Technical Specification

Transport and Main Roads Specifications
MRTS70 Concrete

November 2018

Queensland Government

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1 Introduction

This Technical Specification applies to the construction of concrete road and bridge structures and may also be applied to other specified concrete elements.

For concrete pavements refer to MRTS39 *Lean Mix Concrete Sub-base for Pavements* and MRTS40 *Concrete Pavement Base* and for concrete for machine-manufactured concrete drainage pipes refer to MRTS25 *Steel Reinforced Precast Concrete Pipes* and MRTS26 *Manufacture of Fibre Reinforced Concrete Drainage Pipes*.

The aim of this Technical Specification is to achieve concrete of the required strength, durability and appearance. It describes the materials, supply, placing, compacting, finishing, curing and measurement of concrete.

All concrete shall be manufactured and supplied in accordance with the requirements of AS 1379, where covered by its scope, and the additional requirements of this Technical Specification.

This Technical Specification shall be read in conjunction with MRTS01 *Introduction to Technical Specifications* and other Technical Specifications as appropriate.

The use of commentary text, such as this, is covered by MRTS01 Clause 16.

For clarity, this Technical Specification is divided into sections which identify the requirements for the various concrete types and elements.

Table 1 – Clause applicability of MRTS70

Clauses	Insitu Concrete		Precast and Prestressed Concrete	
	Special Class	**Normal Class**	**Special Class**	**Normal Class**
1 – 6	X	X	X	X
7 – 14	X		X	
15	X			
16			X	
17		X		X

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 Transport and Main Roads website, http://www.tmr.qld.gov.au, or email Structures Construction Materials (TMRStructuralMaterials@tmr.qld.gov.au).

Note the differing submission requirements throughout this Technical Specification. Some approvals (e.g. procedures) are wholly dealt with by registration, some submissions (e.g. mix designs, Hold Points) are assessed by Structures Construction Materials but signed off by the Administrator after receipt of a certificate or similar, and others (e.g. niche project specific requirements) are assessed by the Administrator.

2 Definition of terms

The terms and symbols used in this Technical Specification shall be as defined in Clause 2 of MRTS01 *Introduction to Technical Specifications* and in Table 2(a) and Table 2(b) below.

Table 2(a) – Definition of terms

Term	Definition
Approved	Approved by the Administrator.
ASR	Alkali-Silica Reaction, a subset of Alkali-Aggregate Reaction (AAR).
ATIC	Australian Technical Infrastructure Committee.
Batch	One load or charge of a mixing plant or transit mixer.
Bed	A set of precast elements cast in a line and cured under a single enclosure.
Blended cement (GB)	As per AS 3972.
Blinding concrete	A layer of typically low strength concrete placed on ground to provide a hard surface for construction of concrete members.
Carbonate rock	A rock containing more than 50% by mass of carbonate material.
Characteristic strength (f'_c)	The compressive strength of the concrete at age 28 days as specified in the Contract. The characteristic strength shall be exceeded by at least 95% of the concrete as assessed by standard tests.
Coarse aggregate	Aggregate having a nominal size equal to or larger than 5 mm.
Contractor	Unless noted otherwise, the entity responsible for producing the finished concrete element (insitu or precast). The use of this term does not diminish the responsibility of the Principal Contractor to ensure all works are in accordance with the Contract, nor does it make any comment on the form of agreement between the various parties involved in the contract.
Core temperature	Concrete temperature as measured at the centre of the largest cross-section.
Crushed fine aggregate	A purpose-made, fine crushed aggregate produced under controlled conditions from a suitable sound source rock designed for use in concrete (otherwise known as manufactured sand). General crusher fines (crusher dust) and sand resulting from lightly crushing (disaggregating) decomposed granite, similar igneous rock or weakly cemented sandstone rocks are not considered to be manufactured sand. The latter are classified as natural sands of residual origin.
Designer	RPEQ engineer responsible for the design of the element.
Enclosure	A continuous covered space in which heat is contained for the purposes of heat accelerated curing.
Fine aggregate	Aggregate having a nominal size of less than 5 mm.

Term	Definition
General purpose (GP) cement	As per AS 3972.
Grading	Distribution of aggregate particle size.
High workability concrete (HWC)	Concrete with high workability where consistency is measured as spread. Only used for cast-in-place piles and specialised applications. Distinct from super-workable concrete in that it does not self-consolidate.
Lot	An identifiable quantity of concrete from which samples are taken, and about which decisions are made on the basis of tests carried out on specimen cylinders made from the samples. A lot shall consist of batches of concrete of the same strength grade, produced and placed in an essentially uniform and continuous manner during a day's production. A lot may be further defined by individual product Technical Specifications.
Mass concrete	Unreinforced concrete placed generally in large volumes to the dimensions shown on the drawings.
Maximum nominal aggregate size	As per AS 2758.0.
Mean strength	The arithmetic average of the compressive strengths achieved by two or more specimen cylinders all of the same age.
No-fines concrete	Concrete, typically free draining, containing a minimum portion of aggregate below 4.75 mm (mix contains no fine aggregate source).
Pre-mixed concrete	Concrete delivered to site in an agitator truck having been batched off-site.
Product testing	Testing of a nominated product that is required by the respective technical specification, but where the testing is not detailed in Appendix A of QRS4: *Assigning Quarry-Specific Testing Frequencies for Source Rock Tests*.
RCPT	Rapid Chloride Penetration Test (ASTM C1202).
Registered	Pre-qualified product or supplier in accordance with departmental registration schemes: • *Registration Scheme: Suppliers and Products for Bridges and Other Structures* • *Product Index for Bridges and Other Structures* • *Construction Materials Testing Supplier Registration Scheme* • *Quarry Registration System (QRS)* Registration for certain products and suppliers is a pre-requisite for Administrator approval, not a substitute.
Sample	A portion of fresh concrete drawn from a batch and from which specimen cylinders are made.
Site	The location at which the concrete is placed.

Term	Definition
Source rock	As per AS 2758.0, 'the insitu rock mass located in a quarry, which is used … in the production of crushed rock, aggregate or manufactured sand.' Source rock properties and testing frequencies are quarry-specific and detailed on the Quarry Registration Certificate issued as part of the QRS. The QRS provides testing of each of these properties, undertaken as part of the quarry's ongoing production.
Specimen cylinder	A single concrete cylinder, in accordance with AS 1012.8.1, made from a sample for the purpose of testing.
Spread Measure of consistency	Also known as slump flow.
Standard deviation (s)	A statistical measure of the variation from the mean strengths of the specimen cylinders.
Strength grade	Specified value of the characteristic compressive strength at 28 days.
Super-workable concrete (SWC)	Concrete that is able to flow and consolidate under its own weight, completely filling the formwork even in the presence of dense reinforcement, whilst maintaining homogeneity. Minimal compaction may be required.
Target strength (f'_t)	The compressive strength of the concrete at age 28 days selected for design of the mix as provided for in Clause 9 The mean strength required to ensure 95% of samples exceed the specified characteristic strength.

Table 2(b) – Definitions of Symbols

Symbol	Definition
f'_c	Characteristic strength
f'_t	Target strength
s	Standard deviation
σ	Test result (strength)
$\bar{\sigma}$	Average of test results (strength)

3 Referenced documents

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

Table 3 – Referenced documents

Reference	Title
AS 1012	*Methods of testing concrete*
AS 1141.60	*Methods for sampling and testing aggregates*
AS 1379 (2007)	*Specification and supply of concrete*
AS 1478	*Chemical admixtures for concrete, mortar and grout*
AS 2758.0 (2009)	*Aggregates and rock for engineering purposes – Definitions and Classification*
AS 2758.1 (2014)	*Aggregates and rock for engineering purposes – Concrete aggregates*

Reference	Title
AS 2876	*Concrete kerbs and channels (gutters) – Manually or machine placed*
AS 3582.2	*Supplementary cementitious materials. Part 2: Slag – Ground granulated blast-furnace*
AS 3600 (2018)	*Concrete Structures*
AS 3610 (1995)	*Formwork for concrete*
AS 3799	*Liquid membrane-forming curing compounds for concrete*
AS 3972	*General purpose and blended cements*
AS 5100.5 (2017)	*Bridge Design. Part 5: Concrete*
AS/NZS 2425	*Bar chairs in reinforced concrete – Product requirements and test methods*
AS/NZS 3582.1	*Supplementary cementitious materials. Part 1: Fly ash*
AS/NZS 3582.3	*Supplementary cementitious materials. Part 3: Amorphous silica*
AS/NZS ISO 9001	*Quality management systems – requirements*
ATIC-SPEC Section SP43	*Cementitious materials for concrete*
CIA Z17	*Recommended Practice: Tremie Concrete for Deep Foundations*
CMT SRS	*Construction Materials Testing Supplier Registration System*
Design Criteria	*Design Criteria for Bridges and Other Structures*
Guideline QRS1	*Quarry Registrations System Outline*
Guideline QRS2	*Preparing a Quarry Assessment Report for a Hard Rock Quarry*
Guideline QRS3	*Preparing a Quarry Assessment Report for a Natural Sand and/or Natural Gravel Quarry*
MRTS01	*Introduction to Technical Specifications*
MRTS03	*Drainage, Retaining Structures and Protective Treatments*
MRTS24	*Manufacture of Precast Concrete Culverts*
MRTS25	*Steel Reinforced Precast Concrete Pipes*
MRTS26	*Manufacture of Fibre Reinforced Concrete Drainage Pipes*
MRTS39	*Lean Mix Concrete Sub-base for Pavements*
MRTS40	*Concrete Pavement Base*
MRTS50	*Specific Quality System Requirements*
MRTS63	*Cast-in-Place Piles*
MRTS63A	*Piles for Ancillary Structures*
MRTS71	*Reinforcing Steel*
MRTS71A	*Stainless Steel Reinforcing*
MRTS72	*Manufacture of Precast Concrete Elements*
MRTS73	*Manufacture of Prestressed Concrete Members and Stressing Units*
SA HB79	*Alkali Aggregate Reaction – Guidelines on Minimising the Risk of Damage to Concrete Structures in Australia.*
SCM-P-015	*Registration Scheme: Suppliers and Products for Bridges and Other Structures*

Reference	Title
TN125	*Long Distance Transport and Extended Placement Times for Concrete*

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 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.
Alkali-carbonate reactivity	ASTM C1105
Chloride ion content (acid-soluble)	AS 1012.20.1
Compressive strength	AS 1012.9
Crushed particles	AS 1141.18
Filtration loss Filter cake thickness	A.3 (CIA Z17)
Flakiness index	AS 1141.15
Light particles	AS 1141.31
Mass per unit volume	AS 1012.5
Material finer than 2 µm	AS 1141.13
Material finer than 75 µm	AS 1141.12
Particle density and water absorption	AS 1141.5 AS 1141.6.1
Particle size distribution	AS 1141.11.1
Relative compaction (soil)	Q140A
Resistance of Fine Aggregate to Degradation (by Abrasion in the Micro-Deval Apparatus)	ASTM 7428
Saturated resistivity (Rapid Chloride Penetration Test: RCPT)	ASTM C1202
Slump	AS 1012.3.1
Spread	AS 1012.3.5
Sugar content	AS 1141.35
Texture depth	AG:PT/T250
Visual stability index	ASTM C1611
Weak particles	AS 1141.32
Wet Strength	AS 1141.22
Wet / Dry Strength Variation	AS 1141.22

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(a), 5.1(b), 5.1(c) and 5.1(d). Administrative points in Clause 15 (insitu concrete), Clause 16 (precast concrete) and Clause 17 (Normal Class concrete) apply to that clause only.

Table 5.1(a) – Hold Points, Witness Points and Milestones (special class concrete)

Clause	Hold Point	Witness Point	Milestone
9.2			Submit proposed concrete mix design (4 weeks)
10.1			Submission of on-site batching and mixing procedure (6 weeks)
10.4.1			Submission of long distance travel procedure (6 weeks)
13.1			Submission of hot weather procedure (2 weeks)

Table 5.1(b) – Hold Points, Witness Points and Milestones (special class insitu concrete)

Clause	Hold Point	Witness Point	Milestone
15.1	1. Approval of mix design		
15.1.1		1. Trial Mix	
15.3	2. Approval of falsework		Submission of falsework drawings (4 weeks)
15.4.1	3. Approval of formwork		
15.6	4. Approval of concreting procedures		
15.6.1	5. Approval to place concrete	2. Placing of concrete	
15.5			Submission of temperature control procedure (4 weeks)
15.6.3		3. Placing of concrete	Submission of underwater placement procedure (2 weeks)
15.8	6. Approval to remove formwork	4. Removal of formwork	
15.11.1			Submission of curing procedure (2 weeks)
15.12.2		5. Repair of concrete	

Clause	Hold Point	Witness Point	Milestone
15.13	7. Approval of unspecified construction joints		

Table 5.1(c) – Hold Points, Witness Points and Milestones (special class precast concrete)

Clause	Hold Point	Witness Point	Milestone
16.1.1		6. Trial mix	
16.5.1	8. Approval to place concrete		
16.4.2			Submission of heat accelerated curing procedure (2 weeks)
16.7.4			Submission of heat accelerated curing procedure (2 weeks)
16.8.2		7. Repair of concrete	
16.9	9. Approval of unspecified construction joints		

Table 5.1(d) – Hold Points, Witness Points and Milestones (normal class concrete)

Clause	Hold Point	Witness Point	Milestone
17.5.1			Submission of long distance travel procedure (6 weeks)
17.9	10. Approval of falsework		
17.10	11. Approval of formwork		
17.11.1	12. Approval to place concrete	8. Placing of concrete	
17.16	13. Removal of formwork		
17.17.1		9. Repair of concrete	

5.2 Construction procedures

The Contractor shall prepare and submit, to the Administrator, documented procedures for construction processes in accordance with the quality system requirements of the Contract. These processes are listed in Table 5.2.

All construction procedures for precast concrete (Clause 16) shall be submitted, reviewed and approved as part of supplier registration.

Table 5.2 – Construction Procedures

Clause	Procedure
10	On-site batching and mixing of concrete
10.4.1, 17.5.1	Long distance travel and extended placement times
13.1	Hot weather concreting
15.5	Temperature monitoring (large elements and/or high cementitious contents)

15.6.3	Placement under water
15.11	Curing
15.12, 17.17	Surface dressing of concrete

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
7	Raw materials
11 17.6	Plastic concrete
12 17.7	Concrete strength
15.5 16.4	Concrete temperature
15.7 17.12	Dimensions and levels
15.10 16.6 17.13	Surface finish
15.12 16.8 17.17	Surface condition
16.7.4	Heat accelerated curing

5.4 Testing Frequency

The minimum testing frequency for work covered by this Technical Specification shall be as per:

a) Clause 12 for special class concrete and

b) AS 1379 for normal class concrete.

6 Concrete class

6.1 Designation

All concrete supplied in accordance with this Technical Specification shall be designated as Nx/y (normal class) or Sx/y (special class) where x and y are defined as follows:

a) ‘x’ is the strength grade and characteristic strength (f'_c) of the concrete at 28 days, expressed in megapascals.

b) ‘y’ is the maximum nominal aggregate size in millimetres.

The strength grade of concrete and maximum nominal aggregate size used shall be as specified on the Drawings.

6.2 Normal class concrete

Concrete designated in the Drawings as normal class shall comply with the requirements of Clause 17.

Normal class elements (insitu or precast) will generally have a design life of less than 50 years, be situated in non-aggressive environments, or be used for temporary works.

6.3 Special class concrete

Concrete designated in the Drawings as special class shall comply with the requirements of Clauses 7 to 14 and either Clause 15 (for insitu applications) or Clause 16 (for precast applications).

The need for designating concrete as special class will be identified by the relevant design criteria.

7 Materials

7.1 General

Unless otherwise stated, all concrete shall be composed of cementitious material, fine aggregate, coarse aggregate, additives as approved, and water, proportioned and mixed as detailed in this Technical Specification. All such materials shall conform to the requirements of this Technical Specification.

The mass of all aggregates shall be measured in a saturated surface dry condition (SSD) where applicable.

7.2 Cementitious materials

Cementitious materials shall be a registered product.

Use of cementitious material shall comply with the relevant Australian Standard.

Documentary evidence of the quality of the cementitious material shall be provided by the Contractor if requested by the Administrator.

Proprietary cementitious material systems shall be assessed for approval by the Director (Structures Construction Materials) on a case-by-case basis.

7.2.1 Cement

All cement used shall comply with ATIC-SPEC SP43 and AS 3972.

The type of cement used shall be Type GP or Type GB unless otherwise designated in the Contract or approved by the Administrator.

Cement more than three months old (from date of manufacture) shall be retested for conformance.

