STANDARD INDUSTRI PEMBINAAN
(CONSTRUCTION INDUSTRY STANDARD)

CIS 9:2008
GUIDELINES ON HANDLING, TRANSPORTATION, STACKING AND INSTALLATION OF PRECAST CONCRETE COMPONENTS

Descriptors: handling, transportation, stacking, installation, precast concrete, beams, columns, slabs, walls, lifting inserts, minimum strength, rigging system, support frames

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GUIDELINES ON HANDLING, TRANSPORTATION, STACKING AND INSTALLATION OF PRECAST CONCRETE COMPONENTS
Committee representation

The Industrialised Building System (IBS) Technical Development Committee under whose authority this Construction Industry Standard (CIS) was developed, comprises representatives from the following organisations:

- Association of Consulting Engineers Malaysia
- Construction Industry Development Board Malaysia
- Hume Industries (M) Berhad
- The Institution of Engineers, Malaysia
- Jabatan Kerja Raya Malaysia
- Master Builders Association of Malaysia
- Malaysia University of Science and Technology
- MTD ACPI Engineering Berhad
- Pertubuhan Akitek Malaysia
- Setia Precast Sdn Bhd
- UAC Steel System Sdn Bhd
- Universiti Teknologi Malaysia
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FOREWORD

This Malaysian Construction Industry Standard (CIS) was developed as guidelines on handling, transportation, stacking, and installation of precast concrete components with the assistance of the Construction Industry Development Board Malaysia (CIDB) which acted as a moderator and facilitator for the working committee throughout the development process of this standard.

This CIS 9 on guidelines on handling, transportation, stacking, and installation of precast concrete components was referred from existing Malaysian manufacturers’ on method of statement.

The main objective for developing this guidelines is to establish a detail and systematic framework for:

a) ensuring precast elements supplied to project sites are handled orderly with a recommended and systematic procedures;

b) establishment of a common standard of acceptance for all the relevant parties involved in precast elements; and

c) setting the minimum specifications to be used by the manufacturers, contractors etc.

The use of this Standard is voluntary and compliance with this document does not in itself confer immunity from legal obligations.
Section 1: Handling of precast components

1.1 General

After the precast components are manufactured in production yard, these elements should be handled orderly and proper care is required until being transferred to construction site.

Methods for handling and storage of precast concrete elements will vary depending on the type of element and whether the element is in the factory or on site. The important criteria are safety of personnel and protection of the concrete element.

The handling and storage system must ensure safe transfer of the element from the mould to the storage area and easy access to the element for removal and erection. At no time should a precast element be placed in a position without positive restraint unless it is inherently stable.

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

1.2 Marking

Each unit should be clearly marked with an identification symbol either on the unit or by securely fixing a non-rusting metal tag or water proof label to it. Where the geometry of the unit does not make it obvious, units should also have an orientation mark.

1.3 Surface finishes

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

1.4 Minimum strength

1.4.1 Minimum strength for lifting

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

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

The minimum strength of the concrete at initial lift must be sufficient to develop the required capacity of the lifting inserts.
The following table provides minimum concrete strengths for lifting and handling.

### Table 1: Recommended minimum concrete strengths for lifting and handling

<table>
<thead>
<tr>
<th>Application</th>
<th>Minimum concrete strength, f'c</th>
</tr>
</thead>
<tbody>
<tr>
<td>None specified, fine controlled crane, non-pro-stressed.</td>
<td>10 MPa*</td>
</tr>
<tr>
<td>Lifting which involves significant impact or high acceleration.</td>
<td>15 MPa*</td>
</tr>
<tr>
<td>All units where concrete strength for lifting is specified in the contract documents.</td>
<td>As specified</td>
</tr>
<tr>
<td>Concentrically pro-stressed elements (piles, wall panels or thin floor slabs).</td>
<td>20 MPa</td>
</tr>
<tr>
<td>Eccentrically pro-stressed elements (tees, deep flooring units).</td>
<td>25 MPa</td>
</tr>
<tr>
<td>Bridge beams and similar highly stressed Pro-stressed elements.</td>
<td>30 MPa or as specified</td>
</tr>
</tbody>
</table>

*Dependent on anchor length or as recommended by insert manufacturer.

