

Technical Specification

**Transport and Main Roads Specifications
MRTS270 Precast Geopolymer Concrete Elements**

November 2018

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1 Introduction

This Technical Specification applies to the manufacture of precast reinforced geopolymer concrete elements, with a design life of 50 years or under.

This Technical Specification shall be read in conjunction with MRTS01 *Introduction to Technical Specifications*, MRTS50 *Specific Quality System Requirements* and other Technical Specifications as appropriate.

This Technical Specification forms part of the Transport and Main Roads Specifications Manual.

2 Definition of terms

The terms used in this Technical Specification shall be as defined in Clause 2 of MRTS01 *Introduction to Technical Specifications*.

In addition, terms listed in Table 2 are applicable to this Technical Specification.

Table 2 – Definition of terms applicable to this Technical Specification

Term	Definition
Applied Load per Anchor	The dead weight of the precast concrete element multiplied by the sling angle factor and the dynamic factor and divided by the number of effective lifting points used in the lift.
Geopolymer Concrete	Geopolymer binder with coarse and fine aggregates, and additives.
Designer	RPEQ engineer responsible for the design of the element.
Dynamic Factor	A multiplying factor to account for dynamic effects during lifting.
Factor of Safety	The ultimate capacity (lower characteristic strength) of the lifting anchor divided by the applied load per anchor.
Geopolymer	Polymeric binder formed by reacting alumina-silicate pre-cursors with alkaline activator(s).
Lifting Anchor	A cast-in, bolted-on or otherwise attached device anchored to the unit, at the lifting point, which is provided exclusively for lifting the precast concrete element.
Lifting Attachment	Lifting device used to attach a lifting anchor to the hoisting equipment.
Lifting Point	The designed location of a lifting device to be used for lifting a precast concrete element.
Sling Angle Factor	The factor by which the tension in a sling increases according to the included angle between the slings.
Rigging Diagram	Diagram showing the method for attaching hoisting equipment to the precast concrete element, the required sling angles and load sharing requirements.
Working Load Limit	The maximum load which may be applied to a lifting anchor, device or attachment.

3 Referenced documents

Table 3 lists documents referenced in this Technical Specification.

Table 3 – Referenced documents

Reference	Title
AS 1012.20.1	Methods of Testing Concrete Method 20: <i>Determination of Chloride and Sulfate in Hardened Concrete and Concrete Aggregates</i>
AS 1379	<i>Specification and Supply of Concrete</i>
AS 3600	<i>Concrete Structures</i>
AS 5100.5	<i>Bridge Design Part 5 Concrete</i>
AS/NZS 4680	<i>Hot dip galvanized (zinc) coatings on fabricated ferrous articles</i>
AS/NZS ISO 9001	<i>Quality Management System Requirements</i>
Design Criteria	<i>Design Criteria for Bridges and Other Structures (Transport and Main Roads)</i>
MRTS01	<i>Introduction to Technical Specifications</i>
MRTS50	<i>Specific Quality Systems - Requirements</i>
MRTS70	<i>Concrete</i>
MRTS71	<i>Reinforcing Steel</i>
MRTS71A	<i>Stainless Steel Reinforcing</i>
MRTS72	<i>Manufacture of Precast Concrete Elements</i>
MRTS78	<i>Fabrication of Structural Steelwork</i>
MRTS78A	<i>Fabrication of Structural Stainless Steelwork</i>
SCM-P-015	<i>Registration Scheme: Suppliers and Products for Bridges and Other Structures</i>

4 Quality system requirements

4.1 Hold Points, Witness Points and Milestones

General requirements for Hold Points, Witness Points and Milestones are specified in Clause 5.2 of MRTS01 *Introduction to Technical Specifications*.

The Hold Points, Witness Points and Milestones applicable to this Specification are summarised in Table 4.1.