Non-conformance

Cement shall have a maximum total alkali content (measured as Na_2O equivalent) of 0.6%. Na_2O equivalent is calculated by:

$$[Na_2O]_{eq} = [Na_2O] + 0.658[K_2O]$$

The Contractor may use the following special purpose cements as defined by AS 3972:

a) Type HE 'highly early strength'

b) Type SL 'shrinkage limited'

c) Type LH 'low heat'.

These cements may be used as a substitute for GP cement, subject to the approval of the Administrator. No additional payment shall be made where the Contactor elects to use special purpose cement where its use is not specified.

7.2.2 Fly ash

Fly ash used shall comply with ATIC-SPEC SP43 and AS/NZS 3582.1 and be Special Grade or Grade 1 as defined by the Australian Standard.

Fly ash shall have a maximum total alkali content of 3.0% (Na_2O equivalent).

7.2.3 Slag – ground granulated iron blast-furnace

Slag shall conform to ATIC-SPEC SP43 and AS 3582.2.

Slag shall have a maximum total alkali content of 1% and a maximum available alkali content of 0.5% (Na_2O equivalent).

Local availability of slag should be taken into consideration prior to specifying its use on a particular project.

7.2.4 Amorphous silica

Amorphous silica, including silica fume, shall comply with ATIC-SPEC SP43 and AS/NZS 3582.3.

Amorphous silica shall have a maximum total alkali content of 1% and a maximum available alkali content of 0.5% (Na_2O equivalent).

Amorphous silica shall not be used in bridge decks and flat slabs, in exposure classifications B2 and lower. In exposure classifications C1 and higher, amorphous silica shall only be used in bridge decks and flat slabs if suitable precautions are taken for placement and curing, with approval from the Administrator.

Note that mixes with amorphous silica tend to have less bleed and are therefore more susceptible to early age cracking.

7.2.5 Cementitious blends

Note that this clause relates to the registration of cementitious blends only and not to mix designs.

The following cementitious blends may be registered as a Type GB cement in accordance with this Technical Specification to meet durability and ASR-resistance requirements.

Table 7.2.5 – Cementitious blends (proportions)

Blend	GP Cement	Fly Ash	Slag	Amorphous Silica
Binary 1	≥ 60%	≥ 25%		
Binary 2	≥ 30%		≥ 30%	
Tertiary 1	≥ 50%	≥ 25%	≥ 20%	
Tertiary 2	≥ 60%	≥ 25%		4 – 8%

7.3 Water

All water used in concrete production shall meet the requirements of AS 1379, being clean and free from amounts of suspended material, sugars, organic matter, alkali salts or other impurities which may adversely affect the properties of the concrete or have harmful effects on the reinforcement or prestressing system or other fixtures embedded within the concrete.

Water sourced from other than a stable reticulated drinking water supply shall be tested in accordance with AS 1379. Such water shall only be used in concrete for exposure classifications B2 and below.

7.4 Chemical admixtures

Admixtures shall conform to the requirements of AS 1478 and shall be used in accordance with AS 1379. Admixtures shall be a registered product.

Admixtures other than water reducing (WR, MWR, HWR), set retarding (Re), set accelerating (Ac), air-entraining (AEA), or slump retention admixtures, or a combination of the same (for example, WRRe) shall not be used without the approval of the Director (Structures Construction Materials).

Sugar, independent from an AS 1478 complying admixture, shall not be used as a set retarding agent.

Admixtures containing calcium chloride shall not be used.

The total alkali contribution (measured as Na_2O equivalent) of all admixtures used in a mix shall not exceed 0.2 kg/m³.

Admixtures in a single mix shall be sourced from the one supplier, unless approved on the basis of satisfactory mix trials and evidence of performance.

Where air entrainment is specified, or the Contractor wishes to use an air entraining agent, the air content of the concrete used shall have a maximum value of 6%, as measured by AS 1012.4, unless otherwise specified. The Contractor shall provide an approved air content gauging device (which shall operate in accordance with the manufacturer's instructions) at the place of discharge of the concrete from the concrete agitator or on site batch plant (precast applications) so that the air content of the freshly mixed concrete may be accurately determined. In addition, the Contractor shall submit proof that the air content can be sufficiently controlled and that the compressive strength remains in compliance.

Admixtures added to concrete at the time of batching shall be accurately measured by means of a well maintained and calibrated dispenser. Admixtures added at the time of delivery shall be accurately measured and the amount recorded.

7.5 Concrete aggregate

7.5.1 General

Aggregate shall conform to AS 2758.1 unless specified otherwise. Aggregates shall be supplied by a quarry registered and operated in accordance with the Transport and Main Roads Quarry Registration System (QRS). Aggregates sourced from the following shall not be used:

a) Sedimentary rocks (for example sandstone, siltstone, mudstone, arenite, and chert).

b) Duricrust rocks (for example silcrete, ferricrete, and calcrete).

c) Naturally occurring coarse aggregate derived from (a) to (b) above.

Recycled concrete aggregates, and synthetic and slag aggregates shall also not be used.

Each type and source of aggregate shall be tested separately.

All materials shall maintain conformity and have a homogeneous appearance for the duration of the Work.

7.5.2 Fine aggregate

Fine aggregate shall consist of natural sand, or a combination of natural sand and crushed fine aggregate containing not less than 25% natural sand. Where satisfactory performance can be demonstrated in concrete mixes, for precast prestressed concrete piles, deck units and girders only, the percentage of natural sand may be wholly replaced with crushed fine aggregate.

Particles shall be clean, hard and durable and free from clay and other aggregations of fine material, soil, organic matter and other deleterious material.

The source rock for crushed fine aggregate shall comply with all the property requirements for hard rock coarse aggregates as per Table 7.5.4.

7.5.3 Coarse aggregate

Coarse aggregate shall be clean and durable, consisting of natural gravel, crushed rock, or a combination thereof.

The maximum nominal aggregate size shall be specified in the Drawings but shall not be less than 10 mm. Approval shall be sought from the Designer prior to any reduction in aggregate size from that shown on the Drawings.

For prestressed precast concrete piles, deck units and girders the maximum nominal aggregate size shall be 20 mm with no reductions permitted.

> Drawings may be project-specific drawings or in-house proprietary precast designs.
>
> A reduction in aggregate size may decrease the shear capacity of the concrete (refer to AS 5100.5 Clause 8.2.4.2) and increase creep and shrinkage.

7.5.4 Aggregate assessment – source rock

Source rock shall be tested in accordance with Table 7.5.4 and comply with the criteria listed in that table. Testing shall be conducted in accordance with Clause 8.1.1 of MRTS50 *Specific Quality System Requirements*.

Submission of these test results is not required with mix designs.

Note that the monitoring of source rock properties is handled through the quarry registration process.

Table 7.5.4 – Source rock testing applicability

Source Rock Test Property	Test Method	Hard Rock Quarry		Natural Deposit		Acceptance Criteria
		Coarse	Fine	Coarse	Fine	
Petrographic report[1]	ASTM C295	X	X	X	X	Refer QRS
Wet Strength[2]	AS 1141.22	X		X		≥ 110 kN
Wet / Dry Strength Variation[2]	AS 1141.221	X		X		≤ 35%
Weak Particles	AS 1141.32	X		X		≤ 0.5%
Water absorption[3]	AS 1141.6.1 or AS 1141.5	X	X	X	X	≤ 2.5%
Degradation factor	Q208B	X		X		≥ 50
Particle density	AS 1141.6.1	X	X	X	X	≥ 2.1, < 3.2 t/m³
Chloride content	AS 1012.20.1	X	X	X	X	Report
Sulphate content	AS 1012.20.1	X	X	X	X	Report
Deleterious fines index	AS 1141.66		X			≤ 150
Micro-Deval loss[4]	ASTM D7428		X		X	≤ 15%
Soundness	AS 1141.24	X	X	X	X	≤ 6%
Organic impurities	AS 1141.34				X	Negative
Sugar content	AS 1141.35				X	Negative
Light Particles	AS 1141.31				X	≤ 1%
Particle Size Distribution (grading)	AS 1141.11.1			X	X	Report
Material finer than 75 µm	AS 1141.12				X	≤ 5%
Material finer than 2 µm[5]	AS 1141.13				X	≤ 1%

1. Where coarse and fine aggregate are produced from the same hard rock quarry source only one petrographic report is required.

2. The wet strength and the wet/dry strength variation tests shall be carried out on the fraction from AS 13.2 mm to AS 9.5 mm. For Greenstone source material only, if the Greenstone does not comply with the maximum wet / dry strength variation limits, it may be deemed to comply if its wet strength is 160 kN or greater.

3. For aggregates with water absorption greater than the specified limit, project-specific approval may be granted by the Administrator provided that, in the opinion of the Administrator, the Contractor provides written documentation of a history of satisfactory performance of the aggregate in similar application.
4. When intended for use in concrete wearing surfaces directly trafficked by vehicles not including footpaths or cycleways.
5. Materials such as ultra fine quartz are excluded from this requirement.

7.5.4.1 Alkali-reactivity (carbonates)

Where petrographic analysis, or testing to ASTM C586, identifies aggregates containing, or suspected of containing, reactive carbonate materials, these aggregates shall be tested for alkali-carbonate reactivity using test method ASTM C1105. If the aggregate exhibits expansion of greater than 0.015% over three months, the test shall be extended to six months. If at this time the total expansion is greater than 0.025% then the aggregate shall not be used.

AS 1012.13 is deemed to contain the same sample preparation and measuring regime as ASTM C157 (referenced in C1105). For the purposes of ASTM C1105, 'moist' is defined as 95 ± 5% relative humidity.

7.5.5 Aggregate assessment – products

Individual aggregate products shall be tested in accordance with Table 7.5.4.1 and comply with the criteria in that table. Test results, not more than three months old, shall be submitted with the mix design. Refer Clause 9.2.

Table 7.5.4.1 – Product testing applicability

Property	Test Method	Hard Rock Quarry		Natural Deposit		Acceptance Criteria
		Coarse	Fine	Coarse	Fine	
Flakiness index	AS 1141.15	X		X		≤ 30%
Particle size distribution (grading)	AS 1141.11.1	X	X	X	X	As per supply agreement[1]
Deleterious fines index	AS 1141.66		X			≤ 150
Material Finer than 75 µm	AS 1141.12	X				≤ 2%
Material Finer than 75 µm	AS 1141.12		X		X	≤ 20%

[1.] Where no specific supply agreement is in place, tables B1 and B2 of AS 2758.1 shall apply.

The testing of individual samples shall be carried out in accordance with the Quarry Registration System. The frequency of testing and reporting can be agreed between the quarry and the concrete supplier, but shall be not less frequent then every three months. These records are to be available for viewing during audits of the concrete batch plant.

7.5.6 Aggregate conformance

For all aggregates the conformance with this Technical Specification shall be verified by sampling and testing in accordance with Clause 8.1.1 of MRTS50 *Specific Quality System Requirements*.

Non-conforming aggregate shall not be used in concrete manufactured to this Technical Specification.

7.6 Curing compounds

Curing compounds shall be registered products and comply with the requirements of AS 3799. For registration, the supplier shall provide a certificate of compliance and NATA-endorsed test certificate showing compliance to the Australian Standard.

Type 3 (black) compounds as per AS 3799 are not to be used.

Class C (chlorinated rubber-based compounds) as per AS 3799 are not to be used.

This certificate of compliance shall relate only to the formulation on which the tests were performed and shall be valid for not more than three years from the date of issue.

8 Storage of materials

Materials shall be stored in such a way as to prevent damage, segregation, and degradation.

8.1 Cementitious materials

Bulk cementitious materials shall only be stored in watertight silos.

Bagged cementitious materials shall be stored above ground and level in dry, weatherproof sheds and be protected from dampness which may be acquired from contact with floors or walls. Bags shall be stacked so as to allow counting, inspection and identification of each consignment.

As far as practicable, cement shall be used in order of receipt.

Cementitious materials containing lumps may be rejected irrespective of age, at the Administrator's discretion.

8.2 Aggregates

Aggregates shall not be stored in direct contact with bare earth. Aggregates shall be stored in such a manner to avoid segregation, becoming contaminated by foreign matter, or becoming intermixed. Stockpiles shall be arranged to prevent entry of adjacent surface or ground water and allow free drainage of rain water.

9 Concrete mix – design and acceptance

9.1 General

The Contractor shall be responsible for the design and production of all concrete used in the Works. The use of pre-mixed concrete shall in no way lessen or remove this responsibility.

The Contractor shall ensure that the mix design is suitable for the particular application.

9.2 Proposed mix design

The Contractor shall nominate the special class concrete mix to be used in the Works not less than four weeks prior to the commencement of concreting operations. **Milestone**

> The four weeks lead time allows for the mix to be revised if required, and mix trials conducted, if required.

A full mix design submission shall be made to the department for assessment prior to, or concurrent with, nomination of the mix to be used in the Works. Where this submission is made to Structures

Construction Materials for assessment (see Clauses 15.1 and 16.1) only the assessment certificate shall be submitted to the Administrator. Otherwise, all details shall be submitted to the Administrator.

The submission shall include the following information:

a) Mix code and version

b) intended application: insitu, precast, sprayed, extruded, piling (dry), or piling (wet)

c) strength grade of concrete

d) target strength

e) nominated slump or spread

f) name of the concrete supplier

g) location of batch plant

h) types, proportion by mass, sources, and registration numbers (ATIC and QRS) of the various constituent materials

i) test results as applicable:

   i. aggregate product test properties (refer Clause 7.5.5)

   ii. mean 28 day strength with standard deviation (refer Clause 9.3)

   iii. water retention (cast-in-place pile mixes only) (refer Clause 9.6)

   iv. chloride content of hardened concrete (refer Clause 9.8)

   v. RCPT Test Value (super-workable concrete only) (refer Clause 9.9)

Further information, for example material test certificates, may be required on a project basis.

Consideration should be given to the potential strength of the concrete mix if likely to exceed 1.4 x f'c (see Clause 12.5).

9.3 Target strength

The minimum target strength shall be calculated from the equation:

$$f'_t = f'_c + 1.65s$$

Where the terms of the equation are as defined in Table 2(b). The value of the standard deviation shall be calculated from the most recent 15 consecutive test results for that strength grade of concrete (not necessarily the nominated mix). If the calculated value of the standard deviation is:

a) less than 0.08 f'_c ,then s = 0.08 f'_c

b) greater than 0.20 f'_c, then s = 0.20 f'_c

c) between, or equal to, 0.08 f'_c and 0.20 f'_c, then s = calculated value

Where 15 test results are not available the standard deviation shall be taken as no less than 0.12 f'_c.

For example:

Let f'_c = 40 MPa

Standard deviation (15 results) = 2.4 (= 0.06 f'_c)

Since 0.06 < 0.08, s = 0.08 f'_c

$f'_t = f'_c + 1.65 (0.08 f'_c)$ = 45.3 MPa

9.4 Nominated slump and spread

The nominated slump or spread selected shall be consistent with the production of a workable mix for each section of the Works concerned. The slump or spread nominated by the Contractor for each grade of concrete used in the Works shall be a discrete value which falls within those given in Tables 9.4(a) or 9.4(b) as appropriate.

Table 9.4(a) – Permissible nominated application and slump

Application	Minimum Nominated Slump (mm)	Maximum Nominated Slump (mm)
Insitu	80	150
Precast	80	180
Cast-in-place piles (Dry)	150	180
Cast-in-place piles (Wet)	180	200
Sprayed	As per equipment requirements	
Extruded	As per equipment requirements	

Table 9.4(b) – Permissible nominated application and spread

Application	Minimum Nominated Spread (mm)	Maximum Nominated Spread (mm)
Cast-in-place piles (Wet)[1]	550	650
Precast[2]	650	700

1. Refer Clause 9.10 for additional requirements for high workability concrete for wet cast in place piles.

2. Refer Clause 9.9 for additional requirements for super-workable concrete (SWC)

Note that variations from the nominated value upon delivery are discussed in Clause 11.

9.5 Constituent materials

9.5.1 Cementitious content and maximum water-cement ratio

The minimum cementitious content and maximum water / cementitious ratio shall be as shown in Table 9.5.1(a) for the exposure classification shown on the Drawings.

Table 9.5.1(a) – Minimum cementitious content and maximum water cement ratio by exposure classification

Exposure Class	Minimum Cementitious Content (kg/m³)	Maximum Water/Cementitious Ratio
B1	330	0.50
B2	400	0.45
C1	450	0.40
C2	470	0.36

The minimum cementitious content and maximum water/cementitious ratio shall be as shown in Table 9.5.1(b) for the strength grade of the mix.

