

# TRANSPORT FOR NSW (TfNSW)

## QA SPECIFICATION R24

### PRECAST CONCRETE ARCHES

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#### REVISION REGISTER

<b>Ed/Rev Number</b>	<b>Clause Number</b>	<b>Description of Revision</b>	<b>Authorised By</b>	<b>Date</b>
Ed 1/Rev 0		New specification	GM, IC (M Andrew)	22.09.09
Ed 1/Rev 1	Global	References to “Roads and Maritime Services” or “RMS” changed to “Transport for NSW” or “TfNSW” respectively.	DCS	22.06.20





# PRECAST CONCRETE ARCHES

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VERSION FOR: DATE:
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## FOREWORD

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### REVISIONS TO PREVIOUS VERSION

This document has been revised from Specification TfNSW R24 Edition 1 Revision 0.

All revisions to the previous version (other than minor editorial and project specific changes) are indicated by a vertical line in the margin as shown here, except when it is a new edition and the text has been extensively rewritten.

### PROJECT SPECIFIC CHANGES

Any project specific changes are indicated in the following manner:

- (a) Text which is additional to the base document and which is included in the Specification is shown in bold italics e.g. ***Additional Text***.
- (b) Text which has been deleted from the base document and which is not included in the Specification is shown struck out e.g. ~~Deleted Text~~.

# TfNSW QA SPECIFICATION R24

## PRECAST CONCRETE ARCHES

### 1 GENERAL

#### 1.1 SCOPE

This Specification sets out the requirements for the design, manufacture and installation of precast reinforced concrete arch units (with spans up to approximately 10 m and waterway areas up to approximately 21 sq m) and wingwalls or spandrels. These arches may be used as an alternative to box culverts and large pipe culverts.

This Specification also sets out the requirements for design and construction of the foundations, and associated earthworks, for the arches.

#### 1.2 STRUCTURE OF SPECIFICATION

This Specification includes a series of annexures that detail additional requirements.

##### 1.2.1 Project Specific Requirements

Details of work, specific to this Contract, are shown in Annexure R24/A.

##### 1.2.2 Measurement and Payment

The method of measurement and payment must comply with Annexure R24/B.

##### 1.2.3 Schedules of HOLD POINTS and Identified Records

The schedules in Annexure R24/C list the **HOLD POINTS** that must be observed. Refer to Specification TfNSW Q for the definition of **HOLD POINTS**.

The records listed in Annexure R24/C are **Identified Records** for the purposes of TfNSW Q Annexure Q/E.

##### 1.2.4 Planning Documents

The PROJECT QUALITY PLAN must include each of the documents and requirements shown in Annexure R24/D and must be implemented.

##### 1.2.5 Referenced Documents

Unless specified otherwise or is specifically supplied by the Principal, the applicable issue of a referenced document, is the issue current at the date one week before the closing date for tenders, or where no issue is current at that date, the most recent issue.

Standards, specifications and test methods are referred to in abbreviated form (e.g. AS 1234). For convenience, the full titles are given in Annexure R24/M.

## **1.3 DEFINITIONS**

The terms “you” and “your” mean “the Contractor” and “the Contractor’s” respectively.

The following definitions apply to this Specification:

**Engineer:** Chartered Professional Engineer who is a Member of Engineers Australia, or registered on the National Professional Engineers Register (NPER), with appropriate qualifications and experience for the type of work undertaken.

**Geotechnical Engineer:** Engineer with qualifications and experience in geotechnical engineering.

**Precast Arch Designer:** Engineer with qualifications and experience in the design of precast concrete arches.

**Precast Arch Supplier:** A company approved by the Transport for NSW to design and supply precast arch components. The list of approved Precast Arch Suppliers is given in Annexure R24/E.

## **2 DESIGN**

### **2.1 GENERAL**

The Drawings show only an indicative precast concrete arch design (including foundations). Additional project specific requirements are given in Annexure R24/A.

The precast concrete arch solution that you propose must have at least the span, and where relevant, the waterway area below the Design Flood Level, shown on the Drawings.

### **2.2 RESPONSIBILITIES**

#### **2.2.1 Assessment of Available Site Information**

Carry out an assessment of the available site information and carry out any further site investigations necessary to obtain the topography and properties of all relevant soil strata associated with the precast concrete arch design. The assessment must be carried out by a Geotechnical Engineer and/or the Precast Arch Designer.

#### **2.2.2 Design and Verification of Precast Concrete Arch**

Design of the precast concrete arch units, wingwalls or spandrels, foundations and associated earthworks for the arch must be carried out by a Precast Arch Designer, based on advice from the Geotechnical Engineer for the foundation characteristics.