Table 4.1 – Hold Points, Witness Points, and Milestones

Clause	Hold Point	Witness Point	Milestone
5.3	1. Mix design, and production procedure		Submission of details of process of manufacture (28 days)
5.3	2. Approval of sample panel		
5.4	3. Drawing approval		Submission of design (14 days)
7.4		1. Placing of geopolymer concrete	
11		2. Inspection	

4.2 Conformance requirements

The conformance requirements which apply to lots of work covered by this Specification are summarised in Table 4.2

Table 4.2 – Conformance requirements

Clause	Item
10	Geopolymer Concrete properties
10.10	Tolerances
12	Acceptance

4.3 Testing frequency

The minimum testing frequency for work covered by this Technical Specification is each precast geopolymer concrete element manufactured with the exception of testing for concrete slump and strength. Geopolymer concrete slump and 28 day strengths shall be tested for each load of concrete. No reduced testing shall be permitted.

5 Conditions for manufacture of precast concrete elements

5.1 Standard

All precast geopolymer concrete elements shall be manufactured in accordance with the details shown on the Drawings and in accordance with this specification.

5.2 Manufacture by registered supplier

Precast geopolymer concrete elements shall be manufactured only by a Registered Supplier who is registered to manufacture conventional precast concrete elements to MRTS72. The requirements for registration are outlined in the document *Registration Scheme: Suppliers and Products for Bridges and Other Structures* (SCM-P-015).

5.3 Manufacturing procedure

The manufacturer shall submit the procedure for manufacture of precast geopolymer concrete elements to the department giving details of materials, and processes not less than 28 days prior to establishment of the process. **Milestone**

This submission shall include the following information:

- a) Details of formwork.
- b) Certificate of approval from Structures Construction Materials (SCM) for the proposed geopolymer concrete mix.
- c) Production rate and proposed program of pouring, stripping and handling.
- d) Curing and handling procedure.
- e) Method of achieving desired surface finish.
- f) Inspection and test plan (ITP) including Hold Points acceptable to the department for manufacturing precast concrete boat ramp planks which demonstrates compliance with this specification and the drawing. The ITP shall also address the supply of materials and the identification of non-conforming product.

Manufacture shall not occur until approval of the procedure has been granted by Transport and Main Roads. **Hold Point 1**

Following approval of the above, the Supplier shall produce a sample element for approval using the proposed design geopolymer concrete mix. **Hold Point 2**

5.3.1 Boat ramp planks

For precast boat ramp planks the sample element shall be 400 x 400 x 150 mm and include the chamfered edge and at least two full depth non slip chevrons at the skew angle of the full size element. A new sample will be made if the design mix or the method of applying the nonslip finish changes.

5.4 Preparation for manufacture of precast elements

At least 14 days before manufacture is due to commence, the Contractor shall provide to the Administrator the following information: **Milestone**

- a) drawings showing the profile dimensions of the element, reinforcement details, grade of geopolymer concrete, cover to reinforcement and exposure classification
- b) the calculated mass of element
- c) the place of manufacture
- d) where the design is an alternative product design, a copy of the design approval (see Clause 6).

The manufacturer shall advise the Administrator when the first cast of each member type is to occur.

Hold Point 3

6 Product design

6.1 Design requirements

Alternative product designs which do not comply with the department's Standard Drawings or the certified-for-construction project drawings shall not be used without approval from Transport and Main Roads. Alternative product designs must comply with the relevant design criteria, this Technical Specification and other relevant Technical Specifications. Supply of product to alternative designs shall not occur without approval of the Administrator (see Hold Point 3).

Relevant design criteria can be found on the departmental website as Technical Notes.

6.2 Exposure classifications and cover to reinforcement

Exposure classification and cover to reinforcement shall be as per AS 3600.

6.3 Concrete

Geopolymer concrete shall be as defined in Clause 7 of this specification.

6.4 Provision for lifting

Lifting anchors and locations shall be included on the product drawings. If the estimated mass of the element is significantly greater than the assumed mass on the drawings, a new lifting design shall be completed.