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

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

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

Figure 1. Lifting of precast U-drain / box culvert

Figure 2. Lifting of precast drain cover
Figure 3. Lifting of precast U-drain / box culvert

Figure 4. Lifting of precast L-drain (option 1)

Figure 5. Lifting of Precast L-drain (option 2)
1.4.2 Minimum strength for transport and erection

Transporting and erection will generally impose less stress on precast elements than those caused during lifting from the mould. This may not be the case for panels cast in vertical or tilting moulds. In the case of elements subjected to high stresses due to support conditions on trucks, or elements required to carry significant construction loads, the minimum strength required for transport and erection should be clearly stated on the shop drawings, and on the precast layout drawing. This would normally be the responsibility of the designer of the element.

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

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

1.5 Reinforcement

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

1.5.1 Additional reinforcement for lifting and handling

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

1.6 Lifting

1.6.1 Type of lifting insert

The type of lifting eyes or inserts to be used on a project should be mutually agreed between the manufacturer and the builder or erector.
1.6.2 Setting up lifting anchors in moulds

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

<table>
<thead>
<tr>
<th>Type of Unit</th>
<th>Tolerance</th>
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</thead>
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<tr>
<td>Piles</td>
<td>150 mm</td>
</tr>
<tr>
<td>Flooring units</td>
<td>150 mm</td>
</tr>
<tr>
<td>Beams</td>
<td>Along the length 300 mm</td>
</tr>
<tr>
<td></td>
<td>Across the width 25 mm</td>
</tr>
<tr>
<td>Columns</td>
<td>Along the length 300 mm</td>
</tr>
<tr>
<td></td>
<td>On the end 25 mm</td>
</tr>
<tr>
<td>Wall panels</td>
<td>Face 25 mm in any direction</td>
</tr>
<tr>
<td></td>
<td>Edge 5 mm across the thickness</td>
</tr>
<tr>
<td></td>
<td>and/or 25 mm longitudinally.</td>
</tr>
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1.6.4 Type of lift

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

a) Standard lift

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

b) Non-Standard

A lift that does require special rigging or equalisation procedures. This must be noted on the shop drawings
Figure 11a. First step – hooking onto unit on truck

Figure 11b. Second step – turning unit

Figure 11c. Third step – unit oriented correctly for installation

Figure 11. Non-Standard type of lifting

1.5.5 Units with no lifting inserts

Some precast elements may have no lifting inserts. These units must be handled by means of lifting clamps designed by a suitably qualified person, or by lifting straps or slings. Lifting
equipment of this type wears rapidly, and must be regularly inspected by a suitably qualified person. Inspections must be recorded.

On construction sites, elements handled by means of lifting clamps or forks should have the load secured by safety slings or other securing devices. The location of lifting points should be indicated by the designer or other competent person.

1.7 Handling

Handling methods may vary depending on the facilities available and the types of elements being manufactured. Elements may require multiple handling or rotation for processing or finishing.

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

**Figure 12. Lifting of multiple precast slab**

**Figure 13. Lifting of single precast slab**
1.7.1 Concrete strength for handling

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

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

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

1.8 Stacking

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

Figure 14. Correct method of stacking precast parapet wall

Figure 15. Correct method of stacking precast U-drain
Figure 16. Correct method of stacking precast slab

Figure 17. Correct method of stacking precast M-beams
1.9 Dunnage

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

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

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

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

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

1.10 Storage

The storage area must be large enough for elements to be stored properly with adequate room for lifting equipment and for maneuvering trucks and cranes. The area must be reasonably level and hard surfaced with adequate drainage to ensure that a safe workplace can be maintained.

Elements must not be stored directly on the ground. Generally, two discrete support points must be provided unless specifically approved otherwise by the project design engineer. Timber supports raised above the ground or dedicated racking systems must be used in all cases. Elements should be stored in such a manner that each element supports only its own weight without any load being imposed by other elements. Where elements are stacked horizontally on top of each other, the following must apply:

a) support points must be directly above each other unless specifically approved otherwise by the project design engineer;

b) the stacked height of elements must be limited to ensure that the ground bearers and lowest elements can support the loads from above and that the stack remains stable; and

c) stack height must not be higher than twice the element width unless specifically approved otherwise by the project design engineer and provisions are made to minimise the likelihood of accidental impact from vehicles or other elements.