Table 9.5.1(b) – Minimum cementitious content and maximum water cement ratio by strength grade

Strength Grade (MPa)	Minimum Cementitious Content (kg/m^3)	Maximum Water/Cementitious Ratio
32	330	0.50
40	400	0.45
50	450	0.40
> 50	470	0.36

Minimum cementitious contents and maximum w / c ratios for each strength grade are presented to validate underlying assumptions in the cover-to-reinforcement tables of AS 3600 and AS 5100.

9.5.2 Combined aggregate grading

The combined aggregate grading shall be such that the concrete mix has the required workability, resistance to segregation, and resistance to bleed.

With respect to bleed, some bleed is desirable to aid finishing in flat slabs. However in other applications particularly cast-in-place piles, bleed is detrimental. The CIA Publication 'Recommended Practice – Tremie Concrete for Deep Foundations' contains guidance on aggregate proportions and test methods to manage bleed in cast-in-place piles. See also Clause 9.6.

With reference to coarse aggregate products (e.g. 20 mm graded aggregate), the product representing the maximum nominal aggregate size shall be the largest portion.

For example, an S50/20 mix will contain more '20 mm graded aggregate' than '10 mm graded aggregate'. This is to protect the Designer's assumptions when specifying an aggregate size.

9.6 Water Retention Testing

Cast-in-place pile mixes shall be such that, when tested in accordance with Appendix A.3 of CIA Z17, the filtration loss and filter cake thickness is in accordance with Table 9.6.

Test results submitted with mix design shall be less than 12 months old.

Table 9.6 – Filtration loss and filter cake thickness

Property	Dry pile	Wet pile (≤ 15 m)	Wet pile (> 15 m)
Filtration loss (l/m³) – maximum	30	30	15
Filter cake thickness (mm) – maximum	150	150	100

When assessing mix designs, Administrators may need to note the maximum pile depth for which the mix is suitable.

9.7 Specific exposure class requirements

9.7.1 Exposure Class B2 or less

Cementitious material is to be a blend compliant with any of the following options with the combined total adding to 100%. Blend tolerances to be as per AS 1379:

a) 65 to 75% GP cement, 25 to 35% fly ash

b) 50 to 55% GP cement, 20 to 25% ground granulated blast furnace slag, and 25 to 30% fly ash

c) 65 to 71% GP cement, 4 to 8% amorphous silica, and 25 to 31% fly ash, or

d) 30 to 40% GP cement, 60 to 70% ground granulated blast furnace slag.

Maximum chloride ion content of hardened concrete shall be 0.80 kg/m³ for reinforced concrete, 0.6 kg/m³ for prestressed concrete.

For batch plants in precast yards, where precise control can be demonstrated, the target proportion of fly ash may be decreased provided individual batches of concrete contain at least 20% fly ash by weight of cementitious material.

9.7.2 Exposure Class C mixes

Concrete for exposure classifications C, C1 and C2 shall meet the following requirements.

Cementitious material to be a blend compliant with any of the following options:

a) 50 to 55% GP cement, 20 to 25% ground granulated blast furnace slag, and 25 to 30% fly ash,

b) 65 to 71% GP cement, 4 to 8% amorphous silica, and 25 to 31% fly ash, or

c) 30 to 40% GP cement, 60 to 70% ground granulated blast furnace slag.

Maximum chloride content of concrete is to be 0.4 kg/m³.

There is a strong evidence to demonstrate that concrete mixes containing a ternary blend of cementitious materials and concrete mixes with high ground granulated blast furnace slag content

provide significantly enhanced durability. This is particularly critical in aggressive environments. Use of supplementary cementitious materials such as fly ash and ground granulated blast furnace slag, also significantly decreases the environmental impacts associated with cement production and also controls alkali-silica reaction (ASR).

The use of corrosion inhibiters and other alternatives to ternary blends may be considered through the department's innovation procedure. This procedure is initiated outside of existing contracts.

9.8 Chloride content testing

Chloride ion content of hardened concrete shall be determined by testing in accordance with AS 1012.20.1, on either hardened concrete or on individual components of the mix and summed by calculation in accordance with the following.

9.8.1 Testing of hardened concrete

Sampling to be in accordance with AS 1012.8.1 with a minimum sample size of 1.2 kg. Testing shall be in accordance with AS 1012.20.1 with the following conditions:

a) 2 portions (subsamples) to be tested.
    i. If either is non-conforming, a further three portions shall be tested
b) the test report shall include
    i. details as per AS 1012.20.1 Clause 9
    ii. individual chloride contents (by mass) from each sample
    iii. average chloride content (by mass)
    iv. standard deviation of chloride content (by mass)
    v. average chloride content (kg/m^3)

The average mass of acid soluble chloride ion per unit volume of hardened concrete as placed must not exceed the values given in Clause 9.7.1 or 9.7.2 of this Technical Specification as appropriate.

Tests are to be undertaken by a NATA-accredited laboratory and results submitted with the mix design.

Tests are to be repeated yearly.

9.8.2 Individual components and calculation

Testing of individual components to be in accordance with AS 1012.20.1 for aggregates, and AS 2350.2 for cementitious materials.

Total chloride content of concrete to be calculated by summing the individual chloride contents of the mix components (cementitious material, aggregates, water and admixtures) as per the quantities in the mix design.

Tests are to be repeated yearly.

9.9 Super-workable concrete (SWC)

Super-workable concrete may only be used for precast reinforced concrete, precast prestressed concrete, and special applications.

Super-workable concrete shall exhibit the following properties:

a) Nominal spread of 650 – 700 mm (see Clause 9.4)

b) time to 500 mm spread (T_{500}) of ≤ 5 s

c) Visual Stability Index of 0 or 1, and

d) Rapid Chloride Penetration Test (ASTM C1202) value of less than 1000 Coulombs at 56 days

RCPT tests conducted at any time between 28 and 56 days will provide an upper limit for the value at 56 days. RCPT test indicates whether SWC concrete performance is equivalent to conventional slump concrete with rigid forms and intense vibration.

Visual Stability Index is defined by CIA Z17 and ASTM C1611.

Super-workable concrete is a high risk product in that variations in the mix design normally considered as being insignificant may in a SWC result in the concrete not complying with the specification.

9.10 High workability concrete

High workability concrete shall only be used for cast-in-place pile concrete, and other specialised applications as approved by the Administrator, and shall meet the following requirements:

a) Nominal spread of 550 – 650 (see Clause 9.4)

b) time to final spread (T_{final}) of 4 to 11 s, and

c) Visual Stability Index of 0 or 1

9.11 Mix design acceptance

No concrete shall be placed in the Works until approval of the mix design has been obtained from the Administrator **(Refer to Hold Point 1 and Hold Point 8)**.

Approved concrete mixes shall not be varied beyond the permitted limits in Table 9.11 without the approval of the Administrator. The approved mix shall be used until approval is given for a varied mix. Any change in material sources or types constitutes a variation.

Table 9.11 – Permissible variations in mix design proportions

Component	Maximum Variation
Total cementitious	0, + 20 kg/m³
Aggregates	± 5%
Water	± 3%
Admixtures (excluding types Ac and Re)	± 20%

Notwithstanding variations, mixes must comply with stated requirements at all times.

Note that these variations relate to the design mix only. Batching tolerances remain as per AS 1379.

10 Batching, mixing and transport

10.1 General

The requirements of this section apply whether the concrete is batched and mixed on site or delivered as pre-mixed concrete. The Contractor is responsible for ensuring that these requirements are met by any concrete supplier.

The production and delivery of concrete shall be in accordance with the requirements of AS 1379 except as otherwise specified by this Technical Specification.

The procedure for batching concrete on Site shall be submitted at least 6 weeks prior to the first concrete pour. **Milestone**

10.2 Batching

Aggregates and all cementitious material shall be batched by mass. The method of delivery of the aggregate to the hopper shall be such that only a negligible amount of aggregate enters the hopper after closing off the supply. If bagged cementitious material is used then fractions of bags are not to be used.

Scales for weighing aggregates and all other materials shall be calibrated every 12 months.

Water and admixtures may be batched by mass or by volume. All mixers shall be equipped with adequate water storage tanks and an appropriate measuring device. Volumetric batching of water shall employ the use of a measuring device calibrated in 1.0 litre increments. Measuring devices for admixtures shall be calibrated with the increments not exceeding 5% of the total volume of the admixture to be measured or 20 mL whichever is the greatest.

Tolerances on specified batch components shall comply with the requirements of AS 1379 Table 4.1.

Where concrete mixes are nonconforming or there are concerns or issues with the concrete performance, batch records are to be made available for viewing at an audit.

The addition of dry components to an already mixed batch shall only be permitted under the following circumstances:

a) Concrete has not left the batch plant

b) No concrete from the batch has been discharged

c) Materials are added at the same proportions as the mix designs, and

d) Accurate records are kept of all operations.

10.3 Mixing

Concrete shall be mixed in a mixer of an appropriate type having a capacity suitable for the type of work being undertaken. The mixer drum or mixing paddles shall rotate at the speed recommended by the manufacturer. The volume of mixed concrete in the batch shall not exceed the rated capacity of the mixer.

Mixing shall continue until the materials are thoroughly blended and there are no balls of mixed or unmixed material. The minimum mixing time after all materials have entered the mixer shall be in accordance with the manufacturer's instructions for the mixer.

The entire batch of concrete shall be discharged from the mixer before any further charging of the mixer takes place.

If mixing operations cease for a period of time exceeding 45 minutes, the mixer shall be thoroughly cleaned out before subsequent batches are mixed.

Hand mixing of concrete is not permitted.

This clause applies to whenever and wherever concrete is mixed.

10.4 Transport and delivery

The timing of deliveries shall be such as to ensure an essentially continuous placing operation. If concreting operations, for a single element, exceed 12 m³ per day, the Contractor shall maintain the availability of a standby agitator truck or supply.

> For example, an additional truck over and above that required for completion of the works is required to be held in reserve.

Concrete shall be placed and compacted within the times in Table 10.4 from the discharging of the batch plant.

Table 10.4 – Placement and Transport Time Limits

Temperature of Concrete	Time Limit
< 32 °C	60 minutes
32 – 35 °C	45 minutes
> 35 °C	Reject load

These times may be extended at the Administrator's discretion where set-retarding admixtures are used and a trial mix has been conducted (refer to Clause 10.4.1).

Water shall not be added to offset long travel or wait times under any circumstances.

A manufacturer's certificate in the form of a delivery docket in accordance with AS 1379 shall be supplied for each batch and shall be retained by the Contractor. Such certificates shall be available to the Administrator on request and shall show the total water in the mix as supplied. Total water includes free water in the aggregates, mix water, slump stand water and any ice added.

10.4.1 Long distance travel and extended placement times

Where travel or placement times are, by necessity, longer than those listed in Table 10.4 a procedure for long-distance travel or extended placement times shall be submitted to the Administrator for approval 6 weeks before concreting begins. **Milestone**

> Note that construction procedures for insitu concrete are assessed as part of Hold Point 4.
>
> Technical Note 125 provides further guidance on procedures for long distance travel.

This procedure shall include one or more of the following options:

a) for up to 90 minutes, the use of a set retarding admixture, added at the batch plant

b) for up to 120 minutes, the use of a set retarding admixture at batch plant and high range water reducing admixture at site, and

c) the use of a high range water reducing admixture and hydration stabiliser at batch plant and an activating admixture at site.

Note that additional safety considerations are applicable when adding admixtures to agitators on site.

Transporting dry cementitious material and aggregates together to site and then adding water is not permitted. As per Clause 11.2, water may not be added to increase workability if 45 minutes has elapsed from batching.

11 Acceptance and rejection of plastic concrete

The consistency and workability of concrete shall be such that it can be handled and transported without segregation and can be placed, worked and compacted into all corners, angles and narrow sections of forms, and around all reinforcement.

The consistency of concrete of each batch shall be checked by means of the slump or spread test. Sampling shall be carried out in accordance with AS 1012.1 and testing by AS 1012.3.1 or AS 1012.3.5. Sampling and testing shall be conducted by a NATA-accredited laboratory and reported as a NATA-endorsed test report.

The plastic material properties shall lie within the range established using the approved nominated value and the tolerances specified in Table 11(a) and Table 11(b).

Where the first test falls outside tolerance, an immediate single repeat test for slump or spread, as per AS 1379 Clause 5.2.4 shall be permitted with the results of both tests recorded and reported.

Table 11(a) – Tolerances for consistency test (slump)

Nominated Slump (mm)	Tolerance (mm)
< 60	± 10
≥ 60, ≤ 80	± 15
> 80, ≤ 110	± 20
> 110, ≤ 150	± 30
> 150, ≤ 180	± 40

Table 11(b) – Tolerances for consistency test (spread)

Nominated Spread (mm)	Tolerance (mm)	Visual Stability Index	T_{500} (s)	T_{final} (s)
550 – 650 (HWC)	± 80	0 or 1	–	4 – 11
650 – 700 (SWC)	± 50	0 or 1	≤ 5	–

Note that tolerances do not guarantee similar performance, and changes to procedures may be required to cater for reduced workability. For example, concrete slumping at lower values may require additional compaction.

11.1 Rejection of plastic concrete

Before any concrete is placed in the Works it shall be visually checked and shall be rejected if it is defective in any of the following ways: **Non-conformance**

a) The slump is outside the limits specified in Table 11(a), noting Clauses 11.2 to 11.4, or

b) The spread, VSI, T_{500} or T_{final} is outside the limits specified in Table 11(b), noting Clauses 11.2 to 11.4, or

c) The appearance, colour or cohesiveness of the batch is significantly different from other batches of the same mix, or

d) The concrete contains significant lumps of unmixed material that are unresponsive to further mixing.

If load be rejected due to differences between batches, a visual record should be kept. A significant difference will be one that is immediately obvious to all present on site at the time of delivery.

11.2 Slump or spread below tolerance

If the slump or spread is below the tolerance range, or workability needs to be increased within the tolerance range, it is permitted to add water to the mix to bring the slump or spread within specification, provided:

a) the maximum water available to be added has been listed on the concrete delivery docket or batch record

b) the amount of water added does not exceed 10 litres per m^3

c) the added water is recorded on the delivery docket

d) the design water / cementitious ratio is not exceeded

e) the load is remixed in accordance with AS 1379

f) only a single sample has been taken previously, and

g) the elapsed time from the time of batching does not exceed 45 minutes.

Calculation of water / cement ratio of remaining concrete is impossible without an accurate measurement of amount of discharged concrete. For this reason only a single addition of water and a second slump sample is allowed.

If the addition of 10 L/m^3 of water on site is not effective then this would indicate that batching control should be checked or the mix redesigned.

11.3 Slump, or spread, above tolerance

If the slump or spread initially tests above the tolerance range, the concrete may be accepted provided:

a) a retest falls within the tolerated range

b) the placement time limits are not exceeded (refer to Clause 10.4)

c) a new sample is taken prior to each test

d) the concrete is remixed between samples in accordance with AS 1379, and

e) the results of all tests are recorded.

The addition of more dry concrete mix components to decrease slump or spread is not permitted after any concrete has been discharged (see Clause 10.2).

Note that there is no limit on the number of retests allowed for over slumping concrete, but time limits may come into play (see Clause 10.4).

11.4 Addition of admixtures

Alternatively to the requirements of Clause 11.2 additional admixtures may be added to concrete with insufficient slump subject to:

a) the maximum admixture dose listed on the mix design is not exceeded

b) the load is remixed in accordance with AS 1379

c) the required slump, or spread, is achieved upon a second test, and

d) the elapsed time from the time of batching does not exceed 45 minutes

11.5 Reduced rates of testing

Where approval for reduced rates of testing for compressive strength has been granted (see Clauses 15.2 and 16.2), the rate of testing for slump shall be reduced to the same frequency. For super-workable or high workability mixes, spread testing shall be undertaken on each load or batch.

For super-workable concrete batched at precast yards where appropriate batching control is used and approval for reduced levels of testing have been granted, testing frequencies may be reduced to one test per 5 m^3 plus each of the first three batches of the day.

If any slump or spread test falls outside tolerance, then each subsequent batch shall be tested. Reduced rates of testing shall be restored once three consecutive batches have been tested and are conforming.

12 Acceptance and rejection of hardened concrete

General requirements for testing and acceptance of concrete are listed in the following clauses. More specific requirements are listed in Clauses 15 and 16.

Testing of slip formed median barrier shall be in accordance with AS 1379 Project Assessment.

12.1 General

All concrete used in the Works shall be subject to sampling and testing in accordance with the provisions of AS 1012, along with the additional requirements detailed in this Technical Specification.

12.2 Sampling

A sample for compression testing shall be cast as cylinders in purpose-made moulds according to AS 1012.8, and identified as a set. This set is to be linked to the batch and location it represents.