Lifting designs shall be in accordance with the following:

- a) The designer shall be responsible for certification of the lifting anchors. A rigging diagram shall be shown on the drawing. The rigging diagram shall include details of the required load sharing to equalise loads between lifting points and the included angle between the slings.
- b) The minimum factor of safety for the design of the lifting points for both lifting anchor and concrete pull out capacity shall be 4.0.
- c) The minimum allowance for dynamic effects (dynamic factor) shall be 1.5. Higher values shall be used in the following cases:
 - lifting with a crawler crane travelling with the load suspended on an even surface (1.7)
 - lifting with a rubber tyred mobile crane either stationary or travelling with the load suspended on an even surface (2.0)
 - lifting while travelling with the load suspended over very rough ground (5.0).
- d) Cast-in lifting points shall comply with Clause 9 and shall fail in a ductile manner as evidenced by visible distortion prior to failure.
- e) The number of lifting points and the location of these points shall be designed to provide stability at all stages of lifting, handling and installation, including the requirement to land the product at the required level during installation.
- f) A minimum of two lifting points shall be provided on all products, and no product shall be lifted with less than two points. Lifting of product shall be in accordance with the rigging diagram.
- g) Lifting anchors which are damaged shall not be used without inspection and certification by an RPEQ Engineer.

7 Geopolymer concrete

7.1 General

Geopolymer concrete and concreting operations shall comply with MRTS70, except as modified by the following clauses.

Mixing, transporting and placing geopolymer concrete requires strict attention to the differences between geopolymers and OPC concrete. The concrete supplier and precast manufacturer should be aware of and accommodate these differences in their procedures. For example, wash outs may be required between batching geopolymer and OPC concrete.

7.2 Cementitious materials

Binder material shall be a proprietary blend used at appropriate proportions to maintain the required fresh and hardened concrete properties. Fly ash and slag pre-cursors shall be Transport and Main Roads registered products (see MRTS70).

7.3 Geopolymer concrete mix

The mix design submission shall include everything required by MRTS70, except that only a generic description of the activator is required.

In addition, NATA-endorsed test results confirming material properties conform with Clause 7.3.1 shall be included.

Super-workable geopolymer concrete is not permitted.

7.3.1 Geopolymer properties

The concrete mix shall exhibit hardened concrete material properties as listed in Table 7.3.1.

Table 7.3.1 – Hardened geopolymer concrete properties

	Test Method	Criteria	Age
Compressive Strength	AS 1012.9	As per design	28 days
Flexural Strength	AS 1012.11	≥ 2.5 MPa	28 days
Shrinkage	AS 1012.13	≤ 750 $\mu\epsilon$	91 days
Modulus of Elasticity	AS 1012.17	30 GPa $\pm 20\%$	28 days
Density	AS 1012.12	2.1 – 2.8 t/m ³	28 days
Chloride Permeability	ASTM c1202	< 1000 C	56 days
AAR resistance	AS 1141.60.1	< 0.1 %	to 21 days
Carbonation resistance	ISO 1920-12	Reported only	to 91 days
Chloride ion content	AS 1012.20.1	< 0.4 kg/m ³ (Exposure classification C) < 0.8 kg/m ³ (Exposure classification B2)	28 days

7.3.2 Geopolymer composition

Minimum cementitious contents and maximum water / cementitious ratios shall comply with MRTS70 for the specified exposure classification and strength grade, with 'cementitious' referring to aluminosilicate precursors in this instance.

7.4 Placing geopolymer concrete

Placing of geopolymer concrete shall be a mandatory Hold Point in the manufacturer's Quality Management System. The manufacturer shall also advise the Administrator of the intention to place geopolymer concrete. **Witness Point 1**

7.5 Formwork for precast geopolymer concrete boat ramp planks

Precast geopolymer concrete boat ramp planks shall be cast inverted in formwork supported on a flat, level and firm surface. The chevron pattern shall be incorporated into the base of the formwork. The formwork shall be designed so that the product can be stripped without damage.

