* Published by MBIE 2002.

**Tilt panel** is a concrete element, normally cast horizontally at or near its final location. It is lifted to the vertical with one edge staying on the casting floor.

**Working load** or **Working load limit** see Safe working load.

## **2. THE HEALTH AND SAFETY IN EMPLOYMENT ACT 1992**

The Health and Safety in Employment Act 1992 (the Act) applies to all workplaces and is the overarching legislation for workplace health and safety.

The Act works with regulations, including the Health and Safety in Employment Regulations 1995. Compliance with the Act and the

relevant regulations is mandatory. This Act is expected to be superseded during 2015.

The precast concrete industry is potentially hazardous and safety is a primary concern with all procedures, and every person involved has a duty towards safety.

## 3. PRECAST CONCRETE DESIGN

### 3.1 GENERAL

This section is about design considerations and requirements for precast concrete elements that specifically relate to handling, transportation and erection of precast concrete elements. It does not cover other aspects of design that are relevant to the intended use of those elements. It is to be read in conjunction with other sections of this guide.

The design and construction of all precast concrete elements for building must comply with the *New Zealand Building Code*. Design standards NZS 3101 *Concrete Structures* and AS/NZS 1170 *Structural Design Actions* are a means of compliance with the Building Code. This document provides additional requirements and guidance for the period between initial casting and fixing into final location.

This industry guide assumes a working load basis for design with factors of safety. It is not using a strength based design approach as used with NZS 1170. Design should be either working load based on this guide or strength based using NZS 1170.

This industry guide requires safety factors of 1.5 for base restraint, 2 for braces and props, 2.5 for brace and prop connections and 3 for lifting inserts and drilled in fixings. These are to allow for the practicalities of construction work, design and the assumptions commonly used. They do not imply that the whole system or other parts of the system will have

a capacity greater than that required to resist the design load.

### 3.2 PRECAST ELEMENT DESIGN LOADS

#### 3.2.1 ALL LOADS TO BE CONSIDERED

Slenderness and stability need to be considered at all stages through manufacture, handling, transportation, storage and erection.

In addition to the loads that an element will be subject to in its final location, loads occurring during the manufacturing process, handling, transport, temporary propping and erection must also be considered. These can include:

- variations in load distribution (with time) during construction, such as variations in propping loads due to pre-stressing.
- temporary construction loads.
- loading on the bracing inserts, lifting inserts, lifting gear and precast elements from the self weight, taking account of the sling angles at various stages from manufacturing to erection.
- any extraordinary dynamic load or impact load applied through handling or transport on public roads or building sites.

Impact loads are generated at all stages during handling, transport and lifting.

The safety factors in this guide assume handling with a reasonable level of care to avoid excessive impact loads. The possibility of higher impact loads should be considered by designers and provided for if required.

If impact loads are likely to increase the force on the element or any insert or lifting component by more than 50% they need to be considered and allowed for in the design.

Impact loading only needs to be considered after removal of the concrete element from its mould. Suction or demoulding forces to be overcome when removing the element from its mould do not act at the same time as impact loads and are not cumulative.

### **3.2.2 BUCKLING DURING HANDLING, TRANSPORT, LIFTING OR ERECTION**

Designers should consider the possibility of buckling and instability of long slender concrete elements, which can occur at any stage during handling, transport, lifting or erection.

This is a particular concern where sling angles cause compression in the element and where long slender panels are being rotated.

During transport, tilting of the vehicle due to road camber can increase the risk of buckling of long slender elements such as bridge beams.

Depending on the circumstances, strongbacks, spreaders, additional reinforcing or other measures may be considered to reduce the risk of buckling.

### **3.2.3 LIFTING INSERT ARRANGEMENT**

Refer also to Section 4 of this guide *Lifting inserts and lifting clutches*.

When designing the lifting insert arrangement for an element, the designer must consider:

- the availability of lifting equipment, including cranes, at various stages of handling and erection.
- site limitations that may affect rigging options.
- the lifting insert capacity (proprietary lifting inserts are referred to by their maximum load capacity – their actual safe working load to be used in design may be considerably less depending on conditions such as embedment depth, proximity to edges and other anchors, concrete strength at the time of load application, etc. (Refer to the section on lifting inserts).
- the total weight of the element and its dimensions.
- the position of any cut-outs and openings.
- rigging arrangements including sling angles and use of strongbacks.
- impact loads.
- if the element is intended to be lifted multiple times over a period of more than three months, in which case a safety factor of 5 should be applied to the lifting inserts.

Inserts may be incorporated for:

- use in the manufacturing process.
- on-site handling.
- attachment of temporary bracing.
- permanent fixing of the element in its final location.

Inserts should only be used for other than their intended purpose after consultation with the designer.

A number of rigging arrangements used at various stages including demoulding, loading, and placing are available at

<http://www.precastnz.org.nz/wp-content/uploads/2012/08/precaster-rigging-options.pdf>



### 3.2.4 STRONGBACKS

Strongbacks may be used to strengthen concrete elements or to locate additional lifting points or prevent out-of-plane rotation of odd-shaped concrete elements. Strongbacks should be sufficiently stiff to ensure the loads are distributed as intended. Flexible strongbacks may overload some lifting inserts and may cause cracking or failure of the element.

The location of the strongbacks should not interfere with the rigging

while any element is being lifted, positioned or rotated.

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

Strongbacks should be attached to the precast element by cast in inserts or load controlled expansion inserts.

### 3.2.5 LIFTING FROM CASTING BEDS

Suction or demoulding forces need to be overcome to separate the element from its mould. These are a design consideration as they increase the lifting forces required, the stresses on the element, and the loads on the inserts and lifting equipment.

If excessive forces are required for the initial release from the mould, the possibility and effects of sudden release need to be considered. The sudden release of strain energy can cause high impact loads and unpredictable sudden movements. Particular care should be taken if the lifting force applied exceeds the weight of the precast element by more than 10%.

Pretensioned precast elements may slide in their moulds when the prestress is released and this can cause the elements to wedge in the mould due to small variations in mould profile. This can require a high force to remove the element from the mould.

### 3.2.6 PRECAST ELEMENT SIZE

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

- size, capacity and configuration of crane(s) available to undertake lifting and erection.
- manufacturing restrictions.
- location and proximity of overhead power lines.
- access to and around the site.
- bracing, propping and grouting requirements.
- transport restrictions.
- where levelling shims may cause stress concentrations.
- where mishandling might cause loads in a direction different from that allowed for in design. This is a particular concern for prestressed elements that are designed to take downward loads, but during transport handling or storage may be supported some distance from their ends, a condition they may not have been designed for.

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

Where elements are to be cast offsite, the designer needs to take into account New Zealand Transport Agency authority limits on length, width, height and weight, as well as what transport equipment is available.

### **3.2.7 REINFORCEMENT DESIGN**

To ensure safe handling and propping of elements, extra reinforcement may be needed:

- at temporary support points.
- where lifting, handling, transport, temporary fixing or support, impose stresses on the element exceeding those allowed for in the design of the element.
- for handling elements that do not achieve their full strength until being built in (such as partial-height precast beams).
- at the edges and around openings in the element to resist thermal and shrinkage movements.

Extra reinforcing must not be added to structural elements without the specific approval of the designer of those elements as additional reinforcing can alter performance of the completed structure.

### **3.2.8 PANELS**

Panels do not generally incorporate reinforcement for handling and erection, unless prestressed. However, the designer needs to consider inadvertent overloading and cracking during handling, and make sure there is reinforcement to limit sudden catastrophic collapse.

If panels are being handled flat (such as off a casting bed or truck) and intended to remain flat while being lifted, the centroid of the lifting inserts should coincide with the centre of gravity of the precast element or the non-concentric loading allowed for in the design.

Where a panel is to be lifted flat and then tilted to vertical in one operation, the panel and lifting inserts must be designed for that purpose. It will normally require inserts in the face of the panel for the initial lift, and a separate crane hook connecting to inserts in the top edge of the panel to take the load when the panel is vertical. This is a

complex operation that should only be used where the lifting inserts and layout have been designed specifically for that purpose and the rigging arrangement is compatible. This should not be attempted using a single crane hook and running rigging.

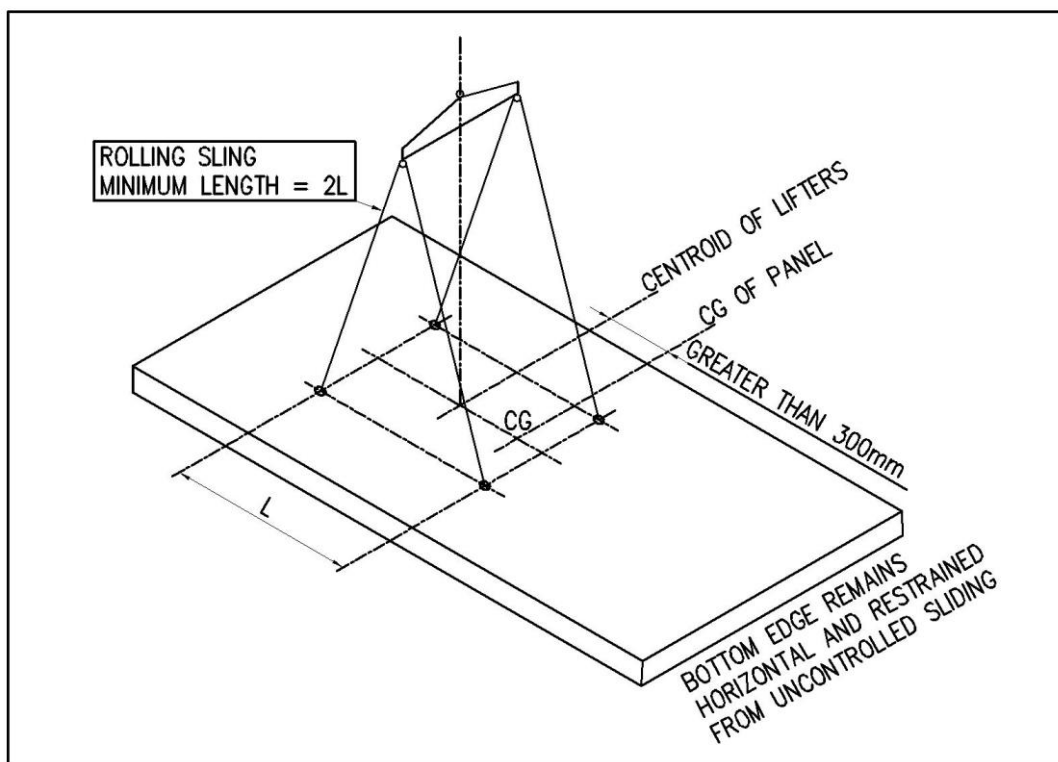
For tilt panels, the centre of the lifting inserts should normally be at least 300 mm closer to the top of the panel than the centre of gravity of the panel to allow the panel to hang nearly vertical when lifted. Running rigging is commonly used with tilt panels. The bottom edge must stay on the ground or platform and any tendency to slide must be controlled, see Figure 1.

