

**Technical Specification**

**Transport and Main Roads Specifications  
MRTS273 Fibre-reinforced Concrete**

**November 2020**

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## 1 Introduction

This Technical Specification applies to the construction of concrete elements containing fibre reinforcement. Fibres may complement or replace (in whole or in part) steel reinforcing bars or mesh. It is not intended for vehicular pavements (refer to MRTS40 *Concrete Pavement Base*).

Fibre-reinforced concrete, in accordance with this Technical Specification, may be used for cast in situ (non-structural elements), shotcrete or precast concrete elements, all where the design life is 50 years or less.

Steel fibre reinforced concrete shall not be used in any applications exposed to salt or brackish water above 2000 ppm. Where the fibre reinforced concrete is exposed to Potential Acid Sulphate Soils (PASS) or Acid Sulphate Soils (ASS), or other aggressive environments that consume the concrete matrix, a sacrificial concrete layer that does not contribute to the design strength equivalent to the cover concrete for conventional steel reinforced concrete shall be used.

The intent is to permit fibres in non-structural applications where normal-class concrete would normally be permitted.

Specifying a fibre dosage or flexural performance makes concrete S-class according to AS 1379 *Specification and supply of concrete*.

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The aim of this Technical Specification is to achieve finished concrete of the required strength, durability and appearance.

Concrete elements shall comply with MRTS70 *Concrete*, MRTS72 *Manufacture of Precast Concrete Elements*, and MRTS272 *Shotcrete for Aboveground Applications* as applicable to the requirements in this Technical Specification.

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.

This Technical Specification draws upon and references MRTS70 *Concrete* extensively. A knowledge of MRTS70 *Concrete* is critical for correct application of this Technical Specification.

### 1.1 Registered products and suppliers

The requirements for the construction of concrete elements include the use of registered products and suppliers. For information regarding these products and suppliers refer to the department's website, <https://www.tmr.qld.gov.au/business-industry/Technical-standards-publications.aspx>, or email [TMRStructuralMaterials@tmr.qld.gov.au](mailto:TMRStructuralMaterials@tmr.qld.gov.au).

## 2 Definition of terms

The terms and symbols used in this Technical Specification are defined in Clause 2 of MRTS01 *Introduction to Technical Specifications*, MRTS70 *Concrete* and in Table 2 of this Technical Specification.

**Table 2 – Definitions of terms**

Term	Definition
batch	One load or charge of a mixing plant or transit mixer.
CMOD	Crack mouth opening displacement (see EN 14651).
Design Criteria	Published department document outlining design requirements, for example Technical Note TN23 <i>Design Criteria of Precast Drainage Pits</i>
$f_{R,j}$	Residual Flexural Strength at CMOD <sub>j</sub> .
Registered	Pre-qualified product or supplier in accordance with departmental registration schemes: <ul style="list-style-type: none"> <li>• <i>Registration Scheme: Suppliers and Products for Bridges and Other Structures</i></li> <li>• <i>Product Index for Bridges and Other Structures</i></li> <li>• <i>Construction Materials Testing Supplier Registration Scheme, and</i></li> <li>• <i>Quarry Registration System.</i></li> </ul> Registration for certain products and suppliers is a pre-requisite for approval, not a substitute.
Macro Synthetic Fibre-fibre	Fibres imparting significant post-cracking capacity to concrete, used as a replacement for steel reinforcement. Macro fibres are typically 40–65 mm long and 0.3-1 mm wide.
Micro Synthetic Fibre	Fibres that create a support network within the concrete which increases its tensile strain capacity for control of plastic shrinkage cracking, but do not offer concrete post-cracking load capacity. Micro fibres are typically 12-51 mm long and < 0.3 mm wide.
Steel Fibre	Straight or deformed pieces of cold-drawn steel wire, straight or deformed cut sheet fibres, melt extracted fibres, shaved cold drawn wire fibres and fibres milled from steel blocks, which are suitable for homogeneous mixing into concrete or mortar to improve prescribed properties.