Verification of the precast concrete arch design must be carried out by an independent Precast Arch Designer. Submit the name of the design verifier to the Principal for approval no later than 10 days before commencement of design.

The arch design must be certified by the Precast Arch Supplier.



Endorse all final drawings as “Approved for Construction” and signed jointly by the Precast Arch Designer, the design verifier and the Precast Arch Supplier to certify that the final drawings have been prepared and verified by competent professional staff and checked for accuracy and conformity with this Specification.

### **2.3 DESIGN REQUIREMENTS**

Design the concrete arch in accordance with the loads specified in AS 5100.2, the design procedures within AS 5100.3 and the design principles within AS 1597.2.

Analyses must include the following:

- (a) Sensitivity of the design to the range of moduli for the soil and rock interacting with the arch, as determined by the Geotechnical Engineer;
- (b) Maximum and minimum groundwater levels;
- (c) Variations in geotechnical conditions in the longitudinal direction;
- (d) Variations in design actions in the longitudinal direction;
- (e) Action effects arising from the headwalls, wingwalls and spandrels.

Concrete cover and other durability requirements must comply with AS 5100.5.

Design the footings and/or capping beams in accordance with AS 5100.

Where piles are used in the arch foundation, design the piles in accordance with AS 2159.

Where reinforced soil walls are used as wingwalls or spandrels, design these in accordance with Specification TfNSW R57.

Provide design assurance and verification conforming to the requirements of Clause 7.3 of AS/NZS ISO 9001. Include a template Design Plan to summarise the design planning process as specified in Clause 7.3.1 of AS/NZS ISO 9001.

### **2.4 DESIGN OUTPUT**

Structural drawings and reinforcement detailing must be prepared in accordance with AS 1597.2 and the TfNSW Structural Drafting and Detailing Manual.

The design output must include:

- (a) A design report describing the precast concrete arch system to be used. The design report must state the structural design assumptions, including, as appropriate, parameters for fill material, foundations, dead loads, superimposed dead loads, hydraulic loads, wind loads, differential settlement and/or mining subsidence effects, earthquake effects, handling and transport loads used in the design. Also state any safeguards needed to counteract potential scouring and any effects from interaction with the surrounding ground;
- (b) All calculations produced during structural design and verification;
- (c) Detailed “Approved for Construction” Drawings showing the geometry, concrete and reinforcement details for the precast concrete arch structure and foundations, the sequence of construction, temporary and final support details and arrangement of precast arch components;

- (d) “Project specific” technical specifications and installation guidelines to supplement this Specification and the Precast Arch Supplier’s drawings, in order to fully define all acceptance criteria for manufacture, lifting, handling, transport and storage of arch units and subsequent installation of the arches.

Submit the draft design output to the Principal for review at 85% completion stage prior to finalising the “Approved for Construction” Drawings. Allow up to 10 working days for the Principal to review the draft design output.

Submit to the Principal the final design output and any comments by the design verifier at least 10 working days prior to the manufacture of precast concrete arch components or the commencement of foundation preparation, whichever occurs first.

**HOLD POINT**

Process Held: Manufacture of precast concrete arch components and preparation of the foundation for the precast concrete arch structure.

Submission Details: At least 10 working days before the manufacture of precast concrete arch components or the commencement of foundation preparation, whichever occurs first, submit the final design output and comments by the design verifier.

Release of Hold Point: The Principal will consider the submitted documents, prior to authorising the release of the Hold Point.

**2.5 ARCH COMPONENT DRAWINGS**

Provide a full set of detailed drawings of the arch structure components, including concrete and reinforcement details, to the Principal.

In recognition of the commercial sensitivity of precast concrete arch component drawings, whilst they must be included in the Schedule of Drawings on the cover sheet of the Drawings for the precast concrete arch structure, these drawings may be supplied separately to be stored and treated as commercial-in-confidence by the TfNSW.

**3 MANUFACTURE OF COMPONENTS**

Manufacture the precast concrete arch components in accordance with the Precast Arch Supplier’s drawings and technical specifications and Specification TfNSW B115.

All concrete work must be in accordance with Specification TfNSW B80.

Submit a Certificate of Compliance stating that the precast concrete arch components produced comply with this Specification.

In addition to the requirements of TfNSW B115, for identification purposes, mark on each component the following:

- (a) the date of casting;
- (b) the number of the component; and
- (c) the position in the structure at which the component will be placed.

## **4 HANDLING, TRANSPORT AND STORAGE OF ARCH UNITS**

Handling, transport and storage of the arch units must be in accordance with the Precast Arch Supplier's specifications and TfNSW B115.