Points of contact between elements and supports must be provided with protective material to prevent breakage and staining. Special consideration must be given to pre-stressed elements to ensure they are only supported at designated bearing points. Pre-stressed elements must not be supported, even temporarily, at any other points.

They must not be tipped sideways or stored directly on the ground.

1.10.1 Storage systems

Storage systems for elements that are not inherently stable must be designed to resist the loads and forces applied to them. This includes wind loads, construction loads and impact loads generated during placement of the element and, where appropriate, accidental impact from vehicles. The design of the storage system must be fully documented.
To minimise the effects of vehicle and other uncontrolled impact, the element support systems (racks and frames etc) must be robust and designed so that failure at one point does not result in progressive failure. Racking systems must be designed so that if one element fails it does not create a domino effect.

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

a) at least two restraint points must be provided so that the panel is stable under the loads as noted above. The top restraint must be above the mid-height or centre of gravity of the panel;

b) the restraint system must be designed to withstand the loads as noted above as well as loads generated when the panel is up to 5 degrees off vertical; and

c) where necessary, provision must be made in the design of the restraint system for panels with corbels and nibs.

Racking systems frames and supports must be constructed in accordance with a design prepared by a qualified engineer suitably experienced in the field of procast concrete construction.

Frames, either single sided, or double sided ‘A’ frames used to store wall panels must be designed and constructed so that:

a) the frame and its supports remain stable and withstand the forces as noted above;

b) panels remain stable in the frame when the panels are not restrained. The slope of the panels must be such that the panel will not tip out of the frame; and

c) the frame and its supports accommodate uneven loading of panels. The limitations for uneven loading must be clearly shown on the frame.

1.10.2 Site storage

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

The required work method must be clearly documented.

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

a) elements must only be stored in a position approved by the project design engineer;

b) ground conditions must be checked to ensure that the mass of the element can be supported;

c) where an element is to be stored on a suspended floor slab, approval and written instructions must be obtained from the project design engineer before proceeding;

d) wall panels may be stored in a suitable ‘A-frame’ or stood and braced in a vertical position. Bracing should be in accordance with the general requirements of this code; and

e) wall panels may only be stored horizontally in accordance with a written instruction from the erection design engineer or project design engineer.
Wall panels should preferably be stored in the vertical position. Where edge-lifted panels are stored horizontally, they must be placed to ensure that component reinforcement around edge lifting inserts is correctly orientated for re-lifting.

![A-Frame Diagram]

**Figure 18. Wall panels stored in A-frame position**

![Horizontal Stack Diagram]

**Figure 1. Wall panels stored in horizontal position**

1.11 **Impact protection**

For precast concrete elements stored in areas of vehicular movement, additional protection may be required. This could include the use of bollards or other physical barriers. During handling and storage, care must be taken to minimise the likelihood of impact between elements.

1.12 **Multiple handling**

The sequence of erection should be such that the multiple handling of elements is minimised. A specific procedure should be developed and the operation supervised by a competent person if multiple handling is required.

Elements should only be stored in a manner approved by the designer or other competent person.

1.13 **Certification of compliance**

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

An example of a manufacturer’s certificate of compliance is provided as Annex A.

Note: It is not intended that a certificate of compliance should be provided or requested for each manufactured element. Where a number of elements of similar design are manufactured under the same or similar conditions one certificate would be acceptable assurance of compliance with this code.
Section 2: Transportation for precast components

2.1 General

The following points must be taken into account when precast panels are to be transported to and around the site:

a) the shape, size and mass of the panels;

b) specific design requirements, including the concrete strength required for transportation and the stability of long or unusually shaped panels during transportation;

c) local traffic regulations governing maximum weight, length, width and height of the laden vehicle;

d) providing all-weather access for the delivery vehicle to and around the site;

e) capacity of permanent structures to carry transport loads where required; and

f) temporary storage, where required.

