CHAPTER 10 - PRECAST ELEMENTS

WJ Martin

10.1 SCOPE

This chapter covers the manufacture of precast elements such as:

- Precast beams;
- Precast parapets and barriers;
- Precast piles;
- Precast culverts; and
- Other precast components.

Precast elements such as precast kerbs, precast pipes, block paving and precast segmental construction are not included.

Site monitoring staff should read and obtain a sound understanding of the relevant section of the Standard Specification and the Project Specifications before applying this section of the Manual.

This chapter is not written to be a stand-alone reference, but aims to give information and advice on precasting that is not included in other chapters of the manual. For formwork, reinforcement, prestressing and concrete, refer to the relevant chapters in the manual. This applies especially to curing of the precast elements – the unformed concrete surface should be protected against evaporation immediately after casting.

10.2 GENERAL PRACTICE IN PRECASTING

The two factors which have the greatest impact on the operation of a precast yard are:

- Formwork: The importance of extremely well made and accurate formwork cannot be stressed enough; and
- Concrete: A good mix design and careful placing to avoid air bubbles and good consolidation are the keys to successful precast elements.

If the contractor deviates from these two principles he or she will not achieve the success that is aimed for. These two principals cannot be stressed enough.

10.2.1 Concrete Quality and Cover To Thin Sections:

Precast components are generally thin. Concrete quality and cover is therefore very important and needs to be monitored carefully. Monitoring staff should be aware that:

- If there is too little cover, the component has a reduced lifespan before corrosion starts; or
- If there is too much cover, the designed lever-arm to the reinforcement is reduced and the component may not be strong enough.
- Poor concrete quality will lead to reduced long term durability performance of the concrete.
Where precast units are manufactured off-site and only periodic inspections of the manufacturing process are made, it is advisable to carry out comprehensive cover meter checks on the units delivered to site. Where durability concrete is specified, regular durability testing in terms of the project specifications should be undertaken during manufacture of precast elements.

### 10.2.2 The Unformed Face of a Precast Component:

In precasting, all of the faces except the top one are shuttered in formwork. The concrete is placed in the top face and is then wood-floated or steel-floated. This face will always appear different to the other faces. The selection of the un-formed face should therefore be made with this in mind, and is usually as follows:

- For precast beams, it is the top face as this will have the deck slab cast on it and is not visible;
- For precast parapets it is the narrow top face, which is then steel floated to give a uniform appearance;
- For precast sidewalk panels it is the bottom surface. The component is cast upside-down; and
- For precast noise barriers it is the bottom or back face.

### 10.2.3 Early Removal of Formwork:

Precast formwork is often removed the day after casting to speed up the construction process.

If concrete laitance stick to the formwork, it is likely that too much shutter oil, which is a retarder, has been used; or the wrong type of form release agent has been used; or the formwork has been removed too early. In the latter case, the formwork needs to be left in place longer or the concrete temperature needs to be raised to increase the rate of strength gain.

Where formwork is removed early, curing becomes critical to avoid excessive shrinkage with its associated cracking. Common curing methods include:

- Steam curing – the component is enclosed and steam-laden air with more than 100% humidity is circulated. The elevated temperature increases the rate of strength gain;
- Continuous spraying with microjets for at least 7 days – if there is a strong wind, this method is not effective;
- Wrapping in plastic or other impervious layer; and
- Wrapping in a water absorbing material such as carpet underfelt and wetting it regularly.

Although curing compounds do reduce water loss from a concrete section, they are not as effective as the above methods or leaving a concrete section in its formwork. Curing compounds alone should therefore not be used when formwork is removed early.

#### NOTE

When steam curing, the concrete must not be overheated as this may cause severe damage. Steam curing typically raises the concrete temperature to between 60°C and 70°C.

### 10.2.4 Moving and Transporting a Precast Component:

The moving and transporting of precast components are generally considered to be temporary works activities. If a component has not been designed to be precast or if the contractor changes the specified lifting points, it is the contractor’s responsibility to show that the component is adequately reinforced and strong enough to be moved.
For example, a 2 m high cast in-situ sound-barrier panel may only have been designed to resist wind loads and will therefore be lightly reinforced. If it is constructed on its side (i.e. horizontal) and will then be lifted up from the top, it may need additional reinforcement to prevent cracking.