All specimens shall be manufactured and tested by a NATA-accredited laboratory.

12.3 Acceptance testing of specimen cylinders

Acceptance of hardened concrete is to be based on the results of compression testing, performed in accordance with AS 1012.9. This testing, including early strength testing, shall only be performed at a NATA-accredited laboratory and departmental registered supplier, and shall be reported to the Administrator as a NATA-endorsed report. All equipment used in testing shall be calibrated as per NATA requirements.

The corresponding sample strengths, when two or more cylinders are crushed at the same age, shall also be submitted to the Administrator.

Therefore, the Administrator will receive:

a) individual cylinder (specimen) results on a NATA-endorsed test report, and

b) calculated strength (sample) results.

Note that the reporting of strength (sample) results is beyond the scope of AS 1012.9 and therefore is the Contractor's responsibility.

A minimum of two cylinders from each sample shall be tested at 28 days. For any early age testing (less than 28 days), including transfer strength testing for prestressed precast concrete, a minimum of one cylinder per sample shall be tested and all sample results shall exceed the early age strength requirements.

In addition to the recording requirements of AS 1012.9, it is strongly recommended that the mass and density of cylinders be recorded for investigative purposes should cylinders not produce expected results.

The test strength of a sample (of more than one cylinder) at a certain age shall be calculated as follows:

a) List the results of all cylinders in the sample tested at that age in descending order

b) Exclude any result that can be attributed to an obvious defect in the cylinder or testing activity

c) Exclude the lowest result if it differs by more than 2 MPa (for two cylinders) or 3 MPa (for three or more cylinders) from the highest result

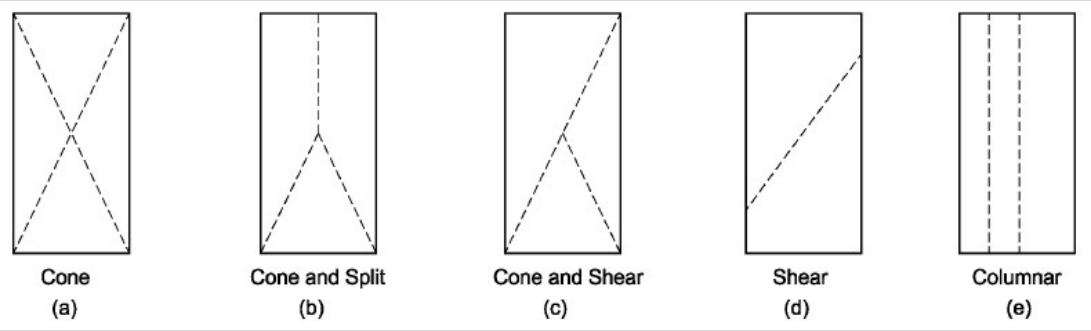
d) Average the results of the remaining cylinders.

In the case when the cylinder results differ by more than 10% of the highest value, this shall be reported to the Administrator along with the cylinder history and condition, including the fracture pattern.

For comparison this is a modified version of the description in AS 1379 Clause 6.2.5.2.

Note that no extra cylinders are required to replace the excluded values, but all cylinder results need to be reported.

As an example, ASTM C39 categorises fracture patterns according to the following illustration.



Source: ASTM C39

With Designer and Administrator approval, testing at ages greater than 28 days may be used for acceptance testing. Approval must be sought prior to concrete being placed.

This would usually only be suitable for mixes with high ash or slag content when either:

- further construction or loading is not required until later-age testing is completed, or
- concrete grade is selected for durability and not strength.

12.4 Monitoring of concrete strength

The compressive strength of the concrete shall be monitored, and trends observed. Where a significant amount of concrete is to be placed in a four-week period, monitoring shall include early age testing (typically seven days) and a comparison of cylinder strengths with previously measured strength gain results.

For each insitu concrete mix, where 10 or more samples have been tested, the Contractor shall provide a monthly report covering the concrete supplied in that month confirming the concrete lies within the limits of Table 12.4.

Table 12.4 – Long-term monitoring of concrete (insitu only)

Measure	Limit
Standard deviation	≤ 1.29 x nominated standard deviation
Average 28 day strength	≥ 0.5 ($f'_c + f'_t$)

Where the concrete performance lies outside these limits, the Contractor shall provide the raw data and a trend graph showing seven day (if available) and 28 day strengths. If the Administrator determines that control of concrete performance is not being maintained, approval of the mix design shall be withdrawn.

Note that an increase in the standard deviation by a factor of 1.29 reduces the confidence of exceeding the characteristic strength from 95 to 90%.

12.5 Acceptance or rejection of hardened concrete on the basis of strength

Subject to the concrete meeting all requirements set out in this specification, it shall be accepted or rejected on a statistical basis using the results of 28 day tests as set out below.

An example format for tracking these statistics is provided as Appendix A.

Concrete in a lot shall be deemed rejected if any of the following apply:

a) Any sample strength is less than 0.9 times the specified characteristic strength, f'_c.

b) The average strength of three consecutive samples is less than the specified characteristic strength.

c) The average 28 day strength of three consecutive samples from the lot is greater than 1.4 times f'_c, without prior Administrator and Designer approval. The following applications are exempt from this requirement:

   i. precast concrete

   ii. extruded concrete

   iii. cast-in-place piling.

The aim of criterion (c) is to ensure that if higher strengths than expected are being achieved or are likely, the Designer has confirmed that there are no adverse effects from the use of a higher strength concrete than that assumed in the design. This should be confirmed before concrete is placed.

It would be unusual for this criterion to be used to reject concrete.

13 Environmental limits for concreting operations

13.1 Temperature limits

No concrete shall be placed in the Works if:

a) the temperature of the concrete is less than 10 °C or exceeds 35 °C, or

b) based on temperature recording at the Site for three days prior to the proposed pour and the forecast by the Bureau of Meteorology, the ambient air temperature is likely to be greater than 45 °C during placement or within two hours subsequent to placement; or

c) the temperature of the formwork or reinforcement exceeds 55 °C

If the ambient air temperature measured at the point of placement is likely to exceed 35 °C, noting an absolute maximum of 45 °C, during placing and finishing operations, the Contractor shall take practical precautions, approved by the Administrator, to ensure that the temperature of the concrete does not exceed the permitted maximum. These precautions shall be submitted as a procedure for hot weather concreting at least two weeks prior to the first concrete pour. **Milestone**

Special attention shall be paid to providing early curing for hot weather concreting operations.

Additional temperature control of the concrete, prior to placement, to achieve the limits specified in Clauses 15.5, 16.4, and 16.7.4 may be required.

13.2 Evaporation Limits

13.2.1 General

When the predicted evaporation rate during the intended period of placement and finishing exceeds 0.75 kg/m²/h, measures shall be taken to reduce the predicted evaporation to below this value.

The forecast evaporation rate shall be estimated by the specified method (refer to Clause 13.2.3) using the latest available data for the area from the Bureau of Meteorology. This information shall be obtained on the proposed day of construction before work commences.

The evaporation rate shall be monitored by the Contractor during concreting operations until such time as curing commences.

If control measures are not successful or are impractical, no concrete shall be poured.

> For example, control measures include addition of chilled water or ice to the concrete, barriers against wind and sun, and pouring in cooler parts of the day.

13.2.2 Application of evaporation retarding compound

The use of a registered evaporation retarding compound on the top surface of the concrete is mandatory for all concrete works. It shall be applied within 10 minutes of placement and initial screeding, and any subsequent screeding or finishing.

Application shall be made in accordance with the manufacturer's instructions. Compounds shall consist primarily of aliphatic alcohol suitable for use on concrete.

Evaporative retarders do not replace curing compounds.

13.2.3 Method for calculation of evaporation rates

The evaporation rate shall be calculated using the following parameters:

a) air temperature

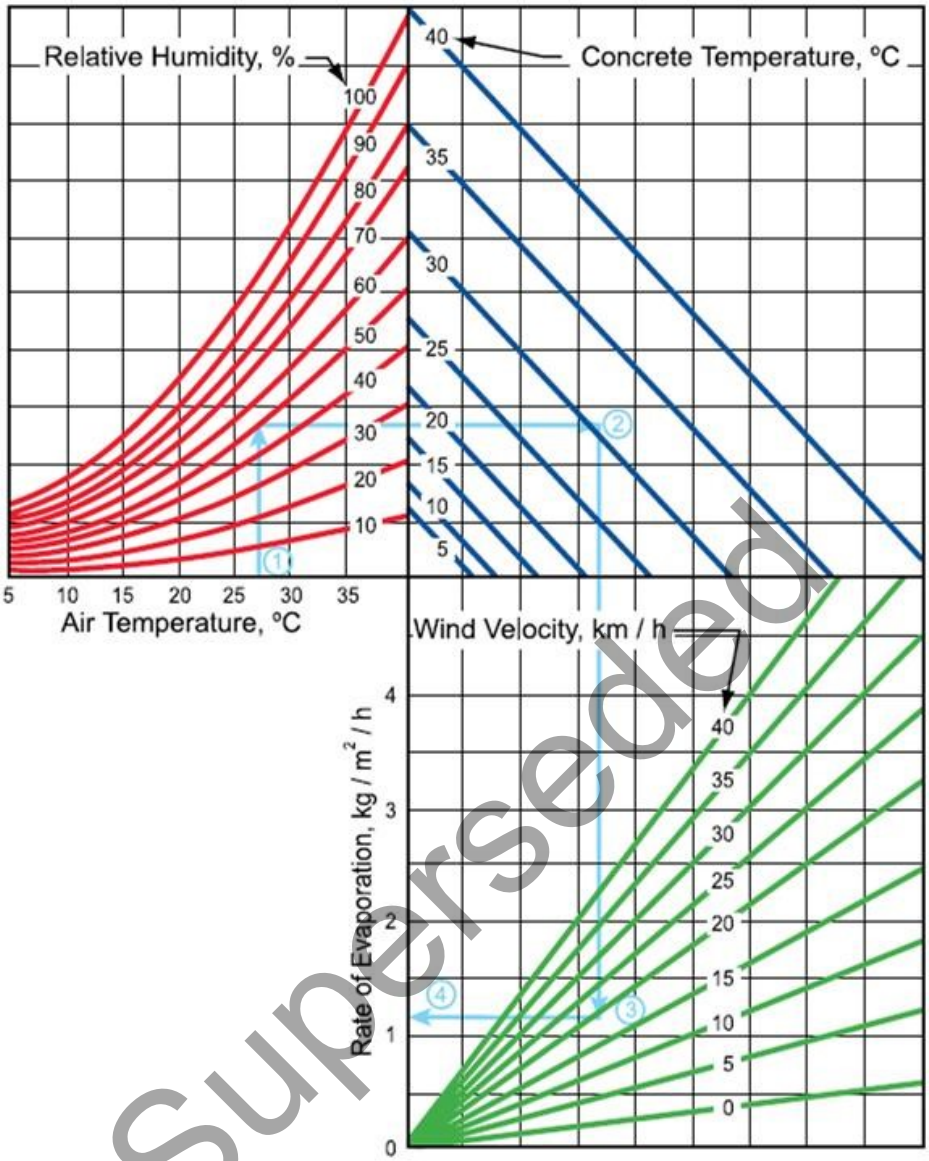
b) relative humidity

c) concrete temperature, and

d) wind velocity.

Figure 13.2.3 is to be used for estimating the evaporation of surface moisture from the concrete for various weather conditions as represented by the above information.

Figure 13.2.3 – Chart for estimation of water evaporation rate



Source: 'Q&A' Concrete International, March 2007 (ACI)

13.3 Protection from rain

Concrete shall not be poured in the rain or if rain is imminent unless adequate measures are taken to protect the plastic concrete from the falling rain. Protection is defined as a waterproof covering which protects all exposed surfaces of the concrete.

For example, suitable protection includes tarpaulins or roofing.

All water shall be removed from the form before concrete is poured.

Concrete which is exposed to significant rain from the time of commencement of placement to the commencement of curing shall be rejected. **Non-conformance**

For example, the effects of significant rainfall may include:

- increased workability
- ponding of water
- disturbance (cratering) of concrete surface

14 Defects and rectification

Where concrete does not comply with the requirements listed in this Technical Specification, the following options are permitted, at the discretion of the Administrator:

a) the concrete, and any portion of the structure built on the non-conforming lot, shall be removed and replaced with conforming concrete, or

b) the non-conforming concrete, and any product containing that concrete, shall be replaced, or

c) the non-conforming concrete may remain in place and additional works, approved by the Administrator, shall be undertaken to achieve adequate strength and durability.

This work shall be at the Contractor's expense.

The method of rectification shall be approved by the Administrator.

For example, cracks in concrete are undesirable, and indicative of non-conformance to this Specification (see Clauses 15.10.2 and 16.6.2). The acceptability of cracks with, or without, rectification will be dependent on crack size, type and extent, and the concrete structure and environment. Structural cracks should be referred to the Designer. Other Specifications may have precise acceptance criteria.

15 Requirements for insitu concrete

This clause applies to mass and reinforced concrete poured insitu including cast-in-place piles.

15.1 Mix designs

Mix designs for insitu concrete shall be as per Clause 9, with additional requirements for mix acceptance as follows.

No concrete shall be placed in the Works until approval of the mix design has been obtained from the Administrator. **Hold Point 1**

For established pre-mix batch plants, with a proven track record and supplying concrete to multiple Transport and Main Roads projects, an application for mix designs assessment may be made direct to Structures Construction Materials (See Clause 1.1). Evidence of this assessment shall then be submitted to the Administrator in lieu of full mix design details.

15.1.1 Trial mixes

When requested by the Administrator, and where extensive performance data is not available, mix design acceptance will be on the basis of trial mixes. Concrete intended for long distance or extended placement time use (see Clause 10.4.1) shall be trialled.

'Extensive performance data' refers to test results for the proposed or similar mixes over a recent timeframe of at least one month. Individual test reports are not expected.

Trial mixes shall be made using the plant and degree of quality control proposed for the Works. The minimum volume of the trial mix shall be 25% of the rated capacity of the mixer. Each trial mix shall be a witness point with a notice period of three days. **Witness Point 1**

Note that higher volumes of trial mix may be required depending on the range of testing to be conducted.

Trial mixes shall be batched using the nominated (design) value for the water / cement ratio.

Each trial mix shall be tested for slump or spread, and strength.

The trial mix shall be batched and delivered in a manner as per the anticipated final procedures used, including any admixtures added on site. Where concrete is not batched and mixed on the site, a time delay equal to an average delivery time on site shall be applied between the mixing of the concrete and the sampling for slump or spread and cylinder tests.

The slump or spread measured shall be within tolerance (see Tables 11(a) and 11(b)) of the nominated slump or slump. At least four cylinders shall be cast from each trial mix for compressive strength testing at 28 days. Additional cylinders (a minimum of three per age) shall be required if strength gain is to be assessed for early stripping or loading.

The Administrator may give provisional approval of a mix based on early testing, provided the mean compressive strength of at least three trial cylinders tested at seven days is not less than 0.8 of the specified characteristic strength. Notwithstanding any such provisional approval, all the concrete shall meet 28 day strength requirements.

15.1.1.1 Trials for extended placement times

Trial mixes for long distance travel and extended placement times shall emulate the estimated travel time. In addition to the requirements of Clause 15.1.1, the trial mix shall be tested, at intervals nominated by the Administrator, for:

a) Workability retention (slump, or spread, as measured by AS 1012.3)

b) Extent of reaction (concrete temperature).

Cylinders for strength testing shall be cast from the final sample drawn from the batch.

For example, samples could be taken at 0, 30, 60, 90 and 120 minutes from time of batching

15.1.2 Trial mix – conformance

The trial mix, the plant and the degree of quality control for the Works shall be approved if the:

a) 28 day sample strength equals or exceeds 0.5 ($f'_c + f'_t$)

b) slump or spread falls within the tolerances in Tables 11(a) or Table 11(b)

c) materials within the mix meet the requirements of this Technical Specification

d) batch records indicate conformance with AS 1379 Clause 4.2.1 (batching tolerances)

e) mix design submission meets the requirements of Clause 9.2, and

f) for trials of extended placement times:

   i. The slump, or spread, is maintained within the acceptable tolerance limits for the entire nominated time frame, and

   ii. no increase in temperature other than expected due to ambient conditions is noted.

Approval of the trial mix does not relieve the concrete supplier of the responsibility to maintain the performance of the concrete mix.

15.2 Testing procedures (compressive strength)

Sampling of concrete for insitu work shall be undertaken in accordance with this clause. Testing and acceptance of acceptance of concrete shall be in accordance with Clause 12.