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

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

a) must be restrained by an appropriate method; and

b) must not be placed in a way that makes the vehicle unsafe or unstable.

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

2.2 Basic principles

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

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

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

The transporter must ensure that the vehicle used is suitable to transport the elements and that they are properly secured. A vehicle must not be moved without the load being secured in the appropriate manner. The transporter must ensure that drivers have been adequately instructed in the safe transportation of precast elements, with particular attention given to:
a) power lines;
b) recognised truck routes for over dimensional loads; and
c) roundabout and reverse camber in the roads.

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

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

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

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

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

The order of stacking and the support details on the delivery vehicle and the design of the transport frames must permit the panels to be safely unloaded to temporary storage or be safely erected into the structure in the required sequence.

Lifting points on the panels should be checked to ensure they are compatible with the lifting system used. Lifting inserts should be clearly identified to assist in the loading and unloading stages.

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

2.3 Support frames

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

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

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

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

Points of contact between elements, supports and restraints must be provided with protective material to prevent breakage and staining. Corner protectors must be used under all restraints to prevent movement and damage to the element. Low friction material should not be used as packing to support an element.

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

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

Special attention must be given to pre-stressed elements to ensure that they are only supported at designated bearing points and that restraint systems do not impose excessive loads. Pre-stressed elements must not be supported, even temporarily, at any other points and they must not be tipped sideways.

2.5 Delivery

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

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

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

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

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

A vehicle must not be moved without the load being secured in the appropriate manner. The transporter is responsible to ensure that the load is secured in the appropriate manner at all times, including during the unloading operation.
Section 3: Erection of precast components

3.1 General

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

The builder must determine that the erection platform (floor slab, footing, suspended slab or surrounding ground, etc.) can support the construction and erection loads and provide verification to the crane owner/operator prior to the commencement of the work.

If a suspended slab is used to support the crane, or transporter, the slab should be designed for the crane point loads, wheel loads, or any other construction loads, by a registered engineer. A temporary propping system may be required. Temporary supports, jointing and bedding materials, fixings and tools should be pre-positioned at the fixing point. All temporary wedges, shims, and spacers ad other item not designed for permanent inclusion in the structure should be removed and the spaces made good as necessary.
3.2 Planning the construction and erection sequence

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

The planning process must take into account:

a) site limitations and local street access;
b) element sizes;
c) crane size configuration, mobility and access;
d) casting sequence; and
e) overhead obstructions, especially overhead power lines and construction site overhead power.

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

a) adequate first aid facilities, workplace amenities, personal protective clothing and equipment in accordance with the safety code;
b) practice of those services according to (a) and equipment as appropriate;
c) adequate site access for the type of construction methods to be employed;
d) adequate access for the size of the crane to be used;
e) adequate access for semi trailers and transport equipment; and
f) serviceable height access equipment appropriate to the construction methods.

3.3 Erection preparation

Prior to commencing the handling and/or erection of precast concrete elements, the following items should be considered by the manufacturer or builder as appropriate:

a) check crane access to the site and erection platform to prevent cranes or trucks damaging the concrete floor during access. A compacted hard-fill ramp at a suitable gradient should be provided to a level slightly above the concrete floor;
b) obtain verification that the erection platform can support the erection loads;
c) ensure the locating dowels and leveling shims are correctly located. Dowels rather than blocks should be used to restrain the base of face-lifted panels when they are being positioned;
d) clear the site for truck and crane access ensuring room for crane outriggers, counterweight tail swing, boom swing and under hook and overhead obstructions;
e) ensure that sufficient space is available for precast propping or panel bracing;
f) the builder must ensure that adequate temporary base restraint is provided for any precast element to prevent a sliding failure (kick out) at the base or support of the element;

g) check that the means of temporary support, including false work is adequate for the intended purpose and located correctly prior to the precast elements being placed;

h) verify that the concrete has obtained the specified strength for lifting. This may already have been done if the element was manufactured off-site; and

i) check that the lifting inserts are in their correct location and that recesses are cleaned out in preparation for lifting.