The lifting inserts and the rigging for tilt panels should be arranged to keep the panel stable and the bottom edge horizontal when lifted.

Designers should ensure the inserts and their arrangement provided for on-site use will permit safe handling when used with appropriate rigging. Designers must make available the rigging or handling requirements for each element.

Some common rigging configurations are shown in Figure 2. The length of rigging slings changes the angle of the slings and the magnitude of loads on anchors and stresses within panels. The minimum length of a rigging sling should allow for a maximum angle of 60 degrees at the hook or pulley block. The designer can give a sling length, or range of lengths, needed for the rigging design.

Further rigging options can be found at <http://www.precastnz.org.nz/wp-content/uploads/2012/08/precaster-rigging-options.pdf>.



**Figure 1: Rigging arrangement for tilt panel**

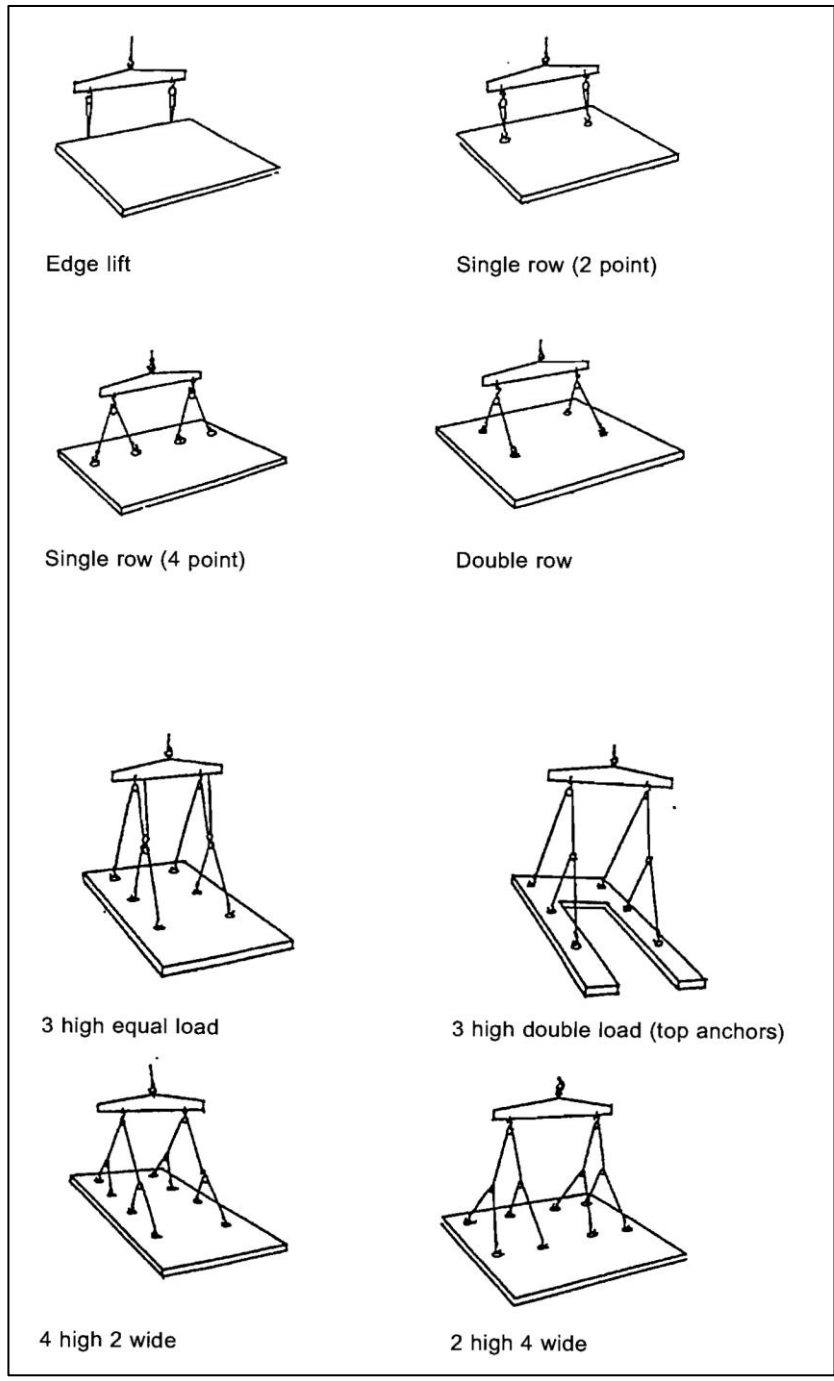


The angle of the tilt changes the loads on anchors and stresses within panels. The designer should allow for the loads and stress at all angles of tilt.

impact effects. These tables must not be used for panels with openings, irregularities or recesses.

Table 2, Table 3, and Table 4 (page 14) give stresses for some simple tilt panels supported from different insert arrangements, without allowance for

If elements are large or of irregular shape, the designer may need to allow for a strong-back, to limit concrete stresses to acceptable levels.



**Figure 2: Common rigging configurations**

# TILT PANEL DESIGN CHARTS

REPRODUCED BY COURTESY OF REID CONSTRUCTION SYSTEMS

## STRESS TABLES – SOLID PANELS WITHOUT OPENINGS ONLY

These tables show the maximum flexural stress about an axis parallel to the base of the panel when tilt panels are being lifted with the three most commonly used rigging arrangements.

They should only be interpreted by a competent person with appropriate design experience.

For a 2 point lift, flexural stresses about an axis at right angles to the base should be checked for panels where their width exceeds twice their height.

For a 4 point lift, flexural stresses about an axis at right angles to the base should be checked for panels where their width exceeds 4 times their height.

Often only the minimum, centrally placed, shrinkage control steel (Cl.8.8 of NZS 3101:2006) will be needed for tilt panels.

Additional reinforcing steel does not reduce the concrete flexural stresses during lifting.

**Table 1: Table of Concrete Stresses**

Table of Concrete Stresses							
$f'_c$	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 <u>at the time of lifting</u> . (MPa)					
$0.75\sqrt{f'_c}$	=	modulus of rupture as recommended by American Concrete Institute (ACI). This is a value which usually produces the first crack in concrete. (MPa)					
$0.41\sqrt{f'_c}$	=	The allowable flexural tensile stress in MPa at the time of lifting.					

**CALCULATED CONCRETE FLEXURAL TENSILE STRESS (MPa) DURING LIFTING (WITHOUT ALLOWANCE FOR IMPACT LOADING)**

**Table 2: Edge Lift – Flexural stresses (MPa)**

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

**Table 3: Single row face lift – Flexural stresses (MPa)**

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

**Table 4: Double row face lift – Flexural stresses (MPa)**

Double row face lift										
Panel Thickness	Panel height (m) – H									
	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0
100mm	1.60	1.86	2.13	2.42						
120mm	1.33	1.55	1.78	2.02	2.28	2.56				
150mm	1.07	1.24	1.42	1.62	1.83	2.05	2.25	2.53		
175mm	0.91	1.06	1.22	1.39	1.56	1.75	1.95	2.16	2.39	
200mm	0.80	0.93	1.07	1.21	1.37	1.53	1.71	1.90	2.09	2.30

## 4. LIFTING INSERTS AND LIFTING CLUTCHES

### 4.1 LIFTING INSERTS FOR LIFTING OR HANDLING

This section is about requirements for lifting inserts that are cast into precast elements for the purpose of lifting or handling the element. It is to be read in conjunction with other sections of this guide.

The device that connects directly to the cast-in insert to enable attachment to and transfer of load to a crane or other lifting or handling piece of equipment is referred to as the lifting clutch.

Proprietary foot anchors and lifting clutches are in common use. The requirements of this section apply to all types of lifting inserts and items cast into elements to enable external attachment for lifting or handling, and their immediate attachment mechanisms where appropriate.

#### 4.1.1 LIFTING INSERTS

This industry guide requires safety factors of 1.5 for base restraint, 2 for braces and props, 2.5 for brace and prop connections and 3 for lifting inserts and drilled in fixings. These are to allow for the practicalities of construction work and design assumptions commonly used. They do not imply that the whole system or other parts of the system will have a capacity greater than that required to resist the design load.

Inserts intended to be used multiple times over an extended period (such as those in reusable manhole covers, concrete counterweights) must have a minimum safety factor of 5. Other lifting inserts must have a minimum safety factor of 3.

Design of inserts for fixing elements into their permanent location is outside the scope of this guide.



Lifting inserts should be made from ductile materials which meet a minimum of 27J impact energy at - 0°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:E23-05.

All proprietary lifting inserts must be clearly marked to enable their length and type to be identified after they have been cast into the element.

Where proprietary cast-in lifting inserts are used, the suppliers must have batch test certificates issued by an independent testing authority or an 'in-house' certified quality assurance programme.

Lifting inserts in prestressed elements should be anchored in compression zones unless subject to specific design.

Each component of the lifting system including the anchor, lifting eye or clutch and recess former must be compatible to ensure correct fitting and the ability to carry the intended load.

Reinforcing should not be used to lift precast elements.

Where lifting eyes formed from prestressing strand are used, they must be free of defects such as nicks, arc strikes or wedge grip marks. They should be sufficiently far out of the surface to permit unrestricted access for the crane hook or other attachment and ensure the crane hook or other attachment does not bear on the concrete surface during lifting or handling.

Lifting eyes formed from prestressing strand should be aligned to avoid sudden changes of direction at the concrete surface when the element is

lifted. Care should be taken to avoid sharp bends in the strand lifting eyes from small diameter lifting attachments.

Where multiple prestressing strands are used for one lifting point, they should be enclosed in a plastic tube.

Prestressing strand lifting eyes should not be used where units are to be turned or re-oriented while suspended.