Lifting hooks and connections need to be strong enough and placed in the designed position, otherwise they may fail, causing the component to crack or break.

![Photo 10.1: Precast pedestrian bridge deck being lifted in place. Lifting points typically coincide with the designed support positions.](image1)

![Photo 10.2: Reinforcement around a lifting point in a precast beam.](image2)
Prior to moving or transporting a precast component, the contractor should provide the following information:

- Method statement of how the works will be executed;
- All lifting arrangements, showing that they have been properly designed; and
- Occupational health and safety plan showing that all safety aspects have been addressed.

The site monitoring staff may need to liaise with the designer regarding the acceptability of the above information.

10.2.5 Uneven Creep and Shrinkage During Storage:

If a concrete component is stored for a long period in a situation where the sun or wind acts predominantly on one side of the member, the creep and shrinkage effects will vary across the member, resulting in distortions which can cause problems during installation. Components such as long precast beams and match-cast precast deck segments are particularly sensitive to this. It is therefore preferable to store such members in an orientation which results in uniform sun and wind exposure.

Poor stacking of precast elements can also cause the lower, more highly stressed elements to deform more due to creep. This often occurs when components are stacked with incorrectly positioned timber spacers.

Site monitoring staff should ensure that the contractor’s storage and support arrangements are approved. This applies especially to precast beams where incorrect temporary support points may adversely affect the stresses in the beam.

10.3 PRECAST YARD

Construction within a precast yard generally yields improved quality and higher rates of production since materials, equipment and staff are all close by, and the work tends to be highly repetitive.

The precast yard can be either:

- A precast supplier’s yard, in which case it is a permanent facility; or
- A temporary precast yard established on site, where all materials and equipment are close at hand.

By its very nature, precast yards can produce components at a very rapid rate. For example, several precast parapets can be cast each day. Quality control is therefore very important.

The precast yard operator must have a quality system in place whereby each stage of the operation is inspected by the operator and signed off before moving to the next stage. These check-points can include:

- Prior to closing formwork: Reinforcement, prestressing, inserts, formwork quality, etc;
- Prior to casting concrete: Formwork, cleanliness, etc;
- Prior to prestressing; and
- Prior to lifting and moving the element.
The site monitoring staff need to visit the precast yard regularly to ensure that the QC system is being maintained and that the paperwork is being signed only after an inspection has actually taken place.

In the case of precast yards established on site, the contractor should obtain prior approval of the casting yard before establishing it. The details required to be submitted for approval include:

- Plans demarcating the layout;
- Layout of the works and storage areas; and
- Flow diagramme for construction stages and storage.

10.4 PRECAST BEAMS

10.4.1 Precast Beds

Precast beds should be suitably shaped to take any precamber requirements into account. If precamber is not given on the drawings, the requirements must be obtained from the designers of the beams.

Precast beam beds should have sufficient longitudinal reinforcement to control transverse shrinkage cracking. If not, cracks in the bed will form marks on the beam soffit, and when erected, the beams themselves will appear to be cracked.

10.4.2 Stressing of Precast Beams

When precast beams are stressed, they need to shorten. The precast bed in contact with the beams must therefore be very smooth with an appropriate bond-breaker/release agent applied. Concrete beds require a steel trowelled finish.

When precast beams are stressed, they tend to hog, transferring their weight to the ends of the beams. This part of the casting bed should be strong enough to carry these loads. Soft material should be placed at the very ends of the precast bed to prevent point loads from the hogging action spalling off the very end of the beams.

10.4.3 Transporting and Placing of Precast Beams

The operations of transporting and placing precast beams are temporary works activities and are therefore the responsibility of the contractor. Strength and stability are the major considerations, and all components making up the lifting equipment, including connection points, straps, cables and cranes, must be able to safely carry the loads. At all times the beam and crane must have an adequate factor of safety in terms of stability.

The contractor must provide full details of his lifting points, lifting straps, transporting and placing procedures for review. Calculations should be called for if there is any doubt about the strength of these components.