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

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

3.4 Planning for requirements

3.4.1 Planning craneage requirements

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

Cranage planning should commence as early as possible in development of the work or project. Designers and engineers must give consideration to crane loadings and access at the initial design stage, especially where cranes may be supported on concrete slabs.

At appropriate stages, the planning process must consider:

a) various stages including initial design, builder or contractor site set out, stage immediately prior to the crane’s use;

b) consultation with the erector;

c) crane selection, access and sitting;

d) ground support conditions and the location of any excavations or underground services likely to be adversely effected by imposed crane loads;

e) proximity of overhead power lines;

f) written procedures for setting up and dismantling of the crane and the lifting method as well as a risk assessment of these procedures;

g) the make-up of the crane crew appropriate to the particular circumstances of the job;
h) the communication system;

i) selection of lifting gear including appropriate snatch block for rotation of panels while suspended if rotation is to be carried out (snatch blocks and other sheave blocks with standard main bearings are not intended to be rotated under load. Thrust races or separate swivel bearings must be used);

j) personal protective equipment for the rigging crew;

k) emergency procedures; and

l) protection of the public.

3.4.2 Crane capacity and operating radius

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

The required crane capacity is affected by factors including the distance from the centre of rotation of the crane to the centre of gravity of the precast element being lifted. The rated capacity of a crane decreases as distance of lift from the centre of rotation of the crane increases. The operating radius for tower cranes and large mobile cranes will generally be much greater, and a methodology should be developed between the builder, crane owner and handling and erection personnel.

Where lifting is not possible with one crane and it is necessary to use two cranes to "dual lift" elements, the required crane capacities should be carefully assessed. The capacity of either crane must not be less than 75% of the mass of the element.

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

3.5 Rigging

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

The rigging system must distribute equal loads to all lifting points unless specifically designated otherwise on the shop drawings and should include the use of slings running through sheaves on spreader or lifting beams.
Figure 22. Crane working radius

Figure 23. Rigging system components

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

Sling lengths are critical where the rigging system includes the use of spreader beams or lifting beams with slings running through sheaves. The rigging system must be designed to suit the spacing and layout of the lifting inserts.
Single, double and four leg slings are commonly used in the handling of elements. In selecting the sling capacity, the increased force due to inclination of the sling and the change of direction at reeving points should be considered. The included angle between slings at reeving points should not exceed 120 degrees.

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

Lifts desirably should be planned so that rotation of snatch-block swivels under load is not required. Where the snatch block is required to rotate it must have thrust races or separate swivel bearings.

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

Where blocks with lockable clamp bolts are not available, care must be taken to ensure that the cheek plates clamp bolt is fully tightened and that rubbing and abrasion under load does not occur. see Figure 24.

![Snatch block diagram](image)

**Figure 24. Snatch block**

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

a) appropriate location of the lifting inserts;

b) correct location of the slinging point or points in the element;

c) use of a lifting beam with offset lifting points; and

d) use of a counterweight.
Where precast elements need to be rotated through 90 degrees by use of a tailing lifter (lifting insert at the bottom of the element), the required capacity of the crane winch being used to rotate the element must be determined.

Up to 70% of the mass of the element can be taken by the tail lifter during rotation. This is particularly critical for edge lifted wall panels (refer Figure 25). Panels should be rotated such that the panel is suspended in its rotated position by the main winch, if one crane is used, or the larger capacity crane if two are used. Where one crane is used each winch drive should be independent. This rotation procedure requires a great deal of skill by crane operators. Components of the rigging system including lifting gear and slings must be checked regularly for damage and excessive wear, corrosion, etc to ensure it is appropriate for the loads being lifted. Regular inspection of the lifting clutches must be carried out to check for wear and deformation.

![Figure 25. Tailing lifters](image)

### 3.6 Erection crew

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

- a) a competent crane operator who holds a national certificate, or one who is competent in the work that is to be performed;

- b) a dogger/rigger who holds a national certificate or one who is competent in the work that is to be performed; and

- c) additional competent labour as required to assist with erection or placement of elements.