15.2.1 General

Samples for compression strength testing, shall be taken from separate batches of concrete during the placing operation. Two cylinders (minimum) shall be cast from each sample. Samples shall be taken in accordance with AS 1012.1 with records kept as per Clause 9 of that Standard.

Standard testing

The normal rate of sampling per lot is defined in Table 15.2.2. For the purposes of determining rate of sampling, a lot shall not extend longer than 24 hours. Sampled batches shall be evenly distributed through the lot.

Table 15.2.2 – Sampling frequencies per lot for 28 day strength tests

Total Number of Batches in Lot (n)	Number of Samples
1 – 3	Every Batch
4 – 10	4
11 – 23	5
> 23	¼

Where sampling, testing and assessment of concrete is carried out in accordance with AS 1379, and AS 1012, and 10 samples of a concrete mix have been tested and are conforming, the Contractor may:

a) seek approval to move to a reduced level of testing, and

b) nominate the level of testing which shall not be less than half the normal level.

Samples shall be taken based on estimated number of batches in the lot.

For example, in a lot of 15 batches the following batches would be sampled: 1, 3, 6, 9, 12 and 15

15.2.1.1 Initial testing

Where the information supplied as part of the mix design does not permit determination of standard deviation, based on previous field testing for each grade of concrete, the frequency of initial sampling shall be increased above that shown in Table 15.2.2. The actual increase in initial sampling shall be at the Administrator's discretion (with Hold Point 1 approval).

Note that this requirement relates to concrete pours with more than four batches of concrete.

15.2.2 Curing of specimen cylinders

Cylinders shall not be moved for a period of 18 hours after casting. Specimens shall be handled with care, transported to the testing laboratory without bumping or vibrating, and placed in standard curing conditions within 36 hours, in accordance with AS 1012.8.1.

The specimen cylinders shall be cured in accordance with AS 1012.8.1. Where cylinders are temporarily stored at the Site of the Works they shall be stored in lime-saturated water at a temperature as close as practical to 27°C.

15.2.3 Early stripping and / or loading

Any proposal by the Contractor for early removal of forms or for early application of significant loads to the structure shall be submitted in writing to the Administrator prior to placing concrete (refer to Clauses 15.8 and 15.9). The Administrator shall then determine the number of additional cylinders required for early testing with advice from the Designer.

15.2.4 Further construction prior to 28 day testing

If concrete is to be placed over or adjacent to and connected with a previous section prior to 28 day testing and acceptance, additional sampling and early age testing shall be undertaken.

15.3 Falsework

Falsework shall conform to AS 3610, except as otherwise required by this Technical Specification.

The design and erection of falsework, the method of founding or supporting the falsework and the time, order and manner of its release shall all require approval of the Administrator. **Hold Point 2** The Contractor shall supply the Administrator with detailed drawings of such falsework at least four weeks prior to the commencement of erection. **Milestone** The provision of such drawings and release of the hold point by the Administrator shall in no way relieve the Contractor of any responsibility for the satisfactory performance of the falsework.

Subject to the Administrator's approval, falsework may be supported on completed sections of the Works provided that the construction loads imposed thereon do not result in over-stressing or instability and that due allowance is made for any deflection of the supporting sections.

The Contractor shall undertake structural strengthening or modification of such sections necessary for their use as support structures.

The Administrator's approval of the use of completed sections of the Works as support structures for falsework shall in no way relieve the Contractor of any responsibility for the restoration or repair of any resulting damage caused by such use.

15.4 Formwork, bar chairs and spacers

15.4.1 Formwork

All formwork shall be subject to inspection and approval by the Administrator. **Hold Point 3**

Any proposal to use completed sections of the Works to fix formwork in place shall be submitted as part of this hold point. Any repairs or restorations required by this activity shall be the responsibility of the Contractor and shall be of a standard equivalent to the existing works.

Formwork shall conform to AS 3610 except as otherwise required by this Technical Specification. Formwork shall provide a Class 2 AS 3610 surface finish, except as otherwise specified. All forms shall be surface smooth, mortar tight and have sufficient rigidity to maintain the tolerances specified when subjected to fresh concrete and other construction loads.

All forms shall be set and maintained to line and level such that the finished concrete shall conform within the specified dimensional tolerances, and to the proper dimensions and contours as shown in the Drawings.

All forms shall be cleaned and coated with the lightest practical coating of release agent prior to pour. Reinforcing steel and construction joints shall not be contaminated with release agent.

Forms for plane exposed surfaces shall consist of plastic coated plywood, waterproof plywood, timber lined with tempered hardboard or close-fitting unwarped metal forms. Unless otherwise specified, joints in the form sheeting for plane, exposed concrete surfaces shall be either vertical or horizontal and spaced with a regular pattern.

Forms for surfaces not exposed to general view may consist of modular timber or metal panels. Timber forms shall be constructed and maintained in such a manner as to prevent warping and opening of joints due to shrinkage of the timber. The timber shall be free of any defects which shall affect the structure.

Where rigid forms are specified on the Drawings, only metal forms are acceptable.

In firm ground, buried reinforced concrete members shown with formed surfaces may be constructed without the use of back forms but, in this case, the specified cover shall be increased by no less than 25 mm, and no more than 50 mm. The increase in cover and member dimensions shall be nominated with tolerances applying to the nominated values. The increase in volume of concrete shall be at no cost to the Principal.

Where a hole or void in the concrete is shown on the Drawing the formwork or void former shall be removed after casting. Permanent hole formers are not accepted unless shown on the Drawing.

Unless otherwise shown in the Drawings, all corners shall be provided with 15 mm x 15 mm chamfers or fillets of an equivalent radius.

Where access is otherwise extremely difficult, openings shall be provided in the forms to facilitate cleaning operations and to allow proper inspection and ease of placement of concrete. Closure and sealing of these openings shall be effected in a manner which prevents mortar loss and results in minimal interference to the surface smoothness of the forms.

Cast-in metal form ties shall be of a type which permits removal of the end fittings to a depth of at least 40 mm below the finished surface of the concrete. Wire ties, not cast into the concrete, shall not be used. Form ties shall be located in a uniform symmetrical pattern relative to the finished surface. The cavities left when the end fittings of embedded ties are removed shall be as small as possible and shall be filled with cement mortar at the earliest possible time. The surface of such filled cavities shall be left smooth and uniform in colour.

When forms are re-used, their original shape, strength, rigidity, mortar tightness and surface smoothness shall be maintained. Forms which become unsatisfactory shall not be used.

15.4.2 Supports (bar chairs and spacers)

All bar chairs and spacers shall comply with AS/NZS 2425 and be a registered product.

Bar chair materials to be as per Clauses 15.4.2.1, 15.4.2.2, and 15.4.2.3 dependant on location. Plastic bar chairs or spacers shall not be used, except in the case of piles (see MRTS63 *Cast-In-Place Piles* and MRTS63A *Piles for Ancillary Structures*).

Supports shall be placed sufficiently close together to ensure that the specified cover is maintained before and during concrete placement and to prevent any potential crushing of the spacers or penetration into the formwork. Long continuous linear runs of supports shall be avoided; each individual length of support shall be laterally offset from its adjacent support by at least 200 mm so as to avoid the potential to induce linear cracking in the concrete. The maximum length of any one support shall be 330 mm.

Concrete supports shall be extruded fibre concrete or conventional concrete manufactured under factory controlled conditions. The minimum concrete strength shall be 60 MPa and the product shall have a maximum RCPT value of 1000 coulombs at 56 days.

The fibres used in extruded fibre concrete bar chairs shall be non-metallic, synthetic fibres. Asbestos or similar fibres based on naturally occurring silicate minerals shall not be used.

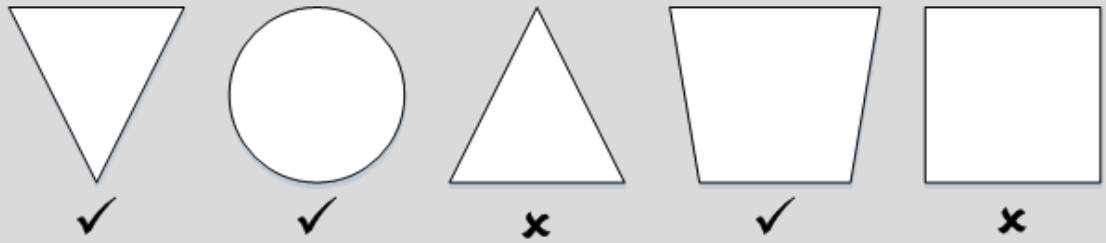
15.4.2.1 Cover to formwork

Where supports are used to distance reinforcement from formwork, the support shall be manufactured from concrete or stainless steel.

Where supports are required to be attached to the reinforcement, such attachment may be via clips or steel wires provided that no part of the wire or clip is located within three quarters of the required cover depth from the surface of the concrete. If stainless steel or galvanised wire or clips are used they must be located at a depth of no less than half the specified cover from the concrete surface.

Supports used to provide cover to the soffit formwork shall either be attached to the reinforcement or shaped to positively interlock into the concrete.

For example, the acceptability of support cross-sections would be as follows (soffit downwards):



Stainless steel nibs are to be manufactured from a material compliant with MRTS71A *Stainless Steel Reinforcing* and welded to the reinforcing complying with the locational tack weld requirements of MRTS71 *Reinforcing Steel*.

15.4.2.2 Cover to concrete

Where supports are used to distance reinforcement from existing concrete such as a construction joint, or cast insitu decks on top of deck units or girders, but excluding blinding concrete, the following support types may be used:

a) concrete spacers,

b) stainless steel nibs, or

c) plastic-tipped wire chairs.

15.4.2.3 Spacing of reinforcement

Where supports are used to distance reinforcement from reinforcement (that is, between two layers of mesh), steel frames may be used. These frames shall be placed so as not to be directly above other spacers.

15.5 Concrete temperatures

Concrete shall be managed to ensure that at no stage does the concrete temperature exceed 75°C or the difference in temperature between two locations exceed 25°C. If these limits are exceeded, appropriate rectification or rejection of the element shall occur, and additional precautions enacted. **Non-conformance**

Internal temperatures above 75°C can cause delayed ettringite formation reducing the durability of the concrete. Excessive differentials can cause thermal cracking.

Monitoring shall be in accordance with Clauses 15.5.1and 15.5.2, as required, with temperatures recorded from placement for 120 h (five days) or until the core temperature has decreased to 50°C. Elements not meeting the criteria of either clause do not need to be monitored.

The Contractor shall submit a procedure and plan for monitoring and procedures for ensuring compliance to this clause to the Administrator for approval at least four weeks prior to the concrete pour. **Milestone** The maximum interval between readings shall be 15 minutes. This plan shall be approved by the Administrator before concrete is placed **(refer to Hold Point 5)**

A record of the monitoring results shall be submitted to the Administrator within 48 hours of the completion of the monitoring.

Precautions to reduce concrete temperatures may include:

- Redesign of the concrete mix
- Reducing the concrete temperature at the time of placement
- Insulating the formwork to reduce temperature differentials
- Other measures as approved by the Administrator

15.5.1 High cementitious contents

For elements manufactured with a concrete mix containing 520 kg/m³ of cementitious material or more, the following location shall be monitored for temperature:

a) one at the geometric centre

For elements with concave sections, the geometric centre shall be determined as the point furthest from the formwork.

15.5.2 Large elements

For elements with a cross sectional area exceeding 1 m x 1 m square, or 1 m diameter, the following locations, at a minimum, shall be monitored for temperature:

a) one at the geometric centre

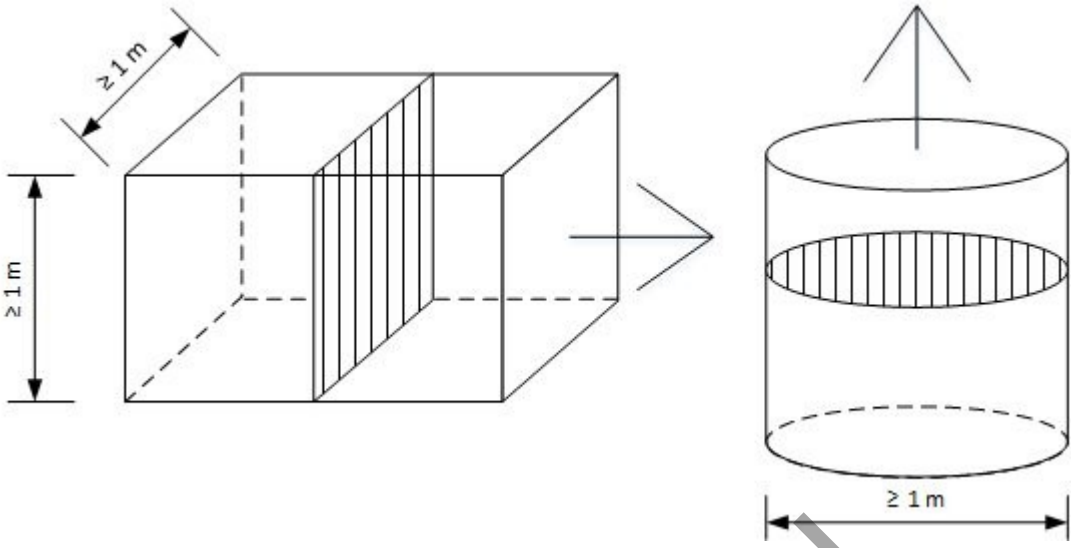
b) one at an upper corner

c) two at centres of side faces.

Surface temperatures (b and c above) shall be measured at the depth of reinforcement.

For the purposes of this clause the cross section is defined as the plane perpendicular to the longitudinal direction (longest dimension).

Figure 15.5.2 – Element cross-sections



15.6 Placing and compacting concrete

Concrete operations shall not commence until all relevant procedures, listed in Table 5.2 have been approved by the Administrator. **Hold Point 4**

15.6.1 General

No concrete shall be placed in the Works until: **Hold Point 5**

a) the formwork and reinforcement have been inspected

b) all foreign material has been completely removed from the forms

c) the mixing, batching, and compaction equipment have been approved by the Administrator.

The Administrator may exclude (a) and (b) above from the Hold Point, reverting it to a Witness Point.

The placing operation shall be conducted in the presence of the Administrator **Witness Point 2** and the Contractor shall give at least 24 hours notice to the Administrator of the time that placing shall start.

Except as provided for in Clause 15.6.3, all concrete shall be placed under dry conditions, all pools of water shall be removed and no inflow of water shall be permitted.

Concreting operations shall be carried out in a continuous manner between the construction joints shown in the Drawings. Fresh concrete shall not be placed against concrete which has taken its initial set. Initial set is defined for this purpose only as the concrete surface not being able to be easily penetrated with a 12 mm bar.

If an interruption to pouring greater than 45 minutes, or initial set has occurred, a construction joint approved by the Administrator shall be placed, or the laid concrete shall be rejected.

Chutes, if used, shall be arranged in a manner which avoids segregation of the concrete. Apart from an initial flushing immediately prior to commencement of concreting, the use of water in chutes to assist movement of concrete shall not be permitted.

Pneumatic placers and concrete pumps may be used only when a concrete mix designed for such placing is approved for use by the Administrator. The equipment shall be positioned such that freshly placed concrete is not damaged by vibration. The initial discharge containing the cement slurry used to coat the pipe line shall be discarded.

Buckets shall have the capability of a controlled rate of discharge. Concrete shall not be allowed to free fall from a height exceeding 2 m, nor shall it be placed in any other manner which results in segregation or loss of mortar or damage to formwork or reinforcement.

If placing operations necessitate a drop of more than 2 m, the concrete shall be placed using a flexible tube reaching to the base of the formwork or another method approved by the Administrator.

Cast-in-place piles shall be placed by means of tremie as per MRTS63 *Cast-In-Place Piles*, direct placement by means of pump is not permitted.

Fresh concrete shall be deposited within the forms as near as possible to its final location. Excessive use of vibrators and tamping rods to move the concrete along the forms shall not be permitted.

Formwork shall not be disturbed or adjusted during the concreting operation and shall remain undisturbed up to the minimum removal time specified in Clause 15.8. No strain shall be placed on any projecting reinforcing steel for a period of at least 12 hours following completion of concreting.

Where reinforced concrete is placed on earth, sand or rock foundations, the earth or sand shall be compacted to 95% Relative Compaction as determined by Test Method Q140A and the rock freed of loose material. Where shown in the Drawings the foundation shall be covered with a layer of blinding concrete. The maximum thickness of unreinforced blinding concrete shall be 100 mm unless otherwise approved.