Do not transport any arch unit to site until at least seven days after casting and until the concrete has reached the specified 28 day strength.

## **5 CONSTRUCTION**

### **5.1 FOUNDATIONS**

#### **5.1.1 Setting Out**

Set out the corners of the footings/capping beams as shown on the Drawings in sufficient detail to identify the location, length and depth to design levels.

The inlet or outlet locations (where the arch is constructed over a waterway) or design levels may be amended by the Principal to suit the actual site conditions encountered. Any such amendments directed by the Principal will be treated as a variation to the Contract, unless the amendments are made to suit your construction procedures.

#### **HOLD POINT**

Process Held: Foundation excavation.

Submission Details: At least 2 working days prior to foundation excavation, notify the Principal:  
(a) that the footings/capping beams have been set out; and  
(b) of your proposed changes, if any, to the design.

Release of Hold Point: The Principal will inspect the set out, including any changes proposed and, where necessary, direct amendments to suit site conditions prior to authorising the release of the Hold Point.

#### **5.1.2 Excavation**

Carry out clearing and grubbing in accordance with Specification TfNSW G40, and remove any topsoil in accordance with Specification TfNSW R44.

Carry out excavation in the arch backfill zone to the width and batter slopes shown on the Drawings or as directed by the Principal.

Carry out excavation for footings in such a manner that the concrete for the footings can be poured directly in contact with the sides of the excavation, or, if side forms are used, fill the space remaining when forms are removed with concrete of the same quality as that of the footing.

Take the excavation sufficiently deep to achieve the founding levels or to achieve a uniform bearing capacity equal to that shown on the Drawings. Remove all loose material.

If excavation in rock is carried out, thoroughly clean out the minor fissures in the rock and refill them with concrete, mortar or grout. Clean and wet the rock surface prior to placing concrete.

Use the excavated material as backfilling around the arch units, if suitable, or for construction of embankments, in accordance with TfNSW R44. Spoil any surplus excavated material.

### **5.1.3 Inspection of Foundation Material for Footings**

Completion of the foundation excavation constitutes a Hold Point. Arrange for the foundation to be inspected by a Geotechnical Engineer to verify that the specified bearing capacity has been achieved. Submit the Geotechnical Engineer's report to the Principal.

#### **HOLD POINT**

Process Held:	Concreting of footings and/or capping beams.
Submission Details:	Foundation levels and Geotechnical Engineer's report on adequacy of bearing capacity.
Release of Hold Point:	The Principal will consider the submitted documents, inspect foundations and confirm founding levels, prior to authorising the release of the Hold Point.

The Principal will direct the extent of removal and replacement of any identified unsuitable material in accordance with TfNSW R44.

### **5.1.4 Removal of Water**

Do not place concrete in excavations when surface or seepage water is present. You are responsible for any required shoring, temporary diversion of stream flows and dewatering.

## **5.2 CAST-IN-PLACE CONCRETE PILES**

Where the Drawings require the construction of cast-in-place reinforced concrete piles, construct the piles in accordance with Specification TfNSW B58 or TfNSW B59 as appropriate.

## **5.3 FOOTINGS, CAPPING BEAMS AND OTHER CONCRETE ELEMENTS**

Construct the footings, capping beams and other concrete elements in accordance with Specification TfNSW B80.

## **5.4 ERECTION**

### **HOLD POINT**

Process Held:	Erection of precast concrete arch units.
Submission Details:	<p>At least five (5) working days prior to the erection of precast concrete arch units, submit to the Principal:</p> <ul style="list-style-type: none"><li>(a) A certificate from an Engineer with appropriate qualifications and experience in the field of structural engineering certifying the structural adequacy and compliance of the proposed method of erection (including all supporting and bracing measures) with this Specification, the Drawings and TfNSW B153.</li><li>(b) Drawings clearly describing the proposed method of erection with clear details of supporting and bracing measures.</li><li>(c) Concrete test results and comparison with design criteria, to verify that concrete strength requirements have been met.</li></ul>
Release of Hold Point:	The Principal will consider the details submitted, prior to authorising the release of the Hold Point.

Erect precast concrete arch, spandrel and wingwall units in accordance with Specification TfNSW B153 and the Drawings under the guidance of the Precast Arch Supplier.

## **5.5 REINFORCED SOIL WALLS**

Where reinforced soil walls are proposed as wingwalls or spandrels, construct these in accordance with Specification TfNSW R58.