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

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

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

In precast construction the risk to persons is significant because:

a) panels are very susceptible to wind loads because of their shape and size;

b) if a panel falls over or an insert fails, while the panel is attached to the crane, it is very likely that the crane will overturn. Other panels may also be struck and fall over. The potential consequences of an incident are therefore usually more serious than when other items are lifted; and

c) there is usually greater risk when lifting a concrete element (i.e., than a steel object) because the integrity of the load relies on a number of factors such as concrete strength, steel content and position, lifting insert integrity and correct operation of the lifting clutch. Due to the greater number of variables there is a greater risk.

All members of the public and workers not involved in the erection of panels must be prevented from accessing the erection area. An exclusion zone should be set up that prevents unauthorised persons gaining access. On some jobs this may necessitate the erection of parawebbing, signage and/or fencing depending on the ease of access and the likely presence of workers or members of the public.

Where a road or other vehicular access way is located in the exclusion zone, traffic should be prevented from passing through the zone while panels are being lifted and prior to securing the panels with braces.

3.7 Erection platform

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

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

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

3.8 Erection sequence

It is essential that the order in which the various components and members of the structure are assembled will maintain stability at all stages, allowing for the effects of high winds on partially completed structures. Overnight it may be necessary to stabilize incomplete structures with well anchored and correctly tensioned flexible steel wire ropes.

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

Elements must not be erected on site within three days of casting unless the concrete in the specific elements has been tested to confirm that the design strength for erection has been attained. Test results must be available on site prior to erecting the element.
The builder must provide the erector with verification that the concrete in brace footings has attained its required strength before elements are erected.

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

**STAGE 1**
- Cast in situ Beam
- Ground Floor Slab

**STAGE 2**
- Ground Floor cast in situ column
- Ground Floor panel
STAGE 3
• Formwork for 1st Floor Cast in situ beam & hood.

LEGEND:
- Double Wall
- Beam
- Hood
- Column
- Concrete Topping
- Cast in situ

STAGE 4
• 1st Floor Half Slab installation
• Concrete topping

LEGEND:
- Double Wall
- Beam
- Hood
- Column
- Concrete Topping
- Cast in situ
STAGE 5
- 1st Floor Panel
- RC Column
- Precast Half Beam

STAGE 6
- 2nd Floor Panel
- Concrete Topping
3.9. Erection of general elements

The dead weight of all elements should be calculated or weighed prior to the commencement of erection, and this information made available to the erection crew.

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

Taglines may be required in some circumstances.

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

Consideration must be given to the effect of wind upon the safe handling and erection of elements.

3.9.1 Erection of other precast elements

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

The erection design engineer must determine the configuration of the required rigging and lifting equipment in consultation with the erector.

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

Taglines may be required in some circumstances.

Personnel must not pass or stand beneath a suspended element.

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

Leveling shims carry the load of the precast concrete element that must be supported adequately to prevent movement until it is incorporated in the main structure.

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

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

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

Shims should be located at least 300 mm in from the ends of the element and bearing support, unless otherwise specified. This is particularly relevant for thin wall panels where edge breakout can occur if shims are placed too close to bottom corners (refer Figure 27).

![Figure 27. Leveling shims](image)

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

The gap between the bottom of the element and the footing must ultimately be grouted or dry packed, to transfer the load to the footings.
Figure 28. Section view of the use of shims
3.11 Fixing inserts

Fixing inserts for the panel connection to roof framing and other structural members must be
designed in accordance with the appropriate standard to resist the forces imposed on the
connections. These forces can be very large in the case of pitched rafters which may result in
inward or outward lateral forces overloading panels and connections if not properly designed.

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

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

3.12 Missing / unusable lifting points

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

Solutions could include:

a) fixing a plate with undercut anchors;
b) fixing a plate with expansion anchors. If using expansion anchors;
c) fixing a plate with chemical anchors. Anchors must be individually proof tested; and
d) drilling through the element and attaching lifting plate(s) by bolting;

3.13 Temporary bracing

Braces are temporary components providing stability in preventing a precast concrete
element from overturning.