#### 4.1.2 LIFTING CLUTCHES

Lifting clutches:

- must be visually inspected for damage or wear each day prior to use.
- must only be used with type and size of inserts that they are compatible with.

- must only be used with lifting inserts approved by the manufacturer.
- must have a safety factor of 5 to 1.
- are to be made from ductile material and not be subject to a brittle failure.
- must be subject to close inspection and testing to twice their rated safe working load at least every 12 months by a competent person and a record kept of those checks. The checks should be made in accordance with the requirements in the *Approved code of practice for load-lifting rigging*.
- how close to holes, recesses or edge rebates the inserts are.
- how close the inserts are to other inserts or lifting devices that may be loaded at the same time.
- the concrete thickness.
- the concrete strength at the time the load is applied.
- the embedment depth of the inserts.
- cracks in the concrete.
- high tension stresses in the concrete that may cause cracks to open up around the anchorage.

Testing of lifting clutches must include for possible misalignment or misplacement that could cause the load to be applied in a manner other than intended.

A record should be kept of all lifting clutch testing.

All lifting clutches should have a tag showing the period of test validity and maximum allowable capacity.

#### **4.1.3 LIFTING INSERT DESIGN LOADS**

All proprietary lifting inserts must be used in accordance with the manufacturer's instructions, and loads applied to them should be limited accordingly.

All lifting inserts must be embedded or anchored well enough to function effectively. The load capacity of any insert is affected by:

- how close to the edges the inserts are.

Manufacturers' data sheets will give design loads for inserts, but may not take all these factors into account.

Designers should also consider impact loads and the effect of the angle of slings or other attachments.

Designers should consider the effect of location tolerance on the capacity of inserts. This particularly applies to inserts in the edges of panels where they may conflict with edge reinforcing causing a reduction in edge distance and load capacity.

#### **4.1.4 REINFORCING AROUND LIFTING INSERTS**

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

Some lifting inserts need reinforcing before they reach their load capacity. This reinforcing must meet the requirements of this guide, the relevant standards and the supplier's recommendations.

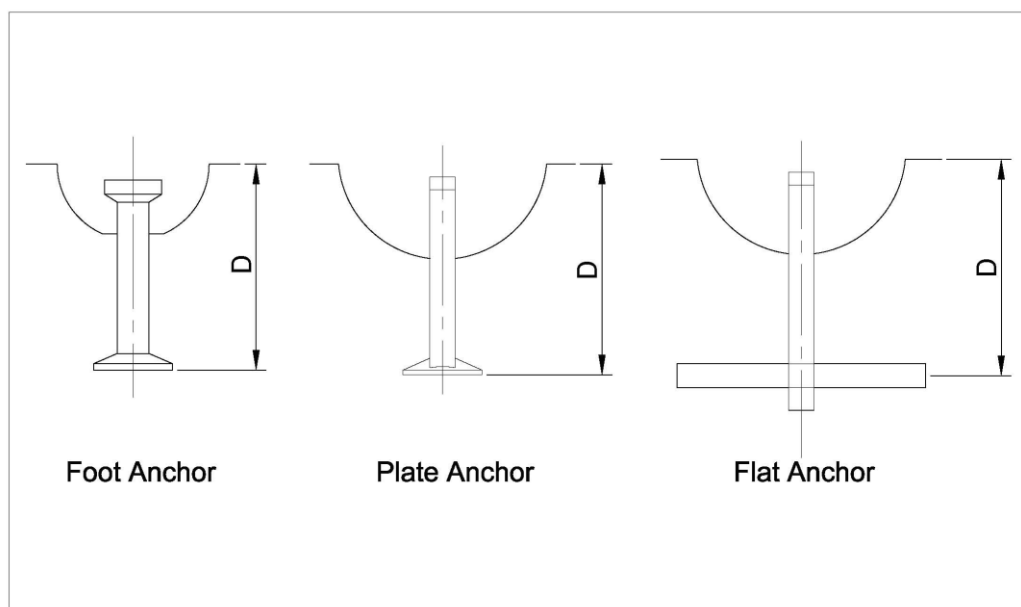
**Table 5: Maximum safe working loads for short foot anchors (tonnes)**

Reproduced by courtesy of Reid Construction systems

Anchor depth (D) (mm)	Concrete strength (f'c)				
	10 MPa	15 MPa	20 MPa	25 MPa	30 MPa
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. Manufacturer's instructions should always be referred to and may provide different safe working loads.
2. The applied load should never exceed the nominal rating load of the anchor.
3. Safe working loads given in Table 5 are reduced by the factors listed above.



**Figure 3: Typical anchor types**

# 5. MANUFACTURE

## 5.1 PRE PRODUCTION

Handling, transportation and erection of precast concrete elements may require casting in of specific components, reinforcing or other modifications during manufacture. This section is about considerations for the manufacture of precast concrete elements.

It is to be read in conjunction with other sections of this guide.

Design and construction of moulds and casting beds are outside the scope of this guide.

### 5.1.1 THE BUILDER'S PRE-PRODUCTION RESPONSIBILITIES

The builder has overall responsibility for the construction site and the construction processes and is required to coordinate between the various parties involved and ensure necessary and correct information is distributed in a timely manner.

The builder must coordinate the precast manufacturer and the erection subcontractors to decide what propping, bracing, on-site lifting and handling is needed.

The builder or their erection subcontractors may have a preferred system for lifting and handling to suit available equipment. They may have special requirements for propping or bracing to ensure stability during construction.

Where additional inserts will be required by the builder or their

erection subcontractors, it is the builder's responsibility to ensure the detailed requirements are clearly communicated to the manufacturer in sufficient time for them to be incorporated during the manufacturing process.

Where the inserts that the manufacturer incorporates for his own in factory use are to be used by the builder or his erection subcontractors, it is the responsibility of the party using them to ensure they are only used within their appropriate limits.

Where the builder will require the elements to sustain construction loads in excess of what the element is designed for, or at an early age before the element has developed sufficient strength, he must make suitable arrangements which may include further design and modifications, additional reinforcing, extra propping or other provisions. In this case he must obtain approval from the designer of the element and the structural designer prior to making the changes and applying the loads.

Where the builder will impose construction loads in excess of 2 kPa on a propped floor system before the floor has developed its design strength, the builder must ensure the load requirements are conveyed to the designer of the floors and the props prior to the props being installed.

The builder must make sure everyone has the information they need to carry out their work safely.



The builder should monitor climatic conditions that may through high winds, excessive precipitation or other adverse events compromise the ability of propping or bracing systems to resist loads applied to them. This may be due to loads being higher than allowed for in the design, or capacity of support systems being reduced.

The builder is responsible for the construction programme. This should make suitable allowance for the manufacturer's programme requirements listed below. It should also allow for construction of any temporary site works required for delivery or erection of precast components to ensure they will be suitable for their purpose at the time they are required. This particularly applies to support pads or foundations and to concrete required to resist temporary propping and other loads.

The construction programmes and updates should be communicated to the precast manufacturer promptly. Delays to the construction programme may cause storage or production problems.

Long term storage of precast elements can result in uneven appearance due to exposure differences while curing, and can result in permanent deformation due to concrete creep.

The precast concrete manufacturer must know the client's requirements. The builder must supply the relevant contract drawings, specification and schedule including latest amendments, notices to tenderers, agreed variations and all necessary information to the manufacturer in time to meet the construction programme.

### **5.1.2 MANUFACTURING PROGRAMME**

The manufacturing programme and resources, including storage facilities, must be matched against the project programme.

The manufacturing programme should allow for:

- production of shop drawings, submission for checking or review and subsequent amendments and re-submission.
- manufacture or modification of moulds.
- curing requirements.
- development of concrete strength for initial lifting from the moulds, and handling at different stages including on site and during transport.
- development of sufficient concrete strength for lifting insert performance.
- special transport requirements or site access limitations may require deliveries outside normal working hours or on special transporters.

### **5.1.3 SHOP DRAWINGS AND APPROVALS**

Shop drawings are an essential part of the manufacturing process. Shop drawings will be submitted to the builder for checking and approval prior to manufacture. The builder may ask the designer of the elements to approve or review the drawings.

Precast shop drawings usually show each element the way the production workers view the mould.

Precast shop drawings should include all details required for manufacture of

the finished element including all inserts and other components to be cast-in including those for lifting, handling or fixing, as well as details such as non-standard finishes, rebates, openings, etc. They may also show the concrete grade to be used and the minimum strength at removal from the mould if these are non-standard. Special lifting and handling procedures must be clearly noted on the drawings.

Where the manufacturer requires additional reinforcing for handling, transport or for other reasons, that additional reinforcing should be clearly identified as such on the shop drawings submitted to the builder.

Where the manufacturer proposes to use a concrete grade different from that specified by the designer and/or additional reinforcing, the manufacturer must seek prior approval. The builder must notify the designer of the elements of these proposals and seek approval for them.

Erection requirements for bracing, propping and any special handling requirements may be incorporated on shop drawings or may be communicated separately.

Where the manufacturer is also the designer of the precast elements, he must clearly communicate any bracing or propping requirements to the builder, and these may be incorporated on the shop drawings.

#### **5.1.4 CONCRETE STRENGTHS**

The designer will provide the concrete strength required for element. Where the manufacturer wishes to use a higher strength concrete he must obtain prior approval from the designer as higher strength concrete can have an adverse effect on a building's performance during an earthquake.

With approval from the building designer, higher strength concrete can be used:

- to allow early removal from moulds.
- to meet handling requirements.
- to accommodate construction loads.

## **5.2 PRODUCTION**

### **5.2.1 DOCUMENTATION AND CHECK SHEETS**

Manufacturing processes should be documented and check sheets used to confirm they are followed.

### **5.2.2 CONCRETE STRENGTH REQUIREMENTS AT DIFFERENT STAGES**

Concrete strength increases over time and is affected by curing conditions, environment and temperature.

The concrete strength required for each stage including lifting from moulds, destressing, factory handling, transport, site handling, temporary fixing, etc. needs to be considered.

Transport over rough ground may cause impact loads. Handling on site may involve rotation or different orientation that can result in higher stresses.

### **5.2.3 MINIMUM STRENGTH FOR LIFTING**

The minimum concrete strength for lifting elements from moulds must allow for the lifting inserts to develop sufficient strength and for the element to have sufficient bending strength.

**Table 6: Recommended minimum concrete strengths for lifting and handling. Higher strengths may be required.**

Application	Minimum concrete strength (f'c)
None specified, fine controlled crane, non-prestressed	10 MPa*
Lifting which involves significant impact or 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
* Higher strengths may be required for lifting inserts to provide sufficient load capacity.	