## **5.6 SUBSOIL DRAINS**

Where subsoil drains are required alongside the base of the arch units, use slotted corrugated plastic subsoil drainage pipe enclosed in seamless tubular filter fabric or strip filters in accordance with Specification TfNSW R33.

## **5.7 BACKFILLING**

Material for each backfill zone must comply with the material characteristics nominated by the Precast Arch Supplier.

Carry out backfilling and compaction generally in accordance with the Precast Arch Supplier's specifications, at the frequency of testing for material characteristics and compaction specified for backfilling in Specification TfNSW R11.

Place and compact embankment layers above the backfill zone nominated by the Precast Arch Supplier in accordance with TfNSW R44.

## **5.8 BRIDGE NAMEPLATES**

Supply and attach two bridge nameplates in accordance with Specification TfNSW B345 on the precast concrete arch departure wingwalls about 1.2 m above the ground level.

## **6 ACCEPTANCE OF ARCH**

The Precast Arch Supplier must certify that the precast concrete arch structure has been constructed in accordance with this Specification, the Precast Arch designer's technical specifications and the Drawings.

As arch structures receive their most severe loading when the fill just reaches the crown of the arch, the criterion for acceptance is that no cracks of width greater than 0.2 mm occur at any location in the arch structure when the fill reaches the crown of the arch, as verified by visual inspection.

If any cracks greater than 0.2 mm exist at any time during or following erection, the arch structure will be deemed to be nonconforming.

## **ANNEXURE R24/A – PROJECT SPECIFIC REQUIREMENTS**

Refer to Clause 1.2.1.

### **A1 GENERAL REQUIREMENTS**

*NOTES TO TENDER DOCUMENTER: (Delete this boxed text after customising Annexure R24/A)*

*Nominate below the Concrete Exposure Classification (whether B1, B2, C or U) by deleting whichever is not applicable.*

<b>Item</b>	<b>List of Available Parameters</b>	<b>Job Specific Parameters</b>
Concrete Exposure Classification for Precast Concrete Arch Components	B1 / B2 / C / U	
Traffic Loading	Refer AS 5100.2	
Other Loadings	Refer AS 5100.2	

Height of embankment over arch: ..... (m)

### **A2 DELIVERY DETAILS**

Place of Delivery:	
Rate of Delivery:	
Place of Acceptance:	

## **ANNEXURE R24/B – MEASUREMENT AND PAYMENT**

Refer to Clause 1.2.2.

Payment will be made for all costs associated with completing the work detailed in this Specification in accordance with the following Pay Items.

Payment for clearing and grubbing will be in accordance with TfNSW G40.

Payment for the removal and stockpiling/spoiling of topsoil, the removal and replacement of unsuitable material and the earthworks outside the backfill zone will be in accordance with TfNSW R44.

Where no specific pay items are provided for a particular item of work, the costs associated with that item of work are deemed to be included in the rates and prices generally for the Work Under the Contract

### **Pay Item R24P1 - Supply of Precast Concrete Arch Components**

This item covers all work required under Clauses 2 and 3 including the design of the concrete arch structure, and supply and delivery to site of all precast concrete components such as arch units, wingwall units, spandrel units, joint fillers and sealants and any other necessary components.

This is a Lump Sum item.

### **Pay Item R24P2 – Excavation and Foundation Preparation**

This item covers all types of material encountered during excavation (both earth and rock) and placed in embankments or disposal of otherwise than in embankments after stripping of topsoil.

This is a Lump Sum item.

### **Pay Item R24P3 – Concrete Foundation Members**

This item covers all activities associated with the construction of footings capping beams and/or piles, including pile excavation (if applicable), formwork, supply and fixing steel reinforcement, supply and placement of concrete and any concrete filling between the footing and sides of the excavation.

This is a Lump Sum item.

### **Pay Item R24P4 – Erection of Precast Concrete Arch Structure**

This item covers all activities associated with the erection of the arch units (including temporary bracing and other protective measures), wingwall units and spandrel units bedding and jointing (including connections) and/or construction of any insitu concrete elements.

This is a Lump Sum item.

### **Pay Item R24P5 – Reinforced Soil Walls**

This item covers all work and materials required for the construction of reinforced soil structures for the wingwalls and spandrels.

This is a Lump Sum item.



**Pay Item R24P6 – Subsoil Drainage**

This item covers all activities associated with the supply and placement of subsoil drainage systems behind the concrete arch (including pipes, strip drain, geotextile and filter material).

This is a Lump Sum item.

**Pay Item R24P7 – Earthworks in Backfill Zones**

This item covers all activities associated with the supply and placing of material in backfill zones as nominated by the Precast Arch Supplier, including the sourcing and processing of materials to conform to the material characteristics specified by the Precast Arch Supplier.