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

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

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

Wherever possible bracing should be fixed to the element before lifting.

When it is necessary to attach the braces after the element has been positioned, the element
should be held safely by the crane whilst the braces are installed on the upper face by the use
of a ladder or alternative access system.

Generally, a minimum of two braces should be used for all elements. Where elements can be
effectively coupled together one central brace to resist rotation or toppling may be sufficient
subject to design by a registered engineer.
Braces shall be attached to a flat surface which is capable of withstanding the applied load.

Bracing bolts should be checked at regular intervals and immediately after any occurrence such as an earthquake or storm.

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

Braces must be marked.

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

3.13.1 Bracing insert

Bracing insert capacities are sensitive to:

a) the method of installation;

b) the strength of the concrete into which they are placed; and

c) the distance from the insert to the edge of the element.

![Placing of inserts](image)

Figure 29. Correct method of placing insert

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

During the lifting process, the braces should not hang below the base level of the element. This may be achieved by the use of adjustable brace lengths or by the use of taglines.
For face lifted wall panels, bracing inserts should be on the same face of the panel as the lifting inserts.

Generally, a minimum of two braces should be used for all precast elements. Two braces may not be necessary where elements are provided with erection brackets or permanent connections to other restrained elements such as steel portal columns or precast walls forming a stable “box” structure. In other situations, where expansion anchors are used in brace footings, three braces may be required on large panels since the expansion anchor capacity may limit the capacity of the brace.

After erection, it is the builder’s responsibility to check braces, bracing bolts and pins at regular intervals to ensure they maintain the required capacity. A check of the torque of the bolts should be made 24 hours after erection and at regular intervals after installation.

Superimposed loads must not be applied to the panels in braced positions unless such loads have been specifically allowed for in the design. These include loads from erection of steelwork, floor units and other attachments. Lateral outward forces on panels during the erection of pitched rafters can result in overloading of temporary bracing and its connections such as inserts and bolts. As well, substantial inward forces may be imposed on panels and fixings to steelwork as a result of temporarily unrestrained steel rafters rotating and moving sideways under self-weight and erection loads. The resulting tensile forces may overload fixing inserts and braces.

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

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

3.14 Temporary propping

Props are temporary components supporting loads which produce compression forces. Braces used to support precast concrete panels during erection must not be used as props.

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

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

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

Where beams are to have floor systems placed on them prior to the beams being fully built into the structure, allowance should be made for uneven loading on the beam during construction. With floor units placed only on one side of a beam, additional temporary propping may be required to each edge of the beam (refer Figure 30).
Where required, all temporary propping should be in place and fully braced prior to commencement of erection of any precast elements.

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

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

Props must be vertical. They may also require bracing to prevent sideway of the whole assembly and the buckling of individual props.

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

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

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

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

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

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

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

Precast shell beams are normally pre-stressed which induces a natural camber into the units. In some cases propping is lowered slightly at mid-span to allow the beams to deflect to a more level shape during placing of the concrete core and topping to the floors. This will result in a much higher than anticipated load being carried through the temporary props at the ends.

The seating for precast beams may not be suitable to transfer high loads during construction and the beams will normally require full propping at each end.

If the designer of the structure requires the beams to be supported without the use of mid-span props (to reduce the end support dead load bending moments), then the requirement must be clearly noted on the contract drawings and on the precast layout drawings.

Where beams are to have floor systems placed on them prior to the beams being fully built into the structure, allowance should be made for the fact that the beam may not be evenly loaded by the floor units during construction. Long-span floor units placed on one side only of a beam may cause the beam to roll on the props. For this reason each edge of the beam may require temporary propping.

Where beams are to support floor units, allowance must be made for the beams to carry an appropriate proportion of the construction load from the floor. Propping for the floor may in some cases be intended to only even out the levels of the underside of the floor units and not to take any significant floor load during construction. This can lead to a higher than anticipated load being carried through the beam propping.

Unless specifically noted otherwise, all temporary propping should be in place, adjusted to the correct levels allowing for any required cambers, and fully braced prior to commencement of erection of any precast beams.