Where concrete work is constructed on ground surfaces or on a foundation bedding, a polythene sheet separator of thickness not less than 100 µm shall be employed between the ground/bedding and the concrete. The separator shall extend not less than 300 mm beyond the concrete work. Care shall be taken to avoid puncturing or tearing the separator. If puncturing or tearing occurs, the damage shall be repaired prior to concreting. Joints in the separator shall be made by overlapping the sheets a minimum of 300 mm or by overlapping and taping.

15.6.2 Compaction of concrete (excluding cast-in-place piles)

Unless otherwise approved by the Administrator, concrete shall be deposited in horizontal layers not more than 400 mm thick.

Compaction of concrete shall commence immediately after deposition. Compaction shall be achieved by use of high frequency internal vibrators supplemented as required by external form vibrators. Where intense compaction is specified the use of external form vibrators is mandatory. The amount and type of vibration used shall be approved by the Administrator.

The following conditions shall apply when using internal vibrators:

a) The vibrators shall be capable of transmitting vibrations at a frequency not less than 150 Hz with an intensity which shall visibly affect the concrete at a radius of 300 mm.

b) The number of vibrators to be used by the Contractor shall be not less than one for each 10 m^3 of concrete placed per hour, with a minimum of two vibrators to be provided at any time.

c) Vibrators shall be inserted vertically at successive positions not more than 450 mm apart and in a manner which ensures compaction of the concrete around the reinforcing steel and any other embedded fixtures, and into all parts of the forms.

d) Vibration shall continue at each position until approximately seven seconds have elapsed. The vibrators shall then be withdrawn slowly so as to avoid leaving a 'pocket'.

e) Care shall be taken to ensure that newly deposited concrete is vibrated into any fresh concrete adjacent to it to provide a homogeneous concrete mass, and

f) Vibration shall not be applied either directly or through the reinforcement to any concrete which has taken its initial set.

Where external form vibrators are used the number, type, spacing and method of support of the vibrators shall be approved by the Administrator. External vibration shall always be accompanied by internal vibration.

15.6.2.1 Compaction of concrete (cast-in-place piles)

Compaction of concrete in cast-in-place piles shall be as per MRTS63 *Cast-In-Place Piles*, MRTS63A *Piles for Ancillary Structures* or MRTS64 *Driven Tubular Steel Piles (with reinforced concrete pile shaft)*, as appropriate.

15.6.3 Placement under water

The Contractor shall submit a procedure for underwater concreting which includes placement of concrete in wet cast-in-place piles at least two weeks prior to concreting. **Milestone**

The placement of concrete underwater shall be carried out in the presence of the Administrator **Witness Point 3** and shall comply with the following:

a) The nominated slump of the concrete to be placed underwater shall be between 180 mm and 200 mm (inclusive) or be high workability concrete.

b) Concrete shall not be placed under running water. The structure shall be sufficiently watertight to maintain effectively still-water conditions at the location required. All pumping of water shall cease and the water level shall stabilise before placement.

c) Any salt water shall be pumped out and replaced with fresh water as much as possible, to the satisfaction of the Administrator.

d) The concrete shall be placed carefully in a compact mass in its final position by means of an approved tremie such that:

   i. The tremie shall consist of a watertight tube fitted with a valve at the base of the tube or other approved device to ensure that the surrounding water is prevented from mixing with the concrete during the initial concrete charge. The base of the tube shall sit on the foundation while this initial charge is effected, and the tube and hopper shall be completely filled with concrete before the base valve is opened for the first discharge of concrete.

ii. The tremie shall be capable of controlled movement at the discharge end in both lateral and vertical directions and shall be capable of rapid lowering at any time to decrease the discharge rate of the concrete. The flow of concrete shall be regulated by adjusting the depth that the discharge end is submerged below the surface level of the concrete already placed.

e) A concrete pump may be used to load the tremie, but not act as a substitute for the tremie.

f) The discharge end of the tremie shall remain submerged to a depth of 2 m in the concrete at all times and remain filled with concrete to a height which shall at least balance the external hydrostatic head. If, for any reason, the discharge end of the tremie is lifted clear of the surrounding concrete, thus breaking the seal and permitting entry of water, the placing operation shall be abandoned and all defective concrete subsequently removed **Non-conformance**.

g) The concrete shall be placed in one continuous operation, the base of the tremie being moved laterally as necessary to maintain an approximately horizontal surface on the concrete.

h) No tamping or vibrating of the concrete shall be allowed. The concrete shall not be subjected to any physical disturbance after deposition.

i) Adequate allowance shall be made when concreting to provide for the subsequent removal of the contaminated surface layer.

j) If the finished surface of the concrete rises above the water level, the contaminated concrete may be removed before hardening occurs. When dewatering is completed, structural concrete shall have all unsound or contaminated concrete areas removed, and the surface thoroughly scrabbled and cleaned prior to subsequent placement of concrete.

k) Cofferdams or cylinders which have been sealed by underwater placement of concrete shall not be dewatered until at least 48 hours after completion of the concreting operation.

15.6.4 Use of spalls

Spalls of solid rock (not exceeding 200 mm in size) compliant to the requirements of Clause 7.5.4 may be used in mass concrete.

The spacing of the spalls shall be such that the clear distance between the spalls and their clearance from faces of forms shall not be less than 150 mm.

The spalls shall be surface wetted and bedded by hand, and the concrete shall be vibrated in place all around the spalls.

15.6.5 Further construction prior to 28 day testing

If concrete is to be placed over or adjacent to and connected with a previous section prior to 28 day testing and acceptance, additional sampling and early age testing shall be undertaken.

Any approval by the Administrator to proceed with construction shall not remove the Contractor's responsibility to satisfy the acceptance criteria.

15.7 Dimensional tolerances

15.7.1 General

Where tolerances for individual components and associated dimensions are not specified in the Drawings, deviations from established lines, grades and dimensions in the completed work shall not exceed the values given in this section.

Dimensions and levels shall be verified for all positions shown in the Drawings.

Note that additional tolerances for individual products may be listed in the relevant Technical Specification.

15.7.2 Dimensional tolerances

The tolerances given in Table 15.7.2 are to ensure strength, durability and fit of cast-insitu elements.

Table 15.7.2 – Dimensional tolerances

Description	Tolerance (mm)
Cross sectional dimension of members and thickness of slabs	+ 10, - 3
Length of members, length and width of slabs: • dimension up to 18 m • dimension 18 m or over	 ± 6 1 in 3000
Clear cover to reinforcement	+ 10, - 5
Fitments for prefabricated elements, girder anchorages (including dimension between anchorages on adjacent piers), cored holes, handrail anchorages and other embedded items	1 in 1000 ± 5 max

15.7.3 Positional tolerances

Positional tolerances, listed in Table 15.7.3, refer to the departure of any point, plane or component of a structure from its correct position within the layout of the structure as shown in the Drawings.

Table 15.7.3 – Positional tolerances

Description	Tolerance (mm)
Level of footings	± 20
Level other than footings	± 5
Horizontal location, where tolerance on fit is not applicable	± 25

15.7.4 Relative position

Relative tolerances refer to departures from linearity or planarity in any part of the structure. Tolerances are measured as the departure of any point in a line or surface from the remainder of that line or surface.

Departure may be sudden (e.g. misfit at joint in formwork) or gradual (e.g. a wobble in the surface). Tolerance on gradual departure is the value calculated by multiplying the overall length of the line or surface under consideration by the factor given in Table 15.7.4.

Table 15.7.4 – Relative tolerances

Description	Tolerance	
	Factor	Maximum (mm)
Exposed edge: Gradual departure	0.001	-
Exposed surface: • Gradual departure • Sudden departure	 0.004 -	 10 3

15.8 Removal of formwork

Forms, falsework and centring shall remain in position until the times stated below have elapsed after completion of concreting. **Hold Point 6**

- for soffits, until seven days
- for side forms, in accordance with Table 15.8.

Table 15.8 – Retention of side forms

Exposure Classification	Minimum Form Retention (hours)
A	48
B1, B2	72
C1, C2	120

In addition, the curing requirements of Clause 15.11 shall apply to the newly exposed surfaces within one hour of stripping the forms.

Forms shall be removed with care, without hammering and wedging, and in a manner which shall not injure the concrete or disturb the remaining supports. Centres shall be lowered gradually and uniformly in such a manner as to avoid injurious stress in any part of the structure. **Witness Point 4**

The Contractor shall repair any damage caused by such operations.

15.9 Early loading

Concrete shall not be loaded until seven days has elapsed from placement of all elements within the load path, including foundations.

Loads which may cause damage to the work shall not be placed on or against any part of the structure. Loads placed on or against any concrete shall be subject to approval by the Administrator, and shall satisfy any requirement specified elsewhere in the Contract.

Loads include, but are not limited to, supported formwork/falsework, construction traffic and material storage

15.10 Finishing operations

15.10.1 General

All unformed surfaces shall be finished true to line and level within the tolerances specified.

All finishing operations shall be completed prior to the application of any curing. The finishing operations shall be such as to provide a dense surface free from visible surface cracking. The concrete surface shall be reworked as necessary to eliminate plastic cracking.

The addition of water to aid finishing is prohibited.

15.10.2 Prevention of cracking

The Contractor shall plan and control the placing, compacting, curing and finishing operations to prevent cracking in the various concrete elements.

15.10.3 Top surface of decks and relieving slabs

Decks and relieving slabs shall be finished and tested in accordance with MRTS77.

15.10.4 Other cast-in-place surfaces

The tops of walls, kerbs, concrete barriers, headstocks and piers shall be steel trowel finished. Other surfaces may be wood float finished.

15.10.5 Special finishes

Special finishes shall be as detailed in the Drawings.

15.11 Curing

15.11.1 General

The Contractor shall submit a procedure for curing, including methods and materials, to the Administrator for approval at least two weeks prior to the first concrete pour. **Milestone** The curing of unformed surfaces of concrete shall commence as soon as the concrete surface has hardened.

Curing shall continue for a minimum period of seven days. If forms are removed in less than seven days, curing of the formed surface shall commence within one hour of stripping, unless otherwise specified in Clause 15.12.

Note that curing for longer periods, up to 28 days, will generally result in a superior product.

Curing shall be effected by one of the methods which follow.

15.11.2 Water curing

Surfaces shall be kept moist for the period specified by continuous spraying, ponding, wet hessian or wet sand blankets. The water used shall conform to the requirements of Clause 7.3.

15.11.3 Membrane curing (compounds)

The curing compound shall be applied by a pressurised sprayer to give a uniform cover. The sprayer shall incorporate a device for continuous agitation and mixing of the compound in its container during spraying.

The curing compound shall be applied using a fine spray at the rate stated on the certificate of compliance, or at a rate of 0.2 L/m² per coat, whichever is the greater. The application rate shall be checked by measuring the volume of compound applied to a given area.

Two coats shall be applied at the full rate.

The time between the first and second coat shall be in accordance with the manufacturer's recommendation, or on the basis of a trial application.

The curing membrane shall be maintained intact after its initial application. Any damage to the curing membrane due to the Contractor's or other's activities shall be made good by respraying of the affected areas.

Where surface treatments other than bagging are to be applied, wax emulsion membranes shall not be used unless provision is made for subsequent removal of wax, prior to applying the coating or wearing surface.

15.11.4 Membrane curing (sheeting)

Polythene sheeting shall be of sufficient strength to withstand wind and any imposed foot traffic and fully enclose the exposed surface. Torn or punctured sheeting shall not be used. Laps shall be 300 mm minimum and edges and laps shall be sealed by tape or held down by boards or reinforcing bars. Water shall be sprayed under the sheeting at edges and at laps on the day after placing concrete and at regular intervals to maintain moist conditions.

15.12 Surface dressing of concrete

Prior to commencing concreting operations, the Contractor shall establish procedures and standards for surface dressing and repair of concrete. The standards and procedures established shall be subject to the approval of the Administrator **(refer to Hold Point 4)**.

Concrete surfaces shall be free of honeycombing and pockets and free of voids larger than 20 mm in lateral dimensions or 3 mm deep.

15.12.1 Formed surfaces

Following the removal of formwork the following operations shall be carried out to the standard approved by the Administrator:

a) all fins and other unwanted projections shall be ground off to provide a smooth surface,

b) where specified in the Drawings, surfaces shall achieve a Class 1 surface finish to AS 3610 (Figure B1) or be bagged as set out below within four hours of removal of formwork from each section of the concrete. Curing as specified in Clause 15.11 shall commence on completion of stripping or bagging as appropriate,

c) where surface finish is not specified in the Drawings, a Class 2 surface finish to AS 3610 is required. Where surfaces of concrete do not achieve a Class 2 surface finish, the surface shall be bagged as set out below. Bagging to achieve this class of finish may be done immediately, prior to curing, or on completion of curing.

15.12.1.1 Bagging to achieve required finish

Bagging shall be carried out by the following procedure:

a) Produce a plastic grout mix consisting of equal parts of cement and fine sand passing a 0.600 mm test sieve, mixed with a suitable bonding additive and water.

b) An equivalent proprietary product (for example a fairing coat mortar) is a suitable alternative.

c) Apply uniformly to the surface in a suitable manner using a pad of hessian or similar material to fill all air holes and other minor surface blemishes.

d) Keep surface damp while this work is carried out.

e) Remove surplus material while the initial application is still plastic.

15.12.2 Rectification of non-compliant surfaces

Where surfaces fail to meet the requirements of Clause 15.12, the following actions shall be undertaken: **Non-conformance**

a) All pockets or honeycombed areas shall be cleaned out to sound concrete.

b) Small voids, not more than 150 mm in lateral dimensions or 20 mm deep, shall be filled with a registered repair mortar, vibrated as necessary. The surface of the patches shall be finished flush with the adjacent formed surface.

c) Large voids shall be formed and filled with vibrated concrete of the same mix design. An effective bonding agent in the mix and on the interface shall be used.

d) The repaired area shall be cured in accordance with Clause 15.11

Repairs shall be a **Witness Point 5**

15.13 Construction joints

Construction joints shown in the Drawings are mandatory. The use of construction joints elsewhere in the concrete work shall require the prior approval of the Designer. **Hold Point 7**

Edges of all joints which are exposed to view shall be carefully finished true to line and level.

At horizontal construction joints along all exposed faces, dressed timber strips approximately 25 mm square shall be attached to the inner face of the form, and the surface of the lower concrete lift shall be stopped slightly above the lower edge of the strips so as to provide a uniformly straight edge along the joint when the strips are removed prior to placing the next lift.

The surface of the joint shall be prepared by removing all laitance and sufficient surface mortar to expose the coarse aggregate, but leaving the coarse aggregate firmly embedded in the mortar matrix, without undercutting. This may be achieved by the use of:

a) sand-blasting techniques

b) wire brushes, hand tools and pneumatic tools

c) a ‘green cutting’ technique whereby the surface laitance and mortar is removed from partially hardened concrete by means of a high pressure combined air/water jet directed through a single nozzle onto the concrete, or

d) proprietary surface retarding agents followed by any of the above (sugar solutions are not to be used).

Construction joints shall be dampened prior to the placement of the adjoining concrete.

Membrane-curing agents shall not be applied to the surface of any construction joint.

The joint shall be cleaned of any foreign material and contaminants present prior to concreting the next lift and the fit of forms along the construction joint shall be checked to ensure a mortar-tight joint.

Construction joints are not to be facilitated with permanent metal formwork, mesh or similar products.

15.13.1 Construction Joints in Marine and Other Aggressive Environments

Construction joints in exposure class C1 or C2, environments shall be prepared as follows:

a) The surface of the joint shall be prepared as in Clause 15.13 immediately prior to casting concrete against the joint. The surface and any projecting steel shall then be washed with clean fresh water to remove any salt deposits or other contaminants, and either blown dry with oil-free air or allowed to dry while protected from further contamination.

b) The concrete surface shall be coated with a wet-to-dry epoxy resin, as approved by the Administrator, followed by placement of the fresh concrete before the epoxy on the interface has hardened.

16 Requirements for precast and precast prestressed concrete

This clause applies to concrete produced for manufacture of precast and precast prestressed concrete items as defined by MRTS24 *Manufacture of Fibre Reinforced Concrete Drainage Pipes*, MRTS72 *Manufacture of Precast Concrete Elements* and MRTS73 *Manufacture of Prestressed Concrete Members and Stressing Units*. Notwithstanding alterations listed below, Clauses 1 to 14 of this Specification continue to apply.

16.1 Mix designs

Mix designs shall be assessed on a yearly basis as part of the registration of precast concrete suppliers.

Trial mixes shall be conducted in the following cases:

a) establishment of new batch plant at casting yard,

b) formulation of new mix type, and

c) super-workable concrete.

Mix design approval certificates shall be submitted to the Administrator for approval to use the mix in the Works **(see Hold Point 8)**.