**NOTE:** Take special care with prestressed elements to ensure lifting devices are anchored in compression zones, unless covered by specific design.

**Table 7: Recommended location tolerances for lifting inserts**

TYPE OF UNIT	INSERT LOCATION TOLERANCE
Piles	150 mm along the length
Flooring units	150 mm along the length
Beams	300 mm along the length 50 mm across the width
Columns	Along the length: 300 mm On the end: 50 mm
Wall panels	On the face: 50 mm in any direction On edges: 50 mm longitudinally, 10 mm across the thickness.  <i>NOTE: Location across the thickness may be restricted by edge reinforcing or edge details and the distance to the nearest edge will affect the capacity of the insert.</i>

#### **5.2.4 MAINTAIN CONTROL WHILE LIFTING**

The possibility of horizontal movement while lifting should be considered and steps taken to control it. This is particularly relevant where panels or other elements may tilt during the lifting procedure.

#### **5.2.5 MANUFACTURING TOLERANCES**

NZS 3109:1997 *Concrete Construction*, Table 5.1 gives tolerances for manufacture of precast concrete elements.

Table 7 (page 22) gives recommended tolerances for location of lifting devices that are cast into precast concrete elements.

#### **5.2.6 MOULD FRICTION OR SUCTION**

Friction or suction to the mould can significantly increase the force required to lift or release the element from the mould. Care should be taken to ensure this does not overload lifting devices or inserts or exceed the concrete strength at the time of lifting. Vibration of moulds, or lifting from one corner to break suction gradually can sometimes reduce the lifting force required.

Proper application of a suitable release agent prior to casting will assist the demoulding process.

Pre-tensioned elements slide in their mould when the prestress is released which can cause them to wedge in the mould.

If excessive forces are required for the initial release from the mould, the possibility and effects of sudden release need to be considered. The sudden release of strain energy can

cause high impact loads and unpredictable sudden movements. Particular care should be taken if the lifting force applied exceeds the weight of the precast element by more than 10%.

#### **5.2.7 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. Panels cast in this way should be stored, transported and handled near vertical at all times. If laid flat, these panels could be damaged by their self weight alone.

### **5.3 CONFIRMATION OF COMPLIANCE WITH THIS GUIDE**

The builder, the crane owner (or their representatives), or the erection subcontractor may require confirmation from the manufacturer that precast elements comply with this guide. See Appendix A for a Manufacturer's Statement of Compliance.

### **5.4 CURING COMPOUNDS AND RELEASE AGENTS**

If any hazardous substances, including curing compounds, are used, a Safety Data Sheet (MSDS) must be obtained and made available to all persons who may be exposed to the substance.

The principal or employer must consult with all persons who might be exposed to a hazardous substance about the intention to use the substance and the safest method of use. Persons likely to be exposed must receive training on health risks,

control measures and correct use. They must also be informed about the need for, and details of, health surveillance where appropriate.

Before a release agent or a curing compound is used, they should be checked for compatibility with each other and with applied finishes and joint sealants.

Department of Labour 1997 publication *Approved code of practice for the management of substances hazardous to health in the place of work* can provide further information on the management of hazardous substances.

## 6. STORAGE RACKS AND FRAMES

This section is about requirements for stacking and storing precast elements in the place of manufacture and on the construction site. It is to be read in conjunction with other sections of this guide. Refer to Section 7 *Transporting precast elements* for requirements specifically relating to transport.

### 6.1 STACKING AND STORAGE

Precast elements should only be stacked and stored in the way the designer of that particular element intended.

Precast elements can become unusable through poor storage.

Incorrect storage or support at the wrong points can cause damage that may not be immediately obvious.

Elements stacked on the ground must be supported at appropriate locations. Prestressed elements in particular can be damaged if supported at inappropriate locations.

Precast elements must be stored in a manner to retain their correct shape. If they are out of shape while stored, even for short periods, concrete creep can cause permanent distortion. Even minor misalignment can make them unusable.

Incorrect stacking can cause long term creep which is difficult to reverse. The younger the age that precast elements twist, deflect or deform while incorrectly stored, the greater the permanent creep deformation.

Elements must not be stacked to a height that can result in instability, particularly if uneven settlement could cause the stack to lean.

Time in storage can increase cambers of eccentrically prestressed elements to unacceptable levels.

Differences in exposure during storage will cause differences to the shape of elements and to their appearance. This can affect the outside panel in a stack against a frame, and the top element when they are stacked on top of each other.

#### 6.1.1 DUNNAGE

Precast elements should be separated by suitable dunnage.

Dunnage used to separate elements during storage can cause permanent or temporary staining or discolouration.

Normally elements in a stack should have all dunnage aligned vertically so that the weight of all elements in the stack is transferred directly through the dunnage to the ground, and no element is loaded by elements stacked above it.

The dunnage below the bottom element should be capable of spreading the load to the ground or whatever surface it is bearing on without overloading it or causing undue settlement or deflection.

### 6.2 RACKS AND FRAMES

Panels are normally stored in racks or against frames. Panels should not be

laid flat at any time or stored flat unless they are designed to be stored flat.

All storage racks and frames are to be certified by a competent person. The certificate should show:

- the maximum size of any element that can be stored.
- any restrictions such as total load or load distribution.
- whether work can be done on the panels while in the racks.
- limits on ground slope if relevant.
- required ground strength if relevant.



People loading the rack must be able to readily access this certificate and rating.

Prior to using a rack or frame, a competent person must check the slope and strength of the ground are suitable for the particular rack or frame and its intended load.

When loading unusual precast elements (such as those with odd shapes, high or 'off-centre' centres of gravity), check with a competent person that the rack or frame can handle the element without causing the panel or the frame to become unstable.

Where storing panels on a frame, ensure the bottom of each panel is bearing against the feet of the frame where that is required to provide stability.

When storing panels on a frame, ensure the frame is not destabilised by overloading on one side at any stage during loading or unloading.

Safe work procedures must be developed for loading and unloading of precast panels into and out of racks and frames.

Only work on precast panels in a racking system when:

- no-one can be injured by panels falling.
- there are no other significant hazards, such as other people working near the storage area.

### 6.2.1 DESIGN OF RACKS AND FRAMES

Racks and frames used for storing precast elements should be designed by a competent person. The designer should give special attention to wind zones and ground conditions and refer to the latest version of the following:

- New Zealand concrete structures standard (NZS 3101:2006).
- New Zealand steel structures standard (NZS 3404:1997).
- New Zealand structural design actions standard (AS/NZS 1170:2002).
- The appropriate standard for the materials used.

# 7. TRANSPORTING PRECAST ELEMENTS

This section is about plant and equipment needed when handling and transporting precast elements from the casting area to the construction site.

It is to be read in conjunction with other sections of this guide.

Handling and transporting include:

- lifting from the casting bed and moving to storage.
- moving from temporary storage to be loaded for transportation.
- loading onto means of transportation.
- transporting on road, rail or sea.
- moving from temporary site storage to final location.



## 7.1 KEY HAZARDS WHEN TRANSPORTING PRECAST CONCRETE

Hazards when transporting precast concrete elements include:

- poor maintenance of A-frames.
- bad storage of frames.
- poor design specifications.
- overloading.
- poor use of ladders to access the load.
- falls from A-frames.
- crushing.
- non-compliant lifting systems.





Control these hazards through:

- maintenance programmes for equipment and frames.
- good planning.
- hazard assessment before starting a task.

If working at height is a hazard, refer to the *Best practice guidelines for working at height in New Zealand*. (MBIE 2012).

## **7.2 PLANT AND EQUIPMENT**

Plant and equipment used during transport includes:

- storage racks (including A-frames and vertical storage racks).
- dunnage.
- trucks, trailers, fork hoists, cranes and other lifting devices.
- load restraints (such as chains, slings, lifting clutches).
- braces and props.

## **7.3 LOAD RESTRAINTS, LIFTING EQUIPMENT AND FRAMES**

All load restraints and lifting equipment must comply with the:

- *WorkSafe New Zealand Approved code of practice for load-lifting rigging*.
- *NZTA official New Zealand truck loading code*.

The design of storage and loading frames must comply with the latest version of the following:

- *New Zealand concrete structures standard (NZS 3101:2006)*.
- *New Zealand steel structures standard (NZS 3404:1997)*.
- *New Zealand structural design actions standard (AS/NZS 1170:2002)*.
- The appropriate standards for the materials used.

Give special attention to wind zones and ground conditions in the precast yard or on site. These will change the loads applied to, and stability of, precast elements and their supports.

### **7.3.1 LOADING AND UNLOADING**

Securely restrained loads on transport vehicles are vital in preventing accidents and injuries. Equipment should be inspected before use to ensure it is serviceable.

Each concrete element should be:

- individually restrained from the sides and ends to prevent movement in any direction.
- individually secured as the unloading sequence can lead to instability of loads.

Concrete elements should be loaded:

- in a sequence compatible with the required unloading sequence at their destination.
- so that identification marks are visible for unloading.

The risk of instability caused by uneven unloading from a frame should be considered when planning the loading and unloading sequences.

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

Unusual or irregular shaped elements may require particular assessment of loading and restraint by a competent person.

The lifting system including lifting clutches should be checked to ensure it is suitable for use with the lifting inserts in the concrete element. If the lifting clutches and the lifting inserts are from different suppliers, obtain confirmation they are suitable for use with each other.

Load restraints may be chains or webbing straps. The method of restraint should be suitable for the type and size of concrete element being transported and the type of vehicle being used. Packing may be required to protect corners, sharp edges, or other details.

### **7.3.2 SUPPORT FRAMES**

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

A frame system that is not an integral part of the transport vehicle or trailer must be adequately secured and be capable of withstanding any forces applied during loading, transportation and unloading.

The support frames should be certified by a suitably qualified engineer. That certification must show the maximum size and weight of individual elements as well as the

maximum total weight that can be carried.

The loading of vehicles must comply with NZTA's official New Zealand truck loading code.

## **7.4 INSPECTION BY COMPETENT PERSON**

A competent person must inspect all plant and equipment to make sure it is correct and safe to use for the job.

Any bent, worn, corroded, or damaged plant and equipment should be repaired and re-inspected by a competent person before it is used again.