In order to pick up a precast beam, some form of lifting point is required. Typical lifting points include:

- Lifting eyes in the form of large diameter reinforcing bars which can deform to fit the shape of the lifting hook;
- Lifting bars threaded through a horizontal hole in the beam end with a double strap around the bar;
• Proprietary lifting connections.

If the lifting straps are not vertical the lifting points must be designed to carry the weight of the beam plus the horizontal component of force. For a 45 degree strap, this increases the force acting on the lifting point by 41%.

During the handling of a precast beam, there is always a danger that the beam may topple over. This has happened several times in the past and can lead to permanent damage to the beam and serious injury to people. It is therefore essential that the contractor’s procedure ensures that the beam remains stable during all stages of the construction. Mistakes to be avoided include:

• The connection point to the beam is below the centre of gravity. This occurs with a lifting bar passing through a hole in the beam is too low. In such situations, while the beam is vertical, it will be in unstable equilibrium with no factor of safety against overturning. However, as soon as the beam tilts slightly, it becomes unstable and falls over.

• The beam is placed on flexible bearings and its weight is taken off the lifting points before the beams have been braced. This rather obvious error has been made often.

During the handling of slender precast beams there is also the danger of the beam buckling. This can occur when the compression flange is narrow and is not sufficiently restrained to prevent lateral buckling. Guidance regarding this behaviour is given in TMH7 Part 3 clause 3.3.1.3, which gives proportions of length to depth to width that ensure lateral stability. Buckling can also occur when the concrete to the in-situ slab is cast.

Where traffic is affected, the contractor needs to provide a traffic accommodation plan for erection of the precast beams. An action plan needs to be provided should there be a possibility that a change in the erection method statement will be required in order to maintain free flow of traffic during erection.

10.5 CONCRETING AND CURING

Normal concreting practice should be followed. Note however that curing requires special attention if formwork is struck early. This is discussed earlier in this chapter.

The method of curing must be approved by the engineer.

10.6 Prestressing

Normal prestressing procedures and approvals should be followed.

The site monitoring staff should ensure that they receive all the prestressing results certificates within 7 days of stressing. These certificates should include records of the following:

• Tendon forces and extensions;
• Cube crushing strengths; and
• Age at transfer.

10.7 Precast Parapets and Barriers

Once installed, the line of the precast parapets, and especially their top rail, must appear smooth to the eye and must follow the designed profile. This is especially the case where additional creep and shrinkage is expected and the parapets are set out to allow for this. Balanced cantilever bridges are particularly sensitive to this. This is of great importance as the top line is close to the motorist’s eye-
height and any misalignment is easily seen. The contractor’s method of installation must therefore allow for fine adjustment of the alignment before concreting the precast parapet into position.

The checking and acceptance of the alignment should always include careful visual checks made by sighting along the upper edges of the parapet/handrail. It is advisable that a generous length of parapet be erected before casting the connection, as this will enable minor alignment imperfections to be easily detected and rectified.

![Photo 10.3: Precast parapet with formwork being struck.](image)

Special attention should be given to the accurate setting out of the connection bars which join the precast parapet and the deck. This is of great importance, and considerable difficulties will be experienced if adequate tolerances are not provided to enable the necessary meshing and overlapping of the connection bars to be achieved. These bars are particularly prone to corrosion in instances where inadequate attention is given to the placing and quality of the connection concrete/grout. The concrete or grout used in the connection must therefore match the quality of the concrete in the parapet and must be properly placed and cured. If this is not done, shrinkage cracks are likely to occur and rain water flowing along the edge of the parapet will make its way to the reinforcement. The entire connection arrangement and process must be critically examined to ensure that there is no possibility of air entrapment within the connection area, as this will weaken the connection and may result in the corrosion of reinforcement.
10.8  PRECAST PORTAL CULVERTS

Good references for precast portal culverts, as well as pipes, are “Concrete pipe and portal culvert handbook” and “Concrete pipe and portal culvert installation handbook, both by the Concrete Manufacturer’s Association (www.cmapipes.co.za). Other useful information is also available from this site.

Precast culverts are designed as fit-for-purpose: Depending on the class (75S to 200S), they are required to withstand specific loadings to SANS 986. This is usually done in the precast yard. The precast supplier will have a quality system in place as previously discussed. The site monitoring staff should attend some of the load tests and review the results of all the load tests as well as the documentation for the quality system.