3.14.2 Propping of precast floor systems

Refer to the floor system designers for the number and position of temporary support points, if any, required for each unit during erection and construction of the floor. Loads to the propping should be calculated by a competent person.

Unless specifically noted otherwise, temporary propping should provide full support of all construction loads including the full self-weight of the completed floor system and possible local concentrations of load during construction. Construction loads may include pallets of infills stacked on the partially constructed floor, reinforcing steel or mesh, excess concrete before being spread and leveled and other loads.

Unless specifically noted otherwise, all temporary propping should be in place, adjusted to the correct levels allowing for any required cambers, and fully braced prior to commencement of erection of any floor units.
Floor units such as the various hollow-core systems which are normally erected without temporary props, may require some amount of temporary propping at mid-span principally to even out the natural variations in cambers of the units, or for other structural or cosmetic reasons. With the specific approval of the floor system supplier in each particular instance, it may be satisfactory to erect the temporary props after the precast floor units are in place, and for the props to take only a portion of the full construction load.

Propping to floor units should have a stable top bearer. This top bearer should be located in the header of the props in such a way as to prevent rolling of the bearer and to ensure that the load from the bearer is transferred concentrically into the prop. The top bearer should be over the centre line of the prop otherwise it may cause the prop to bend leading to failure. Props should be adequately seated, leveled and capable of transferring the full load through whatever structure they are bearing on and into the ground without unacceptable settlement.

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

3.14.3 Temporary supports for precast cladding

Temporary headtrees should be adequate for all the construction loads, including wind, to be sustained and should be securely but temporarily fixed and easily removed. They should be rigid and independent of movement of the scaffolding.

Where the supports are of timber or metal, care should be taken by means of backing and polyethylene sheeting or non-staining protective materials to protect any units on which they rest from staining and damage.
MANUFACTURER'S CERTIFICATION OF COMPLIANCE FOR PRECAST CONCRETE ELEMENTS

Project Name: ________________________________
Site Address: ________________________________
Manufacturer’s Name: _________________________
Designer’s Name: ______________________________
Date of Lift or Erection: ________________________

Element Schedule
Component Identification Numbers:

I, ________________________________, on behalf of the manufacturer, hereby certify that the elements scheduled above, have been manufactured in accordance with section __________ of the Guidelines on Handling, Transportation, Stacking and Installation of Precast Concrete Components and the relevant shop drawings.

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

Element Details
Calculated element weight (tones): ________________
Lifting inserts positioned correctly: ________________
Reinforcement located correctly: ________________
Lifting insert manufacturer/type/safe working load: ________________
Lifting insert length: ________________
Release agent used (for till-up panels only): ________________
Type of lift: ________________
Signature: ___________________________ Position: ___________________________
Date: ___/___/___

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

The committee which developed this Malaysian Construction Industry Standard consists of the following representatives:

Ir. Elias Ismail (Chairperson)
Ir. Noraini Bahri (Vice Chairperson)
En. Muhammad Fadziil Hisham (Secretariat)
En. Abul Aun Hj Ahmad Ahmad Fudzil (Secretariat)
Ir. M. Ramu\r\nEn. Rolfizan Ahmad
En. Rozaiman Hassan
Ar. Lim Peng Keang
En. Yee Hock Hwee
En. Lim Kok Koon
Ir. Yim Hon Wa
Ir. Mohd Noor Azudin Mansor
En. Low Yat Seow
En. Loi Tuck Chow
En. Alphoncous Alban
En. Jamalulaii Abu Bakar
En. Olhman Jaki
En. Lim Li Pin
Ir. Ng Heow Tiarn
En. Julian Christhoper Jock
En. Lai Siew Kheong
Prof. Madya Dr. Ahmad Baharuddin Abdul Rahman
Prof. Madya Dr. Ir. Wahid Omar

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Construction Industry Development Board Malaysia
Construction Industry Development Board Malaysia
Board of Architects Malaysia
Hume Industries (M) Berhad
Hume Industries (M) Berhad
The Institution of Engineers, Malaysia
Jabatan Kerja Raya Malaysia
Master Builder's Association of Malaysia
MTD ACPI Engineering Berhad
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