For the purpose of this Pay Item, the extent of the backfill zones will be as shown on the Drawings.

This is a Lump Sum item.

**Pay Item R24P8 – Bridge Nameplates**

This item covers all activities associated with the supply and attachment of two bridge nameplates.

This is a Lump Sum item

## **ANNEXURE R24/C – SCHEDULES OF HOLD POINTS AND IDENTIFIED RECORDS**

Refer to Clause 1.2.3.

### **C1 SCHEDULE OF HOLD POINTS**

<b>Clause</b>	<b>Description</b>
2.4	Submission of final design output and comments by design verifier
5.1.1	Set out of foundations
5.1.3	Presentation of foundation levels and Geotechnical Engineer's report on bearing capacity adequacy
5.4	Submission of details of erection method, Engineer's certificate and concrete test results verifying that concrete strength requirements of the precast units have been met

### **C2 SCHEDULE OF IDENTIFIED RECORDS**

The records listed below are Identified Records for the purposes of TfNSW Q Annexure Q/E.

<b>Clause</b>	<b>Description of Identified Record</b>
2.4	Design output and verification by design verifier
2.5	Arch component drawings
3	Certificate of compliance for manufactured precast concrete arch components
5.1.1	Any amendments to foundations
5.1.3	Geotechnical Engineer's report on adequacy of bearing capacity of foundations
5.4	Engineer's certificate and drawings of the proposed method of erection, concrete test results of arch units
5.7	Test results of earthworks in backfill zone
6	Certification that the precast concrete arch structure has been constructed in accordance with this Specification and the Precast Arch Designer's technical specifications and Drawings

**ANNEXURE R24/D – PLANNING DOCUMENTS**

Refer to Clause 1.2.4.

The following documents are a summary of documents that must be included in the PROJECT QUALITY PLAN. Review the requirements of this Specification and others included in the Contract to determine additional documentation requirements.

The information to be submitted by you as part of the PROJECT QUALITY PLAN must include, but not be limited to, the following:

- (a) Precast Arch Supplier and arch system (Clause 2);
- (b) Name, qualifications and experience of Precast Arch Designer and independent Precast Arch Design verifier (Clause 2);
- (c) Procedures for manufacture of the precast concrete arch components (Clause 3);
- (d) Method of lifting, handling, transport and storage of arch units (Clause 4);
- (e) Details of foundation preparation (Clause 5.1.2);
- (f) Method of erection of precast concrete arch units (Clause 5.4);
- (g) Details of construction materials to be used and their conformity to design requirements (Clauses 5.1 to 5.8);
- (h) Details of placing and compaction of material in backfill zone.

**ANNEXURE R24/E – SCHEDULE OF PRINCIPAL APPROVED  
PRECAST CONCRETE SOIL ARCH SUPPLIERS**

Refer to Clause 1.3.

<b>System</b>	<b>Supplier</b>
BEBO	Humes
Classic Arch	Humes
Techspan	Reinforced Earth Company

Further details may be obtained from the Bridge Engineer (Policy & Specifications), TfNSW Engineering Services, Ph: (02) 8837 0875.

**ANNEXURES R24/F TO R24/L – (NOT USED)**

## **ANNEXURE R24/M – REFERENCED DOCUMENTS**

Refer to Clause 1.2.5.

### **TfNSW Specifications**

TfNSW G40	Clearing and Grubbing
TfNSW Q	Quality Management System
TfNSW B58	Bored Cast-in-place Reinforced Concrete Piles (With Permanent Casing)
TfNSW B59	Bored Cast-in-place Reinforced Concrete Piles (Without Permanent Casing)
TfNSW B80	Concrete Work For Bridges
TfNSW B115	Precast Concrete Members (Not Pretensioned)
TfNSW B153	Erection of Precast Concrete Members (Not Pretensioned)
TfNSW B345	Supply of Bridge Nameplates
TfNSW R11	Stormwater Drainage
TfNSW R33	Trench Drains
TfNSW R44	Earthworks
TfNSW R57	Design of Reinforced Soil Walls
TfNSW R58	Construction of Reinforced Soil Walls (Contractor's Design)

### **Australian Standards**

AS 2159	Piling – Design and installation
AS 5100	Bridge design
AS 5100.2	Design loads
AS 5100.3	Foundations and soil supporting structures
AS 5100.5	Concrete
AS 1597.2	Precast reinforced concrete box culverts – Large culverts (from 1500 mm span and up to and including 4200 mm span and 4200 mm height)
AS/NZS ISO 9001	Quality management systems – Requirements