## **7.5 TRANSPORTING**

The transporter needs to ensure that drivers are aware of hazards, including those listed in 7.1, and have been adequately instructed in the safe transportation of the concrete elements, with particular attention given to:

- power lines.
- other activities on the site at the time of transportation.
- recognised routes for over-dimensional loads.
- site limitations and local street access.
- the site specific traffic management plan.
- differential road cambers as these may induce torsional loads in long concrete elements.



- road cambers that may cause instability through leaning.
- the need to avoid situations that will result in high impact loads on the elements.

Drivers should stop and check the load and the restraints shortly after commencing the journey and at further intervals when traveling for more than one hour. Restraints tend to loosen due to settling of the load and stretching of the restraints, particularly if webbing straps are used.

Before driving off a public road and onto a construction site, the driver should check with the builder that the access is suitable for the particular size and weight of transporter, that the surfaces are suitable for the transporter to drive on, and there are no dangers such as soft ground, uncompacted fill or overhead services.

The vehicle driver must be adequately trained and competent to manage the hazards associated with this type of load.

Dynamic loads are created during road, rail or sea transport. These loads are more significant than static loads and need to be taken into consideration.

Consideration should be given to the possibility of transport over rough ground causing dynamic loads greater than the elements were designed for.

### **7.5.1 NEW ZEALAND TRANSPORT AGENCY (NZTA) COMPLIANCE**

NZTA compliance must be checked and maintained throughout all transportation phases. This will include all areas where the public has access.

## 8. BRACING AND PROPPING

This section is about specific requirements for bracing and propping precast elements during construction, and provides limited guidance for some common situations requiring bracing or props.

It is to be read in conjunction with other sections of this guide.

For the purpose of this guide, brace refers to a member that is normally placed diagonally and is required to resist horizontal load, and a prop refers to a vertical member to resist vertical loads.

See Section 1.4 Definitions.

### 8.1 BRACES AND PROPS

This industry guide requires safety factors of 1.5 for base restraint, 2 for braces and props, 2.5 for brace and prop connections and 3 for lifting inserts and drilled in fixings. These are to allow for the practicalities of construction work and the design assumptions commonly used. They do not imply that the whole system or other parts of the system will have a capacity greater than that required to resist the design load.



Braces are commonly used during the erection of wall panels to resist wind and other loads during construction until the panels are permanently fixed.

Props are commonly used to support beams and floors during construction.



Bracing and propping systems are to be subject to specific design by a competent person.

Incorrect bracing or propping or incorrect adjustment can cause damage and may result in collapse.

Prestressed elements are particularly sensitive to incorrect propping and support at inappropriate locations, either of which can cause collapse or damage.

Bracing and propping requirements must be established prior to placement of any precast unit.

### 8.2 REMOVAL OF BRACES AND PROPS

Removal of braces and props is potentially hazardous and should be under control of a competent person.

Incorrect removal of some braces or props may cause overloading of others.

Care must be taken to ensure permanent works are complete to a stage to allow temporary supports to be removed without compromising stability or causing overloading.

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

### **8.3 BRACING DESIGN**

Design of bracing for panels must be carried out by a competent person and the detailed requirements should be shown on a drawing where appropriate. Such drawings should include:

- Dimensioned locations of braces or props and their fixings.
- Details of the braces or props, or load and length details to permit selection of appropriate braces or props with a safety factor of 2.0.
- The size and type of fixings to be used for brace or prop connections.
- Concrete strengths required for the inserts or fixings to resist design loads with a safety factor of 3.
- Where drilled piles or dead men are to be used to transfer prop loads to the ground, the minimum dimensions of these are to be

specified and must allow for the spacing and edge distance requirements for the number and type of fixings that may be used.

- Details of base restraint to be incorporated where friction alone will not provide base restraint with a safety factor of 1.5 after considering possible 'vaulting' effects, the coefficient of friction of shims or packers to be used, and the possibility of water affecting available friction.

Where the installation of braces differs from the bracing design provided, any changes must be referred to the designer for approval. This includes changes to location of fixings, change of fixing type, changes to prop locations or lengths.

#### **8.3.1 BRACING LOADS**

Bracing design must allow for wind and construction loads. Any other loads such as earth pressures must be designed for where relevant. Seismic loads are not normally considered in design of bracing for periods of less than a month unless there has been a recent significant seismic event nearby.

A design wind load of 0.5 kPa has commonly been used for temporary support during construction unless high wind zones, exposed locations, seasonal climatic variations or local effects such as wind funnelling make higher design loads appropriate. If the bracing will be needed for more than two weeks, designers should make a more appropriate assessment of design load.

Reference should be made to AS/NZS 1170.0-3 *Structural design actions*.

**NOTE** the reference to commonly used 0.5 kPa design wind load is for a working load design using factors of safety incorporated in this guide. It is not appropriate for strength based design using the factors in NZS 1170.

The designer must consider the risk of a bracing failure and of progressive collapse and the consequences if either or both did occur.

The designer must consider the risk of bottom sliding or 'kick out' of braced panels. Horizontal forces will normally be resisted by a brace part way up the panel, and by friction or some other means at the base of the panel. The force in the diagonal brace will have a vertical component which can tend to lift the panel and reduce the horizontal friction force available at the base.

When assessing friction forces available at the base of panels, the designer must consider the packing materials that may be used and the possibility of water reducing the friction available.

Where friction alone is insufficient to resist the 'kick out' or horizontal force at the base of a panel, some other means must be provided of resisting the total horizontal force at the base with no contribution from friction.

The base restraint must be designed with a minimum safety factor of 1.5.

### **8.3.2 BRACE CONFIGURATION**

Generally, at least two braces should be used for each panel or element. Where one brace is used, extra

support should be incorporated to prevent collapse or twisting.

A common brace arrangement is for a floor-to-wall-panel brace to form a 3/4/5 triangle (that is a 5-metre prop with its base 3 metres from the panel and extending 4 metres up the panel). In practice, 45 to 60 degrees from the horizontal is acceptable.

For narrow wall panels or columns, two braces at right angles may be required.

Normally wall panel braces should be attached at a point not less than two thirds of the height of the panel from its base. Bracing at lower levels increases the risk of 'kick out'. Panels should not be braced below mid-height unless the bending stresses in the panel have been assessed and the panel bracing system is specifically designed and base restraint considered.

Figure 4 (next page) shows typical design considerations.

### **8.3.3 BRACES**

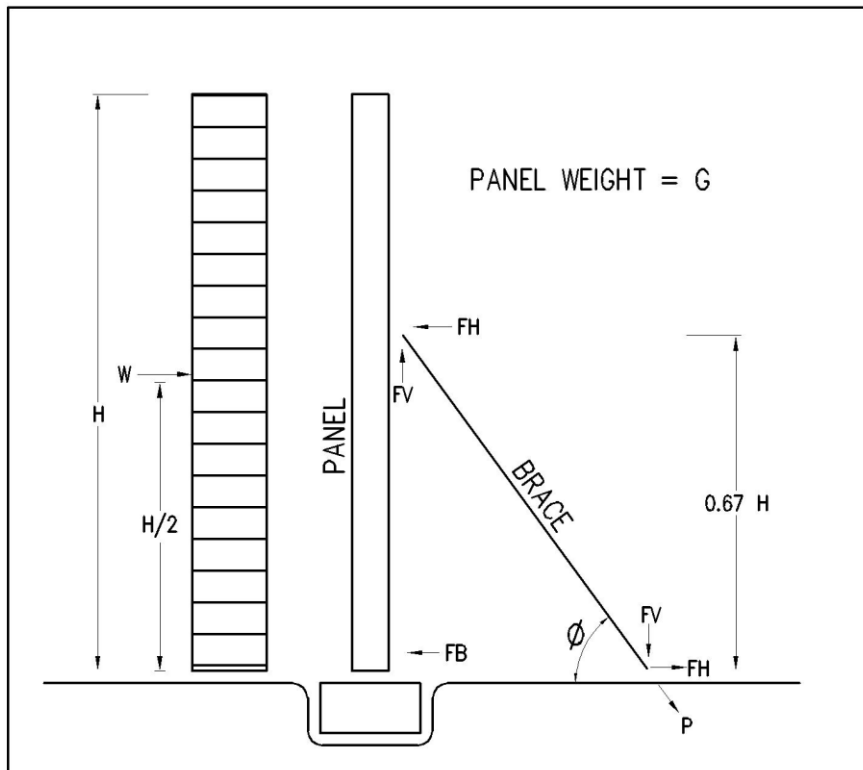
Braces should have a safety factor of 2 against failure.

All braces should have a safe working load rating available to anyone using or inspecting them.

Adjustable braces should have:

- safe working loads at zero and maximum extension available.
- stops on the threads to prevent over extension.





**Figure 4: Typical bracing configuration**

### Sample calculation of forces on braces and connections

For the arrangement above where  $W$  = the total horizontal load on the panel

$$F_H + F_B = W$$

$$0.67H \times F_H = 0.5H \times W$$

$$F_H = 0.5W / 0.67$$

$$= 0.75W$$

$$F_B = W - F_H$$

$$= 0.25W$$

$$\cos\phi \times P = F_H$$

$$\text{Total force in braces } P = 0.75W / \cos\phi$$

$$\text{Design force for braces} = 1.1 \times P/2 \text{ if 2 braces}$$

(allowing for a minimum 10% increase for eccentricities or uneven loading)

The self weight available to develop friction at the base is reduced by  $F_V$

$$F_V = \tan\phi \times F_H$$

$$= \tan\phi \times 0.75W$$

$\mu$  = reliable coefficient of friction at base

$$\text{Friction available at base} = \mu \times (G - F_V)$$

Must be greater than  $1.5 \times F_B$

or  $F_B$  to be resisted by other means

**NOTE:**

- Braces and their fixings should provide for a minimum of 10% more force to allow for eccentricities or uneven loading.
- Plastic shims for packing may have a coefficient of friction of 0.2 or less.
- Where base friction is insufficient to resist  $1.5 \times F_B$  then other means of base restraint should be provided to resist the full  $1.5 \times F_B$ .
- The sample calculation above is for wind forces causing compression in the braces. Wind forces in all directions should be considered.

**8.3.4 CONNECTIONS AND BRACES**

Connections of braces should be designed with a safety factor of 2.5 against failure. Where drilled in inserts are used to attach a brace, the drilled in inserts should be designed with a safety factor of 3.

Braces must be attached to solid, flat concrete or other surface able to resist the applied loads.