The base of the formwork shall be metal that is sufficiently braced to resist deformation and remains flat during placement of concrete. The chevron pattern shall be created using milled High Density Polyethylene (HDPE) or steel securely attached to the formwork base. Blockouts (if required for reduced gap planks) shall be HDPE or an integral part of the formwork front side.

Edge formwork shall be metal and have sufficient rigidity to resist deformation during placement of concrete. The stainless steel link bars shall be fixed to the formwork to positively locate the link bars in both dimensions.

7.5.1 Fillets

Internal corners and external edges of all planks shall be finished with curved or straight fillets appropriate to the application.

Specified cover also includes cover to fillets.

7.6 Installation of lifting devices

Lifting anchors shall be fixed securely in place before placement and compaction of geopolymer concrete. Where the lifting anchor has a recess, cover shall be maintained to the recess.

Puddling in of lifting anchors into wet geopolymer concrete is not permitted.

7.7 Removal of formwork

Formwork shall not be removed from the geopolymer concrete or the product lifted until the geopolymer concrete has attained a strength not less than 60% of the specified 28 day characteristic strength. Curing shall continue as soon as practical but no later than 1 hour after removal of form work. **Nonconformance**

Permission for early stripping or lifting of the product may be granted by the Administrator to a minimum of 40% of the specified 28 day strength, but not less than 15 MPa subject to the following conditions:

- a) product design approval
- b) certification of product lifting points, and
- c) satisfactory performance (e.g. no cracking or defects).

Under no circumstances shall the formwork be stripped or the product lifted before the geopolymer concrete has attained a strength of 40% of the specified 28 day concrete strength. Where a minimum lifting strength is shown on the drawings which is higher than these requirements, the drawing requirements shall apply.

Permission for early stripping or lifting in accordance with the requirements of this specification will generally be granted, provided it can be demonstrated by calculations that the stresses in the product are not sufficient to cause cracking or damage.

7.8 Curing

Precast geopolymer concrete elements shall be steam or membrane cured in accordance with MRTS70. Steamed units shall be coated with a curing membrane within 1 hour of removal from the enclosure.

If temperature-matched curing tanks are used, the manufacturer shall protect the sample cylinders from water infiltration.

Water curing is not permitted as excess water may impede the geopolymerisation reaction at the surface by reducing the alkalinity.

During steam curing, care should be taken to prevent condensation pooling on the surface of geopolymer concrete.

7.9 Finish

7.9.1 Surface condition

The geopolymer concrete shall be dense, hard and substantially free from chipped edges, fins, protrusions, surface roughness and dusting.

Any lifting recesses shall be filled with geopolymer mortar having the same binder as the approved mix.

Elements shall not be coated with cement wash or any other preparation not specified or otherwise approved by the Administrator.

Dustiness of the surface is indicative of improper curing

7.9.2 Cracks, dents and bulges

Precast geopolymer concrete elements shall have:

- No crack or fissure wider than 0.15 mm
- No individual crack longer than 300 mm, and
- A cumulative crack length of no more than 500 mm.

Dents not exceeding 3 mm in depth and bulges not exceeding 3 mm in height shall be permitted provided these do not extend over the surface for a distance of more than 180 mm and the specified cover is maintained.

The intention of this specification is that precast units are produced defect free.

7.9.3 Air holes

Air holes exceeding 12 mm in lateral dimension or having a depth greater than 3 mm shall be filled with geopolymer binder.

The intention of this specification is that precast geopolymer concrete units are produced with very few air holes. Excessive air holes are a strong indication that suitable manufacturing processes are not being observed in the production process and are not acceptable.

7.10 Tolerances

Completed precast geopolymer concrete elements shall comply with the tolerances set out in Table 7.10.

In addition, the following tolerances apply:

- a) Position of lifting attachments ± 5 mm.
- b) Position of ferrules and other cast-in items ± 5 mm. Where a ferrule group or other cast-in items are required to be attached to the same element, the relative tolerance between these ferrules or cast-in items shall be ± 2 mm or as specified by the Designer.
- c) Horizontal and vertical alignment of link bars in precast concrete boat ramp planks ± 3 mm.