## 3 Referenced documents

Table 3 lists documents referenced in this Technical Specification. The latest revision of documents should be used; dates are included when specific clauses have been referenced.

**Table 3 – Referenced documents**

Reference	Title
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>
ASTM A820	<i>Standard Specification for Steel Fibers for Fiber-reinforced Concrete</i>

Reference	Title
ASTM C1116	<i>Standard Specification for Fiber-reinforced Concrete</i>
ASTM D7508	<i>Standard Specification for Polyolefin Chopped Strands for Use in Concrete</i>
EN 14651	<i>Test method for metallic fibre Concrete – Measuring the flexural tensile strength (limit of proportionality (LOP) residual)</i>
EN 14889 (Parts 1 and 2)	<i>Fibres for Concrete</i>
MRTS01	<i>Introduction to Technical Specifications</i>
MRTS40	<i>Concrete Pavement Base</i>
MRTS50	<i>Specific Quality System Requirements</i>
MRTS70	<i>Concrete</i>
MRTS72	<i>Manufacture of Precast Concrete Elements</i>
MRTS272	<i>Shotcrete for Aboveground Applications</i>
PIBOS	<i>Product Index for Bridges and Other Structures</i>
TN23	<i>Design Criteria for Precast Drainage Pits</i>

#### 4 Standard test methods

The standard test methods stated in Table 4 shall be used in this Technical Specification.

Further details of test numbers and test descriptions are given in Clause 4 of MRTS01 *Introduction to Technical Specifications*.

All tests for the purposes of compliance including sampling are to be performed and reported by a National Association of Testing Authorities (NATA) accredited laboratory, whose scope of accreditation encompasses the test method used. Laboratories must also be registered with the department via the Construction Materials Testing Supplier Registration System (CMT-SRS).

**Table 4 – Standard test methods**

Property to be tested	Method No.	Sample Size
Compressive strength of concrete	AS 1012.9	100 Ø x 200 cylinder
Slump of concrete	AS 1012.3.1	
Indirect Tensile Strength of Concrete	AS 1012.10	100 Ø x 200 cylinder
Flexural Strength of Concrete	AS 1012.11	100 x 100 mm beam
Flexural Toughness of Concrete	ASTM C1550	800 Ø x 75 mm
Residual Flexural Strength of Concrete	EN 14651	150 x 150 mm beam
Fibre content	AS 1012.25.1	5 L

Residual flexural strength testing shall be conducted on 150 mm x 150 mm notched beams. Residual flexural strength shall be reported at crack mouth opening displacements (CMOD) of 0.5 mm and 3.5 mm.

## 5 Quality system requirements

### 5.1 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* and Clause 8.3 of MRTS50 *Specific Quality System Requirements*.

The Hold Points, Witness Points and Milestones applicable to this Technical Specification are summarised in Tables 5.1.

There are no Witness Points and Milestones defined.

**Table 5.1 – Hold Points, Witness Points and Milestones**

Clause	Hold Point	Witness Point	Milestone
6.4	1. Substitution of fibres		

### 5.2 Construction procedures

No additional construction procedures are required by this Technical Specification.

### 5.3 Conformance requirements

The conformance requirements which apply to lots of work covered by this Technical Specification are summarised in Table 5.3.

**Table 5.3 – Conformance Requirements**

Clause	Conformance Requirement
10	Concrete strength and toughness

## 6 Design

Designs for fibre-reinforced concrete shall comply with the relevant Design Criteria and the following requirements.

Relevant design criteria include AS 3600 *Concrete Structures*, and the department's Technical Notes.

In all cases, except extruded concrete applications, the design of the fibre reinforced concrete shall provide equivalent performance to a steel bar or steel mesh reinforced concrete section.