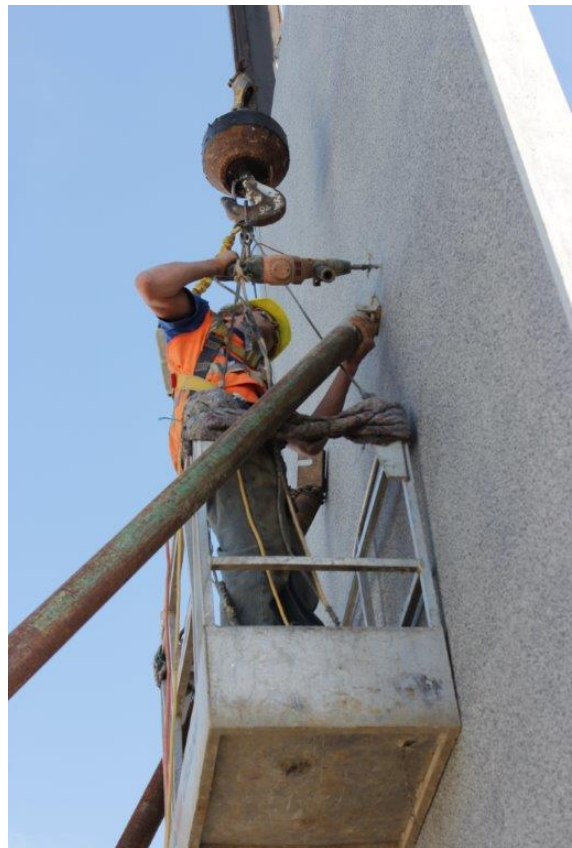
The bolted connection to each end of the brace must be able to provide a clamping force that will cause friction greater than the sliding force that would be imposed on that connection by the design load. This is to prevent creep of the connection under cyclic loads. The design load should normally be limited to 65% of the load at which the connection would slip.

The bracing feet (or shoes) that connect the brace to the concrete element or footing, should be designed to prevent the shoe becoming detached if they become loose and able to slide after installation.

**8.3.5 BOTTOM CONNECTIONS OF BRACES**

Bottom connections for braces are

normally to floor slabs, footings, or other concrete items known as dead men.



The likely strength of the concrete at the time connections are to be made needs to be considered, and the minimum strength at the time of connection specified. A higher grade of concrete may be used to achieve the required minimum strength at an early age.



The thickness and possible construction tolerance of floor slabs used for connecting braces need consideration. Care should be taken connecting to a slab of 100 mm thickness or less.

Dead men are either precast blocks on the surface of the ground and can be re-used, or more commonly they are specifically designed bored and cast into the ground at predetermined locations.

Dead men blocks are susceptible to sliding and overturning.

Use of dead men to resist bracing forces requires specialist design by a competent person.

Dead men dimensions must allow for the likely number of connections,

their spacing and their required edge distances.

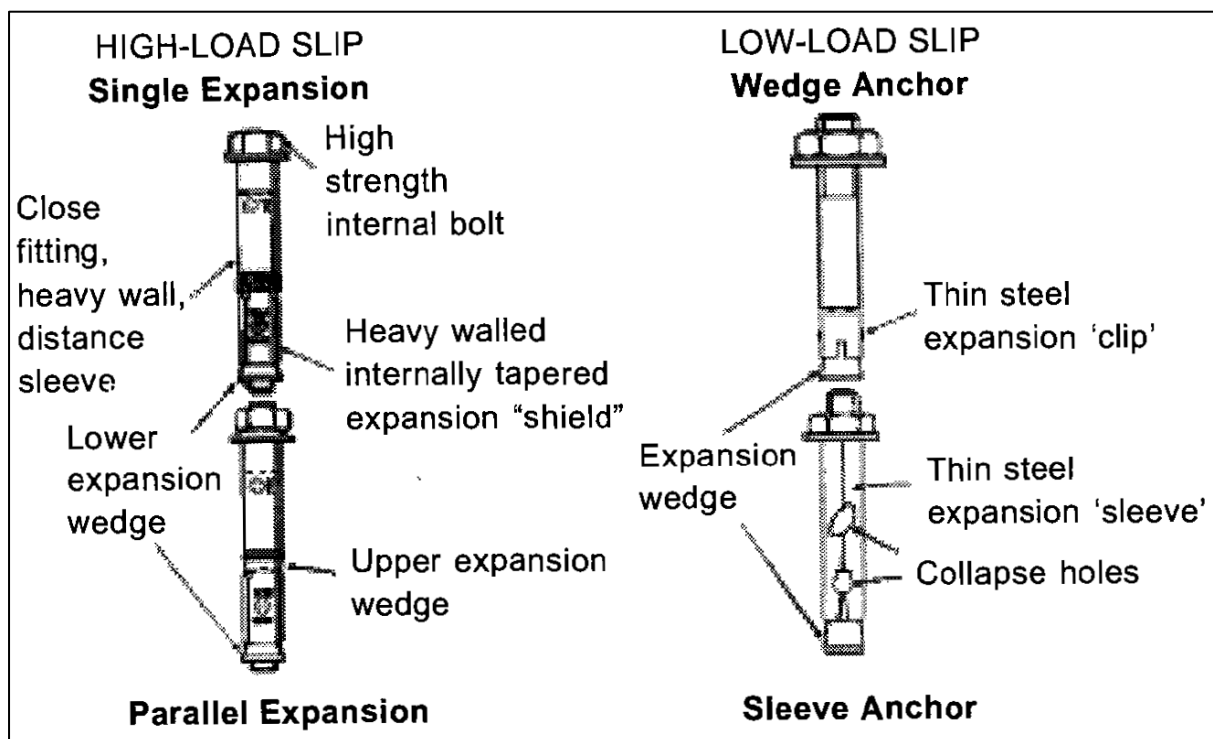
### 8.3.6 INSERTS FOR BRACING CONNECTIONS

Inserts for connection of braces should be designed with a safety factor of 3 against failure.

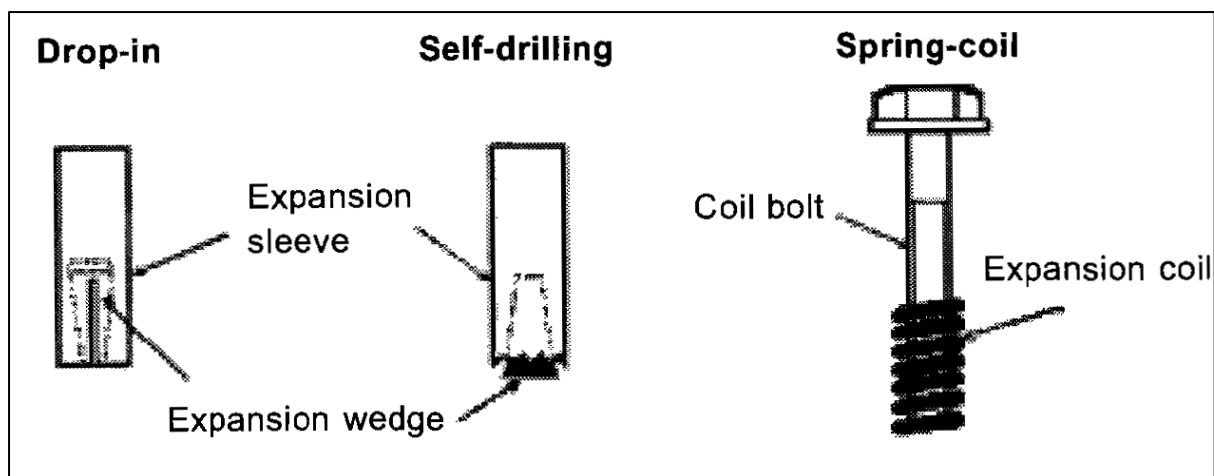
Cast in inserts or inserts which are drilled into the concrete after casting can be used.

Expansion inserts and cast in inserts should be manufactured from ductile material.

Drilled in anchors for connecting braces should be of a type known as heavy duty high load slip expansion anchors or 'load controlled' where an increase in load results in increased wedging force.



**Figure 5: Examples of expansion anchors.**  
(The low-load slip sleeve anchor should not be used)



**Figure 6: Examples of deformation controlled anchors.**  
(These are not acceptable for anchoring braces)

Deformation controlled anchors should not be used to connect anchor braces because they:

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

Where anchors using chemical adhesion are used, each anchor must be tested to its full design load prior to use.

Acceptable mechanical means of fixing bracing connections include drilled through fixings, undercut inserts, load-controlled (torque-controlled) expansion inserts, all used in accordance with the suppliers instructions and with the load limited to 65% of the 'first slip load', established in accordance with AS 3850 or the most recent equivalent.

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

Bracing insert capacities are sensitive to:

- the method of installation.
- the strength of the concrete at the time they are loaded.
- the distance of the insert from the edge of the concrete element.
- the distance to adjacent inserts that are loaded at the same time.

Bracing inserts should be located to allow the braces to hang without interfering with the rigging or the lifting process.

When designing bracing connections, the strength of the concrete in the brace footing and the precast panel at the time of installation must be considered as the concrete is unlikely to have been able to reach its full strength at the time of installation.

The designer of the bracing must ensure the concrete strengths required at the time of installation are clearly specified.

Expansion inserts are more susceptible to installation errors than drilled-through fixings. The supplier's

instructions should be followed when installing expansion anchors and special attention needs to be given to the correct drilling and cleaning out of the holes and the required tightening torque.