For example, new mix types would include triple-blend concrete

16.1.1 Trial mixes

Trial mixes shall be made using the plant and degree of quality control proposed for the Works. The minimum volume of the trial mix shall be 25% of the rated capacity of the mixer. Each trial mix shall be a witness point with a notice period of three days. **Witness Point 6**

Each trial mix shall be tested for slump or spread, workability and strength. Where concrete is not batched and mixed on the site, a time delay equal to an average delivery time on site shall be applied between the mixing of the concrete and the sampling for slump or spread and cylinder tests.

The slump or spread measured shall be within tolerance (see Table 11(a) or Table 11(b)) of the nominated slump or spread. At least four cylinders shall be cast from each trial mix for compressive strength testing at 28 days. Additional cylinders (a minimum of three per age) shall be required if strength gain is to be assessed for early stripping or loading.

The Administrator may give provisional approval of a mix based on early testing, provided the mean compressive strengths of at least three trial cylinders tested at seven days is not less than 0.8 of the specified characteristic strength for that grade of concrete. Notwithstanding any such provisional approval, all the concrete shall meet 28 day strength requirements.

Trial mix programmes for super-workable concrete shall include a minimum of three batches to determine that the mix can be reliably produced.

16.1.2 Trial mix – conformance

The trial mix, the plant and the degree of quality control for the Works shall be approved if the:

a) mean 28 day cylinder strengths equals or exceeds 0.5 ($f'_c + f'_t$),

b) slump or spread falls within the tolerances in Table 11(a) or Table 11(b),

c) materials within the mix meet the requirements of this Technical Specification, and

d) mix design submission meets the requirements of Clause 9.2.

Note that approval of the trial mix does not relieve the concrete supplier of the responsibility to maintain the performance of the concrete mix as per Clause 9.

16.2 Testing procedures (compressive strength)

Sampling for compressive strength testing of concrete for precast work shall be undertaken in accordance with this clause.

16.2.1 Normal rate of testing

Samples shall be taken from each pre-mixed truckload or from each 5 m³ of concrete continuously batched on site at the precast yard. Four cylinders (minimum) shall be cast from each sample. Each sample shall be identified with the relevant batch and the precast elements cast from the batch sampled.

Note that additional cylinders may be required to satisfy all early strength testing requirements and ensure a matched pair is available for 28 day testing.

16.2.2 Reduced rate of testing

Where sampling, testing and assessment of concrete is carried out in accordance with this specification, and 10 samples of a concrete mix have been tested and are conforming, the Contractor may:

a) seek approval to move to a reduced level of testing, and

b) nominate the level of testing which shall not be less than half the normal level.

Half the normal level is defined as one sample from every second truck for premixed concrete delivered in trucks, or one sample every 10 m³ for concrete batched in the precast yard.

This approval will be managed through the supplier registration scheme, and relevant mix design approval certificates. The schedule of sampling for release strength testing shall include a sample taken from the final batch or truck.

For example, testing would be from truck 2 of 2, 1 and 3 of 3, 1 and 4 of 4, and 1, 3 and 5 of 5.

16.3 Formwork, bar chairs and spacers

16.3.1 Formwork

Formwork shall be constructed from metal; timber forms are not acceptable, except as noted below. Forms for surfaces requiring special finishes are specified elsewhere in the Contract.

In the case of flat panel work only, the following exceptions to metal formwork apply:

a) use of timber edge forms for custom panels,

b) use of proprietary form liners or other suitable material as a form liner for patterned panels, and

c) polystyrene to form custom blockouts.

Formwork shall conform to AS 3610 except as otherwise required by this specification. Formwork shall provide a Class 2 AS 3610 surface finish, except as otherwise specified. All forms shall be surface smooth, mortar-tight and have sufficient rigidity to maintain the tolerances specified when subjected to fresh concrete and intense vibration.

All forms shall be set and maintained to line and level such that the finished concrete shall conform within the specified dimensional tolerances, and to the proper dimensions and contours as shown in the Drawings.

All forms shall be cleaned and coated with the lightest practical coating of release agent prior to pour. Reinforcing steel, prestressing strand and construction joints shall not be contaminated with release agent.

Where a hole or void in the concrete is shown on the Drawing the formwork or void former shall be removed after casting. Permanent hole formers are not accepted unless shown on the Drawing.

Unless otherwise shown in the Drawings or relevant specification, all corners shall be provided with 15 mm x 15 mm chamfers or fillets of equivalent radius.

The form's original shape, strength, rigidity, mortar tightness and surface smoothness shall be maintained. Forms which become unsatisfactory shall not be used.

16.3.2 Supports (bar chairs and spacers)

All bar chairs and spacers shall comply with AS/NZS 2425 and be a registered product.

Bar chair materials to be as per Clauses 16.3.2.1 and 16.3.2.2 dependant on location. Plastic bar chairs or spacers shall not be used

Supports shall be placed sufficiently close together to ensure that the specified cover is maintained before and during concrete placement and to prevent any potential crushing of the spacers or penetration into the formwork. Long continuous linear runs of supports shall be avoided; each individual length of support shall be laterally offset from its adjacent support by at least 200 mm so as

to avoid the potential to induce linear cracking in the concrete. The maximum length of any one support shall be 330 mm.

16.3.2.1 Cover to formwork

Where supports are used to distance reinforcement from formworks, the supports shall be manufactured from concrete or stainless steel.

Concrete supports shall be extruded fibre concrete or conventional concrete manufactured under factory controlled conditions and be a registered product.

The minimum concrete strength shall be 60 MPa and the product shall have a maximum RCPT value of 1000 coulombs at 56 days.

The fibres used in extruded fibre concrete bar chairs or spacers shall be non-metallic, synthetic fibres. Asbestos or similar fibres based on naturally occurring silicate minerals shall not be used.

Where supports are required to be attached to the reinforcement, such attachment may be via clips or steel wires provided that no part of the wire or clip is located within three quarters of the required cover depth from the surface of the concrete. If stainless steel or galvanised wire or clips are used they must be located at a depth of no less than half the specified cover from the concrete surface.

Supports used to provide cover to the soffit formwork shall either be attached to the reinforcement or shaped to positively interlock into the concrete.

For example, the acceptability of support cross-sections would be as follows (soffit downwards):

Stainless steel nibs are to be manufactured from a material compliant with MRTS71A *Stainless Steel Reinforcing* and welded to the reinforcing complying with the locational tack weld requirements of MRTS71 *Reinforcing Steel*.

16.3.2.2 Spacing of reinforcement

Where supports are used to distance reinforcing from reinforcing (that is, between two layers of mesh), steel frames may be used. These frames shall be placed so as not to be directly above other spacers.

16.4 Concrete temperatures

Concrete shall be managed to ensure that at no stage does the concrete temperature exceed 75°C or the difference in temperature between two locations exceed 25°C. If these limits are exceeded, appropriate rectification or rejection of the element shall occur, and additional precautions enacted.

Non-conformance

Internal temperatures above 75°C can cause delayed ettringite formation reducing the durability of the concrete. Excessive differentials can cause thermal cracking.

Monitoring shall be in accordance with Clauses 16.4.1 and 16.4.2, as required, with temperatures recorded from placement for 120 h (five days) or until the core temperature has decreased to 50°C. Elements that do not meet either criteria do not need to be monitored. Elements being cured using high temperatures shall instead be monitored in accordance with Clause 16.7.4.

A record of the monitoring results shall be submitted to the Administrator prior to delivery.

Precautions to reduce concrete temperatures may include:

- Redesign of the concrete mix
- Reducing the concrete temperature at the time of placement
- Insulating the formwork to reduce temperature differentials
- Other measures as approved by the Administrator

16.4.1 High cementitious contents

For elements manufactured with a concrete mix containing 520 kg/m³ of cementitious material or more, the following location shall be monitored for temperature:

a) one at the geometric centre

For elements with concave sections, the geometric centre shall be determined as the point furthest from the formwork.

For example, culverts would be monitored in the centre of the haunch.

A reduced rate of monitoring may be sought, following a period of satisfactory results. This rate shall not be less than one element per week.

16.4.2 Large elements

For elements with a cross sectional area exceeding 1 m x 1 m square, or 1 m diameter, the following locations, at a minimum, shall be monitored for temperature:

a) one at the geometric centre

b) one at an upper corner

c) two at centres of side faces

Surface temperatures (b and c above) shall be measured at the depth of reinforcement.

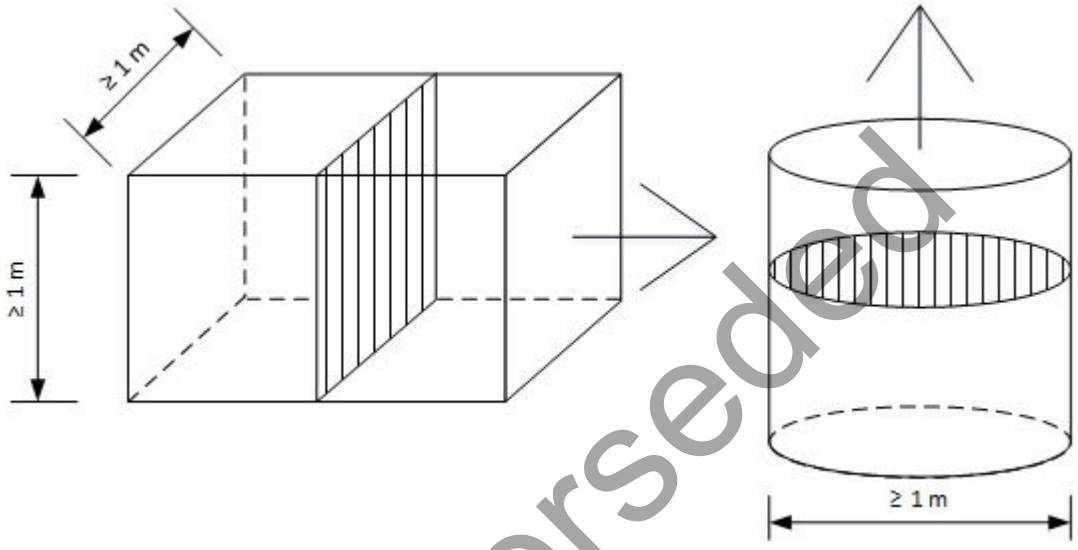
For the purposes of this clause the cross section is defined as the plane perpendicular to the longitudinal direction (longest dimension).

The Contractor shall submit a procedure and plan for monitoring and procedures for ensuring compliance to this clause to the Administrator for approval at least four weeks prior to the concrete pour. **Milestone** The maximum interval between readings shall be 15 minutes. This plan shall be approved by the Administrator before concrete is placed.

A record of the monitoring results shall be submitted to the Administrator prior to delivery.

Elements requiring monitoring due to their size are more likely to be one-off and/or project-specific therefore approval is not managed through the Registration Scheme.

Figure 15.5.1 – Element cross-sections



16.5 Placing and compacting concrete

16.5.1 General

No concrete shall be placed in the Works until: **Hold Point 8**

a) the mix design has been approved by the Administrator,

b) the registration status of the precaster has been confirmed, and

c) any project-specific requirements have been addressed regarding placement and curing.

Note additional Hold Points in product Technical Specifications (MRTS24, MRTS72, MRTS73).

All concrete shall be placed under dry conditions, all pools of water shall be removed and no inflow of water shall be permitted.

Concreting operations shall be carried out in a continuous manner for each precast item or between the construction joints shown in the Drawings. Fresh concrete shall not be placed against concrete which has taken its initial set. Initial set is defined for this purpose only as the concrete surface not being able to be easily penetrated with a 12 mm bar.

If an interruption greater than 45 minutes occurs, without prior approval from the Administrator, or a cold joint occurs, the precast member shall be rejected. **Non-conformance**

Note that particular care is required with SWC to avoid cold joints. Concrete which has been placed can develop a skin very quickly which leads to a cold joint.

Chutes, if used, shall be arranged in a manner which avoids segregation of the concrete. Apart from an initial flushing immediately prior to commencement of concreting, the use of water in chutes to assist movement of concrete shall not be permitted.

Pneumatic placers and concrete pumps may be used only when a concrete mix designed for such placing is approved for use by the Administrator. The equipment shall be positioned such that freshly placed concrete is not damaged by vibration. The initial discharge containing the cement slurry used to coat the pipe line shall be discarded.

Buckets shall have the capability of a controlled rate of discharge. Concrete shall not be allowed to free fall from a height exceeding 0.5 m above the formwork, nor shall it be placed in any other manner which results in segregation or loss of mortar or damage to formwork or reinforcement.

If placing operations necessitate a drop of more than 0.5 m, the concrete shall be placed using a flexible tube reaching to the top of the formwork or another method approved by the Administrator.

Fresh concrete shall be deposited within the forms as near as possible to its final location. Use of vibrators and tamping rods to move the concrete along the forms shall not be permitted.

Note that deposition near final location is particularly important for super-workable concrete.

16.5.2 Compaction of concrete

Compaction of concrete shall commence immediately after deposition. Compaction shall be achieved by use of high frequency vibrators. Where intense compaction is specified the use of external form vibrators is mandatory, with the exception of prestressed concrete piles.

The following conditions shall apply when using internal vibrators:

a) The vibrators shall be capable of transmitting vibrations at a frequency not less than 150 Hz with an intensity which shall visibly affect the concrete at a radius of 300 mm.

b) The number of vibrators to be used by the Contractor shall be not less than one for each 10 m³ of concrete placed per hour.

c) Vibrators shall be inserted vertically at successive positions not more than 450 mm apart and in a manner which ensures compaction of the concrete around the reinforcing steel and any other embedded fixtures, and into all parts of the forms.

d) Vibration shall continue at each position for between 5 and 15 seconds. The vibrators shall then be withdrawn slowly so as to avoid leaving a “pocket”.

e) Care shall be taken to ensure that newly deposited concrete is vibrated into any fresh concrete adjacent to it to provide a homogeneous concrete mass.

f) Vibration shall not be applied either directly or through the reinforcement to any concrete which has taken its initial set.

External vibration shall be supplemented with internal vibration as necessary.

For super-workable concrete (SWC) only, vibration is not mandatory but may be required particularly to ensure that joints do not occur between layers. When used, it shall comply with the above, excluding subclause (d).

Care should be taken to ensure that any layering of SWC is mitigated by the use of vibration to mix the layers together.

16.6 Finishing operations

16.6.1 General

All unformed surfaces shall be finished true to line and level within the tolerances specified.

All finishing operations shall be completed prior to the application of any curing. The finishing operations shall be such as to provide a dense surface free from visible surface cracking. The concrete surface shall be reworked as necessary to eliminate plastic cracking.

The addition of water to aid finishing is prohibited.

16.6.2 Prevention of cracking

The Contractor shall plan and control the placing, compacting, curing and finishing operations to prevent cracking in the various concrete elements.

16.6.3 Degrees of finish

Top surfaces of precast or prestressed piles and surfaces of precast elements visible after installation are to be finished with steel trowels.

Surfaces with starter bars, and those marked in the Drawings as construction joints, are to be treated as construction joints.

Other surfaces are to be broom or trowel finished as indicated on the Drawings.

Special finishes shall be as detailed in the Drawings.

Note that MRTS73 includes more detailed requirements for precast prestressed elements.

16.7 Curing

16.7.1 General

The curing of unformed surfaces of concrete shall commence as soon as the concrete surface has reached initial set.

Curing shall continue for a minimum period of seven days. If forms are removed in less than seven days, curing of the formed surface shall commence within one hour of stripping, except as otherwise specified in Clause 16.8.

In the case where heat accelerated curing is achieved for 420°C·h, curing is deemed complete. If heat accelerated curing is applied but 420°C·h is not achieved, curing shall continue for seven days by either water or membrane curing.

Curing shall be effected by one of the methods which follow.

Precast prestressed concrete constructed in accordance with MRTS73 *Manufacture of Prestressed Concrete Members and Stressing Units* shall be heat accelerated cured for a minimum of 420°C·h.

16.7.2 Water curing

Surfaces shall be kept moist for the period specified by continuous spraying, ponding, wet hessian or wet sand blankets. The water used shall conform to the requirements of Clause 7.3.

16.7.3 Membrane curing (compounds)

The curing compound shall be applied by a pressurised sprayer to give a uniform cover. The sprayer shall ensure adequate mixing of the compound to eliminate separation of product.

The curing compound shall be applied using a fine spray at the rate stated on the certificate of compliance, or at a rate of 0.2 L/m² per coat, whichever is the greater. The application rate shall be checked by measuring the volume of compound applied to a given area.

Two coats shall be applied at the full rate.

The time between the first and second coat shall be in accordance with the manufacturer's recommendation, or on the basis of a trial application.