The design of fibre-reinforced concrete elements shall be the responsibility of an RPEQ Designer and be either:

- a) prescriptive, where the fibre and dosage are specified, or
- b) performance-based, where the flexural strength, residual flexural strength and / or toughness of the concrete are specified.

The designer shall stipulate the necessary performance measure(s) in Annexure MRTS273.1 and whether the fibres are replacing reinforcing bar / mesh.

The Technical Specification of the fibre or concrete performance shall be included on the Drawings.

### 6.1 Minimum performance requirements

Where specified, the required performance measures shall not be less than that listed in Table 6.1.

**Table 6.1 – Minimum performance measures**

Property	Minimum Requirement (at 28 days)
Flexural Strength	3.0 MPa (for $f'_c = 20, 25$ ) 3.5 MPa (for $f'_c = 32$ ) 4.0 MPa (for $f'_c \geq 40$ )
Residual Flexural Strength (at $CMOD_4$ )	1.0 MPa
Toughness (at 40 mm displacement)	360 J

Depending on the design methodology, usually only one of these properties will be the important parameter. It is not necessary to specify or meet all three properties.

These values are baselines and may not be sufficient for all applications.

### 6.2 Minimum dosage

When used, the minimum dosage of fibre shall be:

- a) 20 kg/m<sup>3</sup> for steel fibres, or
- b) 4 kg/m<sup>3</sup> for macro synthetic fibres, or
- c) 0.6 kg/m<sup>3</sup> for micro synthetic fibres.

Note: these are minimums only and will not be sufficient in all cases.

### 6.3 Design Approval

Proprietary precast product designs shall be submitted for approval prior to manufacture (refer to Clause 6 of MRTS72 *Manufacture of Precast Concrete Elements*). Evidence shall be included that the performance of the element by load testing is equivalent to that achieved from the relevant Standard Drawing or Design Criteria.

A typical precast element suitable for fibres is small drainage pits designed to TN23 *Design Criteria for Precast Drainage Pits*.

Suitable evidence would include an engineering report incorporating load testing and modelling.

### 6.4 Substitution

Where the Contractor wishes to propose an alternative fibre to that specified in the Drawings, or use fibres in place of conventional reinforcement, the request shall be referred to the designer and Administrator for approval, prior to use. **Hold Point 1**

Submissions shall include a nominated fibre and dosage.



## 7 Materials

### 7.1 Concrete

Concrete shall be designated Special Class and conform to MRTS70 *Concrete* and the following requirements.

In addition to MRTS70 *Concrete* requirements, the mix design submission shall include:

- a) fibre name and nominated dosage, and
- b) Technical Data Sheet (TDS) of the fibre product.

#### 7.1.1 Non-structural use of fibres

Where the designer has indicated that fibres do not contribute to the structural capacity of the concrete element, concrete testing and acceptance shall be as per MRTS70 *Concrete* (instead of Clauses 10 and 11 of this Technical Specification).

Only the following scenarios are permitted under this clause:

- a) Addition of micro synthetic fibres to extruded concrete.
- b) Addition of macro and/or micro synthetic fibres to conventionally reinforced sections.

In these cases fibres are added to enhance concrete's plastic properties only.

#### 7.1.2 All other fibre-reinforced concrete

A trial mix is required for fibre-reinforced concrete mixes, and shall include testing for compressive, flexural and indirect tensile strength, and, if specified by the designer, residual flexural strength and toughness. The number of specimens to be taken are listed in Table 7.1.2.

**Table 7.1.2 – Trial Mix Samples**

Test (at 28 days)	Number of Specimens
Compressive Strength	4 cylinders <sup>Note 1</sup>
Flexural Strength	3 beams
Indirect Tensile	3 cylinders
Residual Flexural Strength <sup>Note 2</sup>	3 notched beams
Toughness	3 panels

<sup>Note 1</sup> Extra cylinders required (as per MRTS70 *Concrete*) if early stripping/loading is proposed.