### 8.3.7 CORNER BRACING

Figure 7 shows a method of bracing corner elements without having to

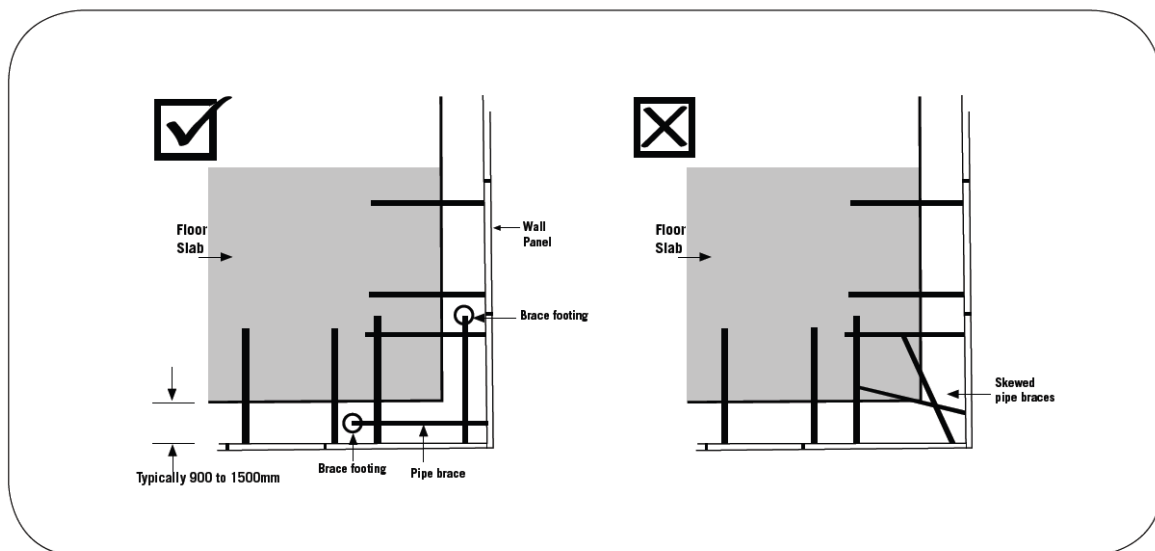
skew the braces. Attachment of braces to concrete blocks (dead men) in the leave-out area between the floor slab and the concrete elements allows the braces to be located without skew.

When braces are skewed, wind loads will cause a force along the panel which must be considered in design and assessing the stability of the system.

## 8.4 PROPPING OF BEAMS AND FLOORS

### 8.4.1 PROPPING REQUIREMENTS

The designer of precast beams and precast floor systems must ensure any propping requirements are clearly communicated to the builder and are available on request. These should include the number of temporary support points and their location. They must include any particular requirements for prop levels, cambers, or situations where props are installed to allow a predetermined amount of settlement during construction.



**Figure 7: Corner panel bracing without skewing**

### **8.4.2 PROPPING LOADS**

Propping for precast beams and precast floor systems should allow for changes to the distribution of loads during construction.

The builder is responsible for advising the precast manufacturer and the propping designer of any temporary construction loads that will exceed 2 kPa prior to precast floor systems reaching their design strength.

Temporary construction loads may include pallets of infills or building materials such as reinforcing stacked on the partially constructed floor, excess concrete before being spread and levelled.

### **8.4.3 PROPPING TO BE IN PLACE**

Unless specifically permitted otherwise, before starting to erect any precast beam or precast floor system, all temporary propping should be:

- in place.
- adjusted to the correct levels allowing for any camber.
- fully braced.
- seated on a suitable sole plate or bearing onto a suitable surface to avoid settlement when it is fully loaded at any stage during construction.
- where not bearing directly onto the ground, props must be able to safely transfer the full load through whatever structural system is involved without excessive settlement, deflection or overload.

Props should be properly aligned and braced to prevent side sway of the

whole assembly or buckling of individual props. Props are normally to be vertical.

## **8.5 PROPPING OF BEAMS**

### **8.5.1 POST-TENSIONED BEAMS**

Where beams are post tensioned, the stressing process can change the shape of the beam, thereby reducing the load on some props and increasing the load on others. In some cases the beam can lift off props in the middle, shifting the entire load to the props at the ends.

### **8.5.2 PRECAST SHELL BEAMS**

Precast shell beams are normally prestressed, causing a natural camber. In some instances the designer may require the props at mid span to be set slightly lower to let the beams settle back to a more level shape when the concrete core and floor topping is placed. In this case, props at the ends of the beam will take a much higher load.

### **8.5.3 SUPPORT AT THE ENDS OF PRECAST BEAMS**

Where the seating at each end of a precast beam is unsuitable to reliably take the full construction load, the beam will require full temporary propping at each end capable of supporting the full construction load.

### **8.5.4 BEAMS THAT SUPPORT FLOOR UNITS**

Where beams are to have floor systems placed on them during construction, allowance should be made for the likelihood of the beam being loaded on one side resulting in torsional stresses and causing it to roll. For this reason each edge of the beam may require temporary propping or other means of restraint.

Where beams will support floor units, beam propping should allow for load from the floor units. Propping for the floor units may 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. In this case, the beam propping may take a higher than anticipated load.

## 8.6 PROPPING PRECAST FLOOR SYSTEMS

### 8.6.1 TOP BEARER

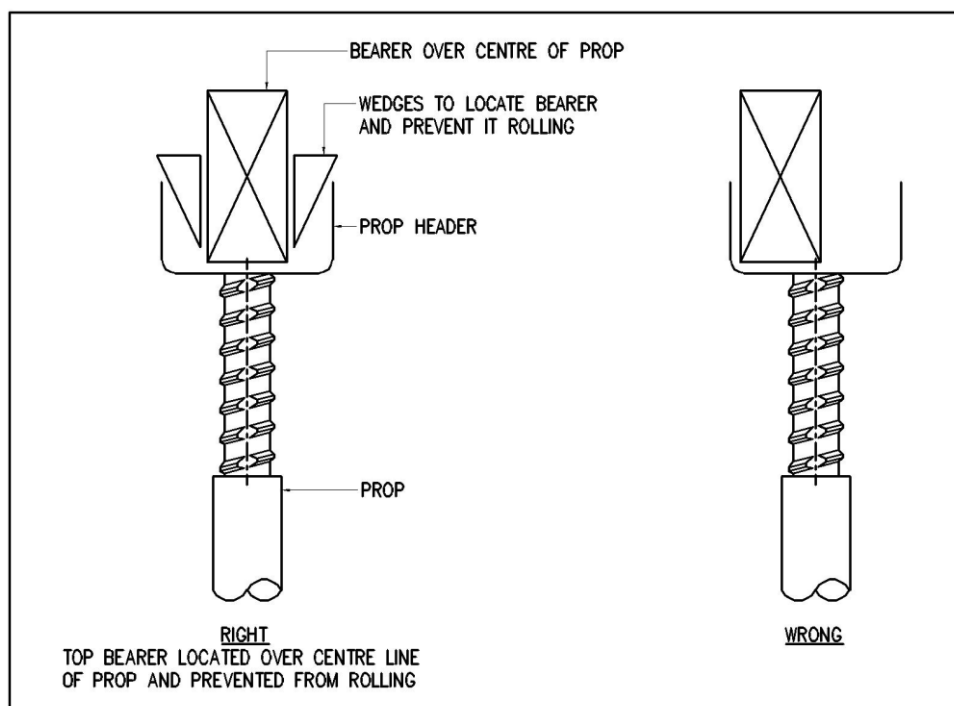
Propping to floor units should have a stable top bearer. The top bearer should be centred in the header so that the load is transferred concentrically into the prop. The top bearer must be over the centre line of the prop, otherwise the prop will be eccentrically loaded and may buckle, bend or break. The top bearer in the header of the props must be prevented from rolling.

### 8.6.2 UNPROPPED FLOOR SYSTEMS (HOLLOWCORE & TEES)

Hollowcore and tee floor systems are typically erected without temporary propping, but propping requirements should be confirmed prior to erection.

They may require some propping at mid span to even out the natural camber variations, or for other structural or cosmetic reasons. With the approval of the designer, props to take only a part of the construction load can be installed after the precast floor units have been placed.

These floor systems may require temporary support at the ends because of poor or inadequate seating, or to reduce the load on the support during construction. Where they are propped at the supports, the propping should be within 500 mm of the end of the unit unless specified otherwise by the designer.



**Figure 8: Top bearer**

## 9. BUILDER'S RESPONSIBILITIES

### 9.1 SCOPE

This section is about responsibilities and duties specific to delivery and erection of precast concrete and not further responsibilities of the builder. It is to be read in conjunction with other sections of this guide. Responsibilities of the builder prior to commencement of precast manufacture are also listed in Section 5 *Manufacture*.

Construction sites are rarely designed specifically to handle and store precast elements. The health and safety plan for the construction site must cover precast elements.

This can include:

- a traffic management plan.
- a site hazard identification process.
- a site safety plan.
- a vehicle unloading area.
- a designated temporary storage area.

As well as being in control of the construction site, the builder has overall responsibility for coordination between the different trades and the subcontractors involved from the production of the precast elements through to fixing into their permanent position.

The builder must ensure all parties have all necessary information at a suitable time.

The coordination responsibilities of the builder are referred to elsewhere throughout this guide.

### 9.2 PROGRAMME

The builder has responsibility for the construction programme. This should consider the time required for the precasting process including shop drawings, approvals and resubmission, mould manufacture or modifications, production rates, storage, time required for precast concrete to develop sufficient strength for the various procedures, time for concrete on site to develop sufficient strength for delivery, bracing and propping and erection procedures.

The construction programmes and updates should be communicated to the precast manufacturer promptly. Delays to the construction programme may cause storage or production problems.

Long term storage of precast elements can result in uneven appearance due to exposure differences while curing, and can result in permanent deformation due to concrete creep.

Precast concrete is susceptible to damage each time it is handled or moved. Where possible, the builder should programme to have precast elements lifted directly into their final position when they are delivered without the need for temporary storage on the construction site.

### 9.3 RESPONSIBILITIES RELATING TO PRECAST CONCRETE

The builder has responsibility to ensure the stability of the structure





throughout the construction process. This can be affected by the installation of precast elements.

The risk of progressive collapse should be considered and the failure or dislodgement of a single element or an item such as a prop or a brace should not lead to progressive collapse.

Installation procedures can alter the weight distribution and affect stability of the structure or part of the structure.

The construction procedure should consider the contribution of the precast elements to the stability of the structure.

The builder must ensure that construction loads do not exceed the capacity of any part of the structure at the time the loads are applied. In

particular storage of precast elements or other materials, or loads from vehicular traffic should not overload floors, beams, propping systems, retaining walls or the ground or other surface.

The builder should monitor weather forecasts and in the event of adverse weather being predicted, ensure adequate steps are taken to stabilise incomplete structures and assess temporary supports. Where adverse weather could lead to failure of any bracing or propping system or dislodgement of any precast element that is not fully fixed into its final location in the structure, the builder must ensure all persons are removed from locations where they may be harmed.

The builder is responsible for providing suitable access for the vehicles, cranes and other equipment

necessary to deliver and erect precast elements.

The builder must ensure the crane operator and erection subcontractor have all necessary information prior to lifting any element. This may include:

- Weights of elements to be lifted.
- Details of lifting inserts and lifting clutch requirements.
- Rigging arrangements required for each element.
- Manufacturer's statement of compliance.