Table 7.10 – Tolerances for precast geopolymer concrete elements

Precast Geopolymer Concrete Element	Tolerance (mm)				
	Thickness of Any Section	Length or Width	Internal Dimensions	Straightness [†]	Squareness
Slabs and panels	± 3	± 3	-	3	± 3 in 2000 mm
Pits, gullies and manholes	+ 5, - 3	± 5	± 5	-	± 5 in 2000 mm
Kerbs, channels and blocks	+ 5, - 3	± 5	-	5	± 3 in 2000 mm
Traffic barriers	± 5	± 10	-	5	± 5 in 2000 mm
Boat Ramp Planks	± 3	± 3	-	5	± 3 in 2000 mm
All other products	+ 5, - 3	± 5	± 5	3	± 5 in 2000 mm

[†] Deviation from a 1 metre long straight-edge.

8 Reinforcing steel

8.1 General

Reinforcing steel shall conform to MRTS71 / MRTS71A, as modified by the following clauses.

8.2 Cover

The tolerance for cover to steel reinforcing shall be ± 5 mm from the design nominal value.

8.3 Bar chairs

Bar chairs and spacers shall not be used. All reinforcement is to be suspended or supported on stainless steel nibs.

9 Cast-in items

Cast-in items including but not limited to ferrules, formwork anchors, lifting devices, and cast-in bolts, shall be either:

- a) Fabricated by an approved steel fabricator in accordance with MRTS78 / MRTS78A, or
- b) Proprietary items as specified in the Drawings or approved equivalent. Proprietary cast-in items shall be a Transport and Main Roads registered product.

10 Marking, handling, storing and transporting

10.1 Marking

On each precast concrete element, the following information shall be clearly and permanently marked on a surface which shall not be on permanent display when erected:

- a) the date of manufacture
- b) the identification number
- c) the manufacturer's name or registered mark, and
- d) the maximum mass of the element.

10.2 Handling

Precast geopolymer concrete elements shall be handled in a manner which shall avoid damage to the element and shall be lifted using the lifting points provided. Lifting of product shall be in accordance with the rigging diagram.

10.3 Transporting

Precast geopolymer concrete elements shall not be transported from the place of manufacture until the greater of 7 days has elapsed since casting and the time when concrete has attained 70% of the specified 28 day characteristic strength.

Adequate packers or supports shall be provided to support and firmly hold precast geopolymer concrete elements during transport. The packers or supports shall not damage or stain the product in any way.

10.4 Storing

Precast geopolymer concrete elements shall be stored clear of the ground on adequate supports placed on a plane surface in a manner that shall avoid damage, twisting or warping. The ground shall not be subject to subsidence under the weight of the elements.

Planks and panels may be stacked up to 6 layers high provided that supports are provided to separate each layer. Supports for upper layers shall be placed directly above the supports of the layer below.

Material used for supports shall not damage or stain the product in any way.

11 Acceptance

Precast geopolymer concrete elements shall remain available for inspection for a minimum of 7 days from the date of manufacture. **Witness Point 2**

The acceptability of precast concrete elements in accordance with this specification shall be determined by inspection on the basis of visual inspection, geometric measurement, measurement of clear cover to reinforcement, reinforcement spacing and location, and specified 28 day concrete strength.

Precast geopolymer concrete elements may be rejected should the products fail to meet any of the requirements of this specification.

Any damage to the product during handling or transporting to site shall be assessed in accordance with Clause 7.9 of this specification.

This specification states that 'Precast geopolymer concrete elements may be rejected should the products fail to meet any of the requirements of this specification'. It should be noted that manufacture of defect free product in accordance with this specification is always the preferred outcome. However, where issues exist, early submission of non-conformances in accordance with the contract to the Administrator may assist with resolving issues. Acceptance of non-conforming or defective product is always at the discretion of the Administrator.