<sup>Note 2</sup> If specified by designer.

For the trial to be considered successful, the concrete (as the average of matched specimens) shall achieve the minimum properties at 28 days, as specified by the designer in Annexure MRTS273.1.

For testing other than compressive strength, where the specimen results varying by more than 10%, the lower value shall be excluded from the average.

The indirect tensile results from the trial shall become the nominal indirect tensile strength.

The indirect tensile strength is nominated at this point as a benchmark for production testing.

## 7.2 *Fibres*

Fibres shall be either synthetic fibres conforming to EN 14889-2 or steel fibres conforming to EN 14889-1.

Steel fibres shall not be used for footpaths or bikepaths, or other concrete trafficked by vehicles or people.

Fibres shall be a registered product as described by the Product Index for Bridges and Other Structures. Application submissions shall include:

- a) Technical Data Sheet confirming compliance with the relevant EN Standard.
- b) Declaration of dosage required to meet concrete properties stated above.
- c) NATA-endorsed test reports confirming those declarations.
- d) NATA-endorsed test reports confirming compliance with the relevant standards.

Fibres compliant with ASTM C1116 are acceptable, noting residual strength at 3.5 mm CMOD is only roughly equivalent to  $f_{150}^D$ .

Fibres shall be supplied in fully degradable and disintegrating bags or boxes, or dosed automatically through batch plants.

## 8 **Batching**

Fibres shall be batched into concrete in accordance with the manufacturer's instructions, being uniformly distributed and without balling. Fibres shall be added as full bags only and the mass added shall be recorded with the batching records.

## 9 **Concrete Placement**

Delivery, placement, compaction and curing of concrete shall be in accordance with MRTS70 *Concrete*.

### 9.1 *Surface finish*

The surface shall be finished to the requirements on the drawing or MRTS70 *Concrete* and shall minimise protrusions of fibre from the surface. In drainage works, any fibres near the surface shall be sufficiently embedded so as to not wash into surrounding creeks or rivers.

The following surfaces shall be made free of protruding fibres (by removal or recasting):

- a) where visual appearance or serviceability is critical
- b) footpaths and bikepaths, and
- c) exposed precast elements **Nonconformance**

Adjustments to the mix design, such as increasing slump, can assist in preventing reoccurrence. Correct finishing techniques are also critical to prevent fibres protruding through the surface.

Fibres shall not be used with exposed aggregate finishes. On coloured concrete surfaces fibres shall not be used unless the final finished surface is acceptable to and approved by the Administrator.

## 10 Sampling and testing

Routine testing shall be conducted at the frequencies listed in Table 10. The designer shall nominate which tests are applicable in Annexure MRTS273.1.

**Table 10 – Testing Frequencies**

Test	Sample Frequency
28 day compressive strength	1 per 50 m <sup>3</sup> (2 cylinders) <sup>Note 1</sup>
Slump	As per AS 1379
28 day indirect tensile strength	1 per 100 m <sup>3</sup> (2 cylinders)
Fibre count	1 per 100 m <sup>3</sup>

<sup>Note 1</sup> Minimum 1 per day and where other Technical Specifications or project specific requirements apply and more frequent testing of compressive strength is specified, the frequency of testing in that Technical Specification shall apply to compressive strength.

Flexural strength, residual flexural strength and toughness are not specified as routine tests. A correlation with indirect tensile strength is relied upon.

## 11 Acceptance

Acceptance of plastic concrete shall be as be MRTS70 *Concrete*.

Acceptance, and any rectification, of hardened concrete shall be as per MRTS70 *Concrete* and the following:

- a) 28 day indirect tensile strength, the average of a pair of cylinders, shall meet or exceed 90% of the nominated indirect strength (from the concrete mix trial).  
  
Should the specimen results of the cylinders differ by more than 10%, the lower value shall be discounted.
- b) The measured fibre content shall meet or exceed 85% of the nominated design dosage.