The builder must ensure adequate clearance is provided for cranes and their loads allowing extra clearance where precast elements are to be turned or re-orientated while suspended from a crane. In particular, consideration must be given to power lines and other services, and areas where the public have access.

The builder is responsible for ensuring the erection platform (floor slab, suspended slab, surrounding ground, etc.) can carry the construction and erection loads that will be imposed at all stages of the delivery and erection process.

The builder is responsible for the construction programme.

The programme must allow for the time required for concrete to develop sufficient strength for the loads to which it will be subjected. This applies to floor slabs and concrete dead men that braces and props are attached to, and slabs that may be loaded by vehicles or cranes.

Where a mobile crane is to be used, provision must be made to safely support the loads from the crane's outriggers.

The site hazard identification process should take account of the specific hazards associated with precast concrete. In particular:

- elements falling.
- heavy elements moving in unexpected ways possibly causing crushing.
- risks associated with transporting precast elements on site.
- risks of elements falling while they are temporarily supported prior to permanent fixing into their final location.
- the risk of extreme weather conditions causing elements to fall due to failure of a temporary support.
- the risks of accidental damage to braces or props causing an element to fall.
- the risk of ground settlement causing a delivery vehicle or its load to become unstable.
- the risk of ground settlement causing instability of stored or propped elements.

Exclusion zones should be established to keep non-essential workers out of danger areas.

Drop zones should be identified where elements may fall due to accidental damage or failure of a supporting component and non-essential workers kept out of these zones.



# 10. ERECTION OF PRECAST ELEMENTS

## 10.1 SCOPE

This section is about specific requirements for erecting and placing precast elements. It is to be read in conjunction with other sections of this guide.

Handling and erecting precast elements is potentially hazardous.

The possibility of progressive collapse should be considered at all stages.

All parties involved have a responsibility to ensure the work is carried out safely.

Personnel involved with handling and erecting should be adequately trained and supervised. Personnel not directly involved should be excluded from any area where they might be at risk if an element fell or a support failed.



## 10.2 PREPARTION

Confirm that access is suitable considering the following:

- Suitable ground conditions for transporters, cranes, crane outriggers or other equipment.
- Adequate concrete strengths for loads that may be applied by transporters, cranes or other equipment.
- Clearance for lifting and manoeuvring precast elements.
- Clearance for crane outriggers and counterweights.
- Clearance between all crane operations and any braces, props or components that will be in place to avoid accidental damage.
- It is desirable for the crane operator to be able to retain visual contact with the loads throughout the erection process.
- Clearance of power lines and other services.
- Clearance from public spaces.

Check:

- the weather forecast for the possibility of unsuitable weather conditions.
- the rigging arrangements for which inserts have been provided in the elements – confirm that suitable rigging systems are available (this is particularly important where load equalisation is required or elements require turning while suspended).
- the rigging arrangement results in suitable sling angles that don't increase loads above the safe capacity of any insert, sling or part

of the system – in some cases spreader bars or longer slings may be required.

- if strong backs or load spreaders are available when required.
- that all necessary setting out points, lines, etc. are available.
- bracing and propping where required are designed by a competent person.
- there is a suitably detailed design, where bracing systems are required, and all necessary information is available. (Refer Section 8 *Bracing and propping*).
- all necessary components for bracing or propping systems and the necessary tools and equipment are available.
- if propping is required to be in place prior to placing elements.
- if precast elements are to be supported on formwork – confirm that the formwork and its supports have sufficient strength.
- if manufacturer's statement of compliance is required and available (see Appendix A).
- that drop zones have been identified and a means of excluding people is available.

Confirm:

- concrete strengths are adequate for the loads that may be required for the inserts or applied by braces, props and their connections.
- the crane has sufficient capacity at the required reach for the weights of the elements and lifting equipment.

- that the lifting and rigging equipment, clutches and connections are compatible with the lifting inserts in the elements to be lifted.
- the compatibility of lifting inserts and lifting clutches when they are from different suppliers.

### **10.3 LIFTING**

When unsuitable weather conditions are predicted or imminent, lifting operations must be stopped and all temporary supports completed. If high winds are expected, ensure personnel are kept clear of potential drop zones.

Lifting operations must be under control of a competent person.

Prior to lifting an element, ensure the drop zone is clear.

Ensure the correct inserts are used for lifting. Inserts may be cast in the element for other purposes such as handling during the manufacture or for permanent fixing. Use these other inserts only after confirming that they will be used within their capacity.

Check lifting inserts are not damaged and lifting clutches or other attachments are not damaged and are able to connect properly. Threaded inserts should be clear. Foot anchors and all lifting inserts, lifting loops, etc. should have sufficient clearance to permit attachment of the lifting clutch or whatever connection is intended in such a way to permit it to function correctly without inappropriate restriction of its movement during lifting or handling.

Where lifting eyes fabricated from prestressing strand are used, they must be free of defects such as nicks,

arc strikes or wedge grip marks. They should be sufficiently far out of the surface to permit unrestricted access for the crane hook or other attachment and ensure the crane hook or other attachment does not bear on the concrete surface during lifting or handling.

Slings attached to strand lifting eyes must not be at an angle that would cause a sharp bend at the concrete surface. The angle at the concrete surface can be reduced by use of longer slings or spreader beams.

Where multiple strands are used for one lifting point, they should be enclosed in a plastic tube.

Elements must only be lifted in a controlled manner.

Elements must be restrained from uncontrolled horizontal movement as they are lifted.



Panels lifted from a flat orientation are particularly susceptible to horizontal movement as they are lifted. The risk of this should be assessed and suitable measures put in place to restrain or control this movement and to exclude personnel from any areas where they may be at risk.

If running rigging is used, care should be taken to ensure the element will not tilt uncontrollably.

Where tag lines are used to control the swing of an element, people using the tag lines must remain a safe distance from the element.

### **10.3.1 MISSING OR UNUSABLE LIFTING INSERTS**

If any inserts are in the wrong place, faulty, missing or cannot be used, the element must not be lifted until a competent person has designed a suitable and safe solution. Solutions may involve:

- Attaching a plate with undercut anchors.
- Attaching a plate with expansion anchors. Expansion anchors used for lifting require a factor of safety of 3.
- Attaching a plate with chemical anchors. Chemical anchors can only be used for lifting after each one has been individually proof tested.
- Drilling through the element and bolting on a lifting plate.

### **10.3.2 UNITS WITH NO LIFTING INSERTS**

Some precast elements (such as prestressed hollowcore floor slabs) may not have lifting inserts. They

must only be lifted at locations approved by their designer.

Where units are to be lifted or supported close to their ends, lifting or supporting further from their ends may cause collapse.

Use lifting clamps where they are available or lifting strops or slings to handle these elements. This type of lifting equipment wears rapidly, and must be regularly inspected by a qualified person and inspections recorded.

When lifting elements by using lifting clamps or forks, secure the load with safety slings or other securing devices.

### **10.3.3 BRACES ATTACHED TO WALL PANELS**

Where possible, attach braces to wall panels and precast elements before lifting.

### **10.3.4 ATTACHING BRACING AFTER POSITIONING**

If bracing has to be attached after the element is in place, the crane must hold the element while braces are installed using a suitable access system.

### **10.3.5 SAFE REMOVAL OF BRACES**

Removal of braces and props is potentially hazardous. Refer to Section 8.2 *Removal of braces and props*.

## **10.4 LEVELLING SHIMS**

### **10.4.1 MATERIAL FOR LEVELLING SHIMS**

Levelling shims should be made from suitable durable materials with

enough strength to carry a full load.

The coefficient of friction of the levelling shim material is a consideration in design of the bracing system. Where friction is relied on for base restraint while braced, low friction shim material should not be used without reference to the bracing designer. The effect of water on the coefficient of friction of the shims should be considered in design of the bracing system.

As well as for levelling, shims are used to avoid direct concrete to concrete, or concrete to steel contact, because it frequently causes edge spalling and cracking.

### **10.4.2 LEVELLING SHIMS TO BE ON SOLID FOUNDATIONS**

Levelling shims should be on solid foundations, not on thin layers of site concrete. Levelling shims carry the full construction load of the pre-cast element resulting in higher stresses under the shims. Any settlement under the levelling shims will cause alignment problems and may be difficult to correct once the panels have been braced.

### **10.4.3 HEIGHT OF SHIMS**

The total height of levelling shims should be limited to 40 mm unless the stability is assessed by a competent person.

### **10.4.4 LOCATION OF SHIMS**

Where practical, shims should be at least 100 mm in from the ends of the element. Edge break-out can occur in thin wall panels if shims are placed close to bottom corners.

# APPENDIX A: Manufacturer's Statement of Compliance for Precast Concrete Elements

Item	Description	Response
1	Project name	
2	Construction site address	
3	Precast manufacturer's name	
4	Date of transport to site	
5	Product type	
6	Concrete grade used	
7	Component identification marks	
8	Certification	I, (Name): .....
		on behalf of the manufacturer, certify that the elements in the schedule above were manufactured to the standards in the Industry Guide for the Safe Handling, Transportation and Erection of Precast Concrete, and the relevant shop drawings.
		Signature: .....
		Date: .....

**NOTE:** The precast manufacturer is not responsible for the on-site rigging, handling or slinging of the precast elements listed above.

# APPENDIX B: Publications and References

The following documents are listed for reference. Where these have been superseded the latest versions should be used.

## STANDARDS

*NZS 3101.1&2 Concrete structures standard*

*NZS 3109 Concrete Construction*

*NZS 3404.1&2 Steel structures standard*

*AS/NZS 1170.0–3 Structural design actions standard*

*NZS 1170.5 Structural design actions – earthquake actions – New Zealand*

*AS 3850 Tilt-up concrete construction*

## NEW ZEALAND APPROVED CODES OF PRACTICE

*Approved code of practice for load-lifting rigging.*

*Approved code of practice for cranes – includes the design, manufacture, supply, safe operation, maintenance and inspection of cranes.*

## AUSTRALIAN CODES OF PRACTICE

*Australian national code of practice for precast, tilt-up and concrete elements in building construction.*

## NEW ZEALAND BEST PRACTICE GUIDELINES

*Best practice guidelines for working at height in New Zealand, 2012.*

*CCANZ Publication TM 34 - Tilt-up Technical Manual.*

*New Zealand Concrete Society – Guidelines for the use of Structural Precast Concrete in Buildings.*