Precast culverts must be labeled correctly. This avoids the incorrect culvert being installed in the incorrect position. The site monitoring staff should check that the labeling is correct, both when delivered to site and when installed.

When the culverts are being constructed, lifting points must be included to suit the contractor’s proposed installation process on site. This usually consists of one or two holes in the top slab to take a fabricated steel lifting hook. Lifting points consisting of looped mild steel reinforcement can also be cast in. Note that culverts must butt up flush with each other so slings around the top slab will not work.
Culverts must be properly stored on site to prevent damage or distortion. If a culvert is not supported evenly under the legs, the culvert can twist due to creep. If culverts are not stacked correctly, they can crack or distort.

Culverts can be easily damaged on site. They are heavy and just need to touch another object while being lifted for a corner to spall off. This must be avoided. Care needs to be taken during the entire process of handling the culvert so as not to damage them: from handling them within the precast yard, to transporting them, to storing them on site to finally installing them. Any minor spalls on culverts must be repaired before installation. If there are major spalls or cracks, the culverts must be rejected.

10.9 PRECAST PILES

The largest loads on precast piles usually occur during handling and driving. The reinforcement that is detailed by the designer is usually for the pile in its final position. The contractor needs to provide additional reinforcement for handling the piles on site and for driving the piles on site.

Precast pile couplers need to meet the same durability requirements as the remainder of the pile. The piles have been designed to last 50 to 100 years: the connections must meet the same criteria.
INDEX TO APPENDICES

APPENDIX 10A - PRECAST YARD CHECK LIST

APPENDIX 10B - CRANE ERECTION CHECK LIST

**NOTE**
For formwork, reinforcement, concrete, prestressing, etc., the standard check-lists apply.
CONSTRUCTION MONITORING CHECKLIST

PROJECT NO. / NAME: ..............................................................................................................................

INSPECTOR’S NAME(S): ............................................................................................................................

STRUCTURE: .............................................................................................................................. ELEMENT: ................................................................

<table>
<thead>
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<th>ACTIVITY AND DETAILS</th>
<th>APPROVAL</th>
<th>SIGNED</th>
<th>DATE</th>
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<tbody>
<tr>
<td>1 Quality system in place</td>
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<td>2 Concrete mix design approved</td>
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<td>3 Formwork well-made and accurate</td>
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<td>4 Concrete vibration system approved</td>
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<td>5 Control of concrete cover suitable</td>
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<td>6 Procedure and timing for removing of formwork approved</td>
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<td>7 Curing procedure approved</td>
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<td>8 Lifting method and points approved</td>
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<tr>
<td>9 Transporting and storing system approved</td>
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APPENDIX 10A
## CONSTRUCTION MONITORING CHECKLIST

### PROJECT NO. / NAME:

### INSPECTOR’S NAME(S):

### STRUCTURE: ...........................................................  ELEMENT: ............................................................

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<th>ACTIVITY AND DETAILS</th>
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<tbody>
<tr>
<td>1 Traffic accommodation and control approved, signs and barriers ready for placement, Road closure permits in place, Public notifications in place</td>
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<tr>
<td>2 Municipal/provincial traffic officers notified and will be on site</td>
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<td>3 Sufficient staff including flag-men and OHS officer on site</td>
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<tr>
<td>4 Cranes are of sufficient capacity and can be rigged on site (sufficient foundation strength, space, boom reach, obstacles etc) Crane load test certificate and maintenance compliance received</td>
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<tr>
<td>5 Crane lifting procedure approved, including safety of staff and public, stability, etc)</td>
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<tr>
<td>6 Channels of communication and responsibilities between crane operator, traffic control, contractor and the resident engineer clear and in place</td>
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<tr>
<td>7 Programme for procedure approved along with deadlines, after which the lift is abandoned</td>
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<tr>
<td>8 Site is taped off to prevent non-essential personnel entering the area of operation</td>
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<tr>
<td>9 As-built dimensions and levels have been checked to ensure component will fit in, including bearings, supports, etc</td>
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<tr>
<td>10 Procedure to ensure stability of component during erection approved</td>
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