The curing membrane shall be maintained intact after its initial application. Any damage to the curing membrane due to the Contractor's or other's activities shall be made good by respraying of the affected areas.

Where surface treatments other than bagging are to be applied, wax emulsion membranes shall not be used unless provision is made for subsequent removal of wax by sandblasting, prior to applying the coating or wearing surface.

16.7.3.1 Membrane curing (sheeting)

Where used as an alternative to curing compounds, polythene sheeting shall be of sufficient strength to withstand wind and any imposed foot traffic and fully enclose the exposed surface. Torn or punctured sheeting shall not be used. Laps shall be 300 mm minimum and edges and laps shall be sealed by tape or held down by boards or reinforcing bars. Water shall be sprayed under the sheeting at edges and at laps on the day after placing concrete and at regular intervals to maintain moist conditions.

16.7.4 Heat accelerated curing

Heat accelerated curing shall be effected using either steam or hot water curing methods.

Where a new heat accelerated curing process is being established, the Contractor shall submit the procedure and Drawings detailing the proposed system, to Structures Construction Materials, at least two weeks prior to commencing establishment of the plant. **Milestone**

> Note that this procedure will be assessed as part of the supplier registration scheme.

16.7.4.1 Steaming curing arrangement

Steam curing of precast and precast prestressed concrete units shall be effected within an appropriate enclosure.

The formwork, enclosure and steam lines shall be arranged so that the temperature distribution around the units being cured is uniform. The temperature variation between any two enclosure locations, in a single bed/enclosure, shall not exceed 10°C for a cumulative period for 30 minutes throughout the curing cycle. Formwork and supports shall be designed to allow the heat to circulate freely around all sides of the units. The enclosure shall fully enclose the units including the top surface and be maintained in good condition.

The atmosphere within each enclosure shall have a minimum average relative humidity of 90% over the heating and curing cycle. This shall be confirmed by spot checks.

It is recommended that spot checks on temperature or humidity be conducted by the Administrator when concerns are raised regarding the steam curing system or the condition of the enclosure.

16.7.4.2 Hot water arrangement

Curing of precast and precast prestressed concrete units shall be effected within a steel mould fitted with hot water piping that transfers the heat from the hot water uniformly to the steel mould and the concrete.

At all times the difference between the inlet temperature and the outlet temperature of the hot water curing system shall not exceed 10°C for a cumulative period for 30 minutes throughout the curing cycle. An enclosure shall fully enclose the free concrete surface of the units being cured and a system used to ensure that the minimum average relative humidity in the enclosure shall be maintained at 90%.

For example, a typical system to ensure that the relative humidity in the enclosure remains at 90% would be wet hessian and a soaker hose running along the top of the units.

16.7.4.3 Process Control

Where a number of identical units are to be cured, uniform curing conditions shall be maintained for each of the units to minimise geometrical, in particular hog, variations between units.

The maximum temperature within the enclosure (steam curing), or the maximum water temperature (hot water curing) shall not exceed 70°C.

The maximum temperature at any point within the concrete shall not exceed 75°C at any point during or after the heating or curing process. The internal concrete temperatures shall be measured at the largest cross section for a period of 48 hours after concrete placement or until temperatures have dropped to 10°C below the peak temperature whichever occurs first.

The maximum internal temperature of the concrete is limited to avoid damage due to delayed ettringite formation.

The supplier shall provide accurate and sufficient instruments for controlling and digitally recording the relevant temperatures detailed in the following sections throughout the entire heat accelerated curing

operation. Accurate control is considered to be the ability to maintain an enclosure (or hot water) temperature at ±5°C of the target temperature at a given point in time.

16.7.4.4 Temperature monitoring locations (steam curing)

All relevant temperatures, as described below, are to be recorded, at no more than 10 minute intervals, for each bed and submitted to the Administrator.

Temperatures shall be monitored at concrete core and enclosure locations at a rate as described in Table 16.7.4.4.

Core temperatures shall be recorded at the geometric centre of the element's largest concrete cross-section or centre of mass of the largest concrete volume.

For elements with continuous cross sections along the length (for example, prestressed piles, and panels) temperatures shall be recorded evenly along the length.

For elements with a concave cross-section (eg box culverts) consider only the centre of mass of largest portion of concrete volume (for example, in culverts this is the centroid of the haunch).

> The aim is to find the point in the concrete the furthest away from the surface/formwork as this will typically be the location with the highest temperature.

Where curing is carried out in accordance with this clause, and consistent and even temperatures can be demonstrated, the Contractor may seek approval, as part of the Registration Scheme, to move to a reduced level of monitoring. The reduced rate of monitoring shall be not be less than that listed in Table 16.7.4.4. Approval for reduced monitoring shall be granted on a bed-by-bed basis. For the purposes of this clause, the definition of a bed includes a batch of elements (for example, culverts) run off a single heat controller.

> Note that approval for a reduced level of monitoring will be managed through the supplier registration scheme.

Table 16.7.4.4 – Number of temperature monitoring points

Element	Location	Standard Rate	Reduced Rate
Prestressed piles	Core	1/element	1/bed
	Enclosure	≤ 10 m apart[1]	1/pile
Prestressed decks and girders	Core	1/element[2]	1/bed
	Enclosure	≤ 10 m apart[1]	≤ 20 m apart
Precast Elements (continuous enclosure)[3]	Core	≤ 10 m apart	1/bed
	Enclosure	≤ 10 m apart	≤ 20 m apart
Precast Elements (individual enclosures)[4]	Core	1/element	1/batch (largest element)
	Enclosure	1/element	1/element

1. Minimum of 2.

[2.] For end-to-end units, these shall be non-adjacent ends (that is, monitor the same end of each unit).

[3.] Typically panels.

[4.] Typically culverts.

16.7.4.5 Temperature monitoring locations (hot water curing)

For hot water curing processes temperature monitoring shall be conducted in accordance with Table 16.7.4.4 except that the enclosure temperature requirements shall be satisfied by measuring the inlet and outlet water temperatures.

16.7.4.6 Curing process

The curing process for both steam and hot water curing systems shall proceed as follows:

Delay period

The application of heat to a freshly concreted unit shall be delayed for a period of time after completion of concreting.

The delay period (t) in hours shall be calculated as follows:

$t = \frac{K}{T}$ where

T = concrete temperature (°C) after finishing,

K = 40 (precisely controlled system) or 60 (otherwise).

Control is considered precise when it can be demonstrated that the enclosure or hot water temperature increases at a uniform rate and is within 5°C of the predicted temperature at any time.

If cracking occurs in units which have been cured using accelerated curing and the Administrator attributes such cracking to an early application of heat, the delay time shall be extended for future units as approved by the Administrator. **Non-conformance**

Heating period

The application of heat shall be such that the enclosure temperature or hot water temperature is raised at a linear rate not exceeding 24°C/h, with no more than an 8°C rise in any 15 minute interval. Any further temperature rise within the curing period shall be at the same rate.

Curing period

For precast prestressed concrete components manufactured to MRTS73 *Manufacture of Prestressed Concrete Members and Stressing Units*, the curing period shall commence once the temperature of the enclosure or the hot water temperature exceeds 50°C. The curing period shall continue, while the temperature exceeds 50°C, until the product of time and enclosure temperature exceeds 420°C·h. This product shall be calculated using either the enclosure temperatures for steam curing, or the outlet hot water temperatures for hot water systems.

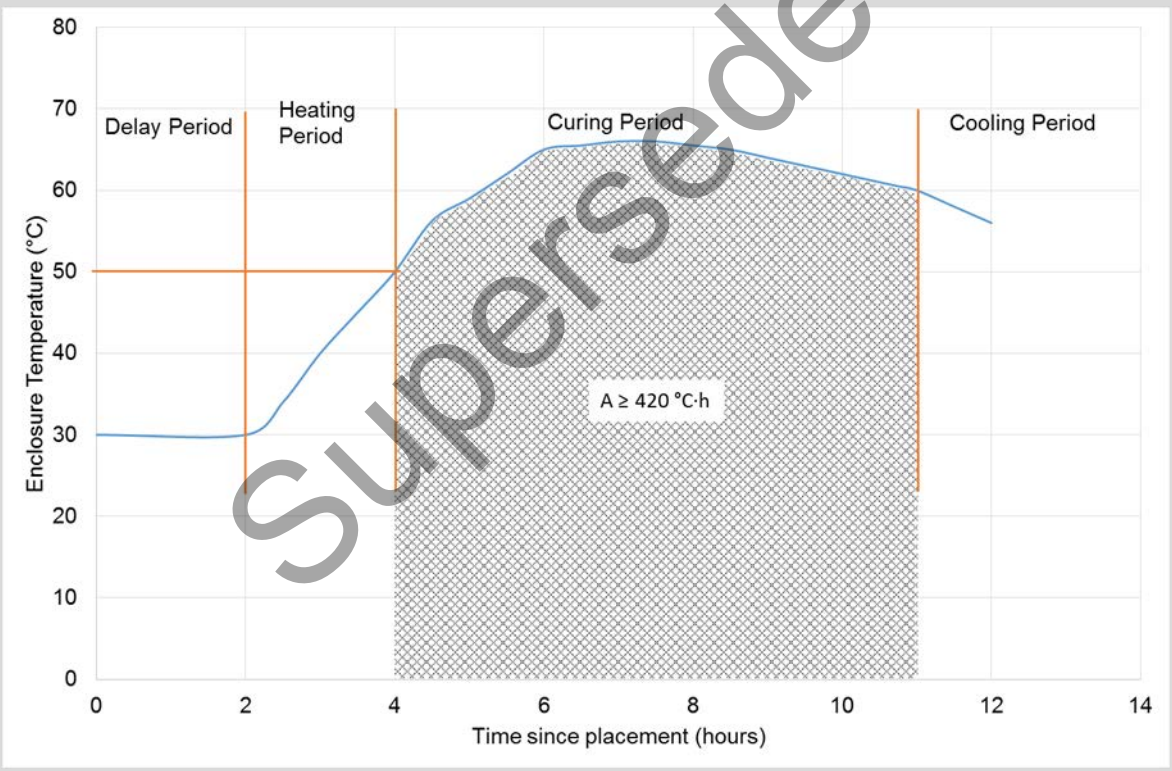
For precast concrete products manufactured to MRTS24 *Manufacture of Precast Concrete Culverts* and MRTS72 *Manufacture of Precast Concrete Elements* the curing period shall be as per the previous paragraph or until the required strength is achieved noting the requirements of Clause 16.7.1 if 420°C·h is not achieved.

Clause 16.7.1 describes the requirements should 420°C·h not be reached for precast concrete products. This may be either due to system failure or when heat is used only for the purpose of gaining early release strengths.

Cooling period

For products manufactured to MRTS73 *Manufacture of Prestressed Concrete Members and Stressing Units* transfer of prestress may be performed when the concrete external surface temperature of the units has cooled to 60°C and the design concrete transfer strength has been achieved. For all products the enclosure shall not be removed until the surface temperature of the unit has cooled to within 40°C of the ambient air temperature.

This chart exemplifies a compliant steam curing regime. Note that actual steam records require more data series (see Clause 16.7.4.9).



The enclosure could be removed in this instance at 11 hours if the ambient temperature exceeded 20°C

16.7.4.7 Test cylinders (steam curing)

Curing of associated concrete test specimen cylinders shall be achieved by either:

a) Placing all cylinders within the enclosure in a position adjacent to the lower face of the structural units which they represent. The cylinders shall be located midway between heat input points and shall be distant at least half the width of the structural unit from these input points. The cylinders shall not be positioned on top of the structural units, or on the steam lines and shall not be directly in line with any steam jet, or

b) Placing all cylinders in a temperature matched curing (TMC) tank which is controlled by a thermocouple placed 100 mm below the surface at the largest cross-section of the member being cured. Where multiple units are being curing the TMC thermocouple shall be inserted into the youngest (last poured) element. The TMC shall be controlled within -10°C and +2°C of the thermocouple 100 mm below the surface. When the cylinders are placed into the TMC, the TMC tank temperature shall be equal to the concrete temperature. The TMC tank temperature shall be monitored using a thermocouple to ensure it matches the temperature 100 mm below the surface.

16.7.4.8 Test cylinders (hot water curing)

Curing of associated concrete test specimen cylinders shall be achieved by either:

a) Using a TMC tank as per Clause 16.7.4.7(b), or

b) Using a TMC tank as per Clause 16.7.4.7(b) but with the tank controlled by the outlet hot water temperature.

16.7.4.9 Submission of Data

The following temperature records shall be submitted on one graph to the Administrator:

a) Core and enclosure temperatures as per Table 16.7.4.4.

b) Temperature 100 mm below the surface and TMC tank temperature if TMC is used.

16.8 Surface dressing of concrete

Prior to commencing concreting operations, the Contractor shall establish procedures and standards for surface dressing and repair of concrete.

Concrete surfaces shall be free of honeycombing and pockets, and free of voids larger than 20 mm in lateral dimensions or 3 mm deep.

16.8.1 Formed surfaces

Following the removal of formwork the following operations shall be carried out to the standard approved by the Administrator:

a) all fins and other unwanted projections shall be ground off to provide a smooth surface,

b) where specified in the Drawings, surfaces shall achieve a Class 1 surface finish to AS 3610 (Figure B1) or be bagged as set out below within four hours of removal of formwork from each section of the concrete. Curing as specified in Clause 16.7 shall commence on completion of stripping or bagging as appropriate,

c) where surface finish is not specified in the Drawings, a Class 2 surface finish to AS 3610 is required. Where surfaces of concrete do not achieve a Class 2 surface finish, the surface shall be bagged as set out below. Bagging to achieve this class of finish may be done immediately, prior to curing, or on completion of curing.

16.8.1.1 Bagging to achieve required finish

Bagging shall be carried out by the following procedure:

a) Produce a plastic grout mix consisting of equal parts of cement and fine sand passing a 0.600 mm test sieve, mixed with a suitable bonding additive and water.
An equivalent proprietary product (for example a fairing coat mortar) is a suitable alternative.

b) Apply uniformly to the surface in a suitable manner using a pad of hessian or similar material to fill all air holes and other minor surface blemishes.

c) Keep surface damp while this work is carried out.

d) Remove surplus material while the initial application is still plastic.

16.8.2 Rectification of non-compliant surfaces

Where surfaces fail to meet the requirements of Clause 16.8, the following actions shall be undertaken: **Non-conformance**

a) All pockets or honeycombed areas shall be cleaned out to sound concrete.

b) Small voids, not more than 150 mm in lateral dimensions or 20 mm deep, shall be filled with a registered repair mortar, vibrated as necessary. The surface of the patches shall be finished flush with the adjacent formed surface.

c) Large voids shall be formed and filled with vibrated concrete of the same mix design. An effective bonding agent in the mix and on the interface shall be used.

d) The repaired area shall be cured in accordance with Clause 16.7.

Repairs shall be a **Witness Point 7**

16.9 Construction joints

Construction joints shown in the Drawings are mandatory. The use of construction joints elsewhere in the concrete work shall require the prior approval of the Designer. **Hold Point 9**

Edges of all joints which are exposed to view shall be carefully finished true to line and level.

At horizontal construction joints along all exposed faces, dressed timber strips approximately 25 mm square shall be attached to the inner face of the form, and the surface of the lower concrete lift shall be stopped slightly above the lower edge of the strips so as to provide a uniformly straight edge along the joint when the strips are removed prior to placing the next lift.

The surface of the joint shall be prepared by removing all laitance and sufficient surface mortar to expose the coarse aggregate, but leaving the coarse aggregate firmly embedded in the mortar matrix, without undercutting. This may be achieved by the use of:

a) sand-blasting techniques

b) wire brushes, hand tools and pneumatic tools

c) a “green cutting” technique whereby the surface laitance and mortar is removed from partially hardened concrete by means of a high pressure combined air/water jet directed through a single nozzle onto the concrete, or

d) proprietary surface retarding agents followed by any of the above (sugar solutions are not to be used).

Construction joints shall be dampened prior to the placement of the adjoining concrete.

Membrane-curing agents shall not be applied to the surface of any construction joint.

The joint shall be cleaned of any foreign material and contaminants present prior to concreting the next lift and the fit of forms along the construction joint shall be checked to ensure a mortar-tight joint.

Construction joints are not to be facilitated with permanent metal formwork, mesh or similar products.

16.9.1 Construction Joints in Marine and Other Aggressive Environments

Construction joints in exposure class C1 or C2, environments shall be prepared as follows:

a) The surface of the joint shall be prepared as in Clause 16.9 immediately prior to casting concrete against the joint. The surface and any projecting steel shall then be washed with clean fresh water to remove any salt deposits or other contaminants, and either blown dry with oil-free air or allowed to dry while protected from further contamination.

b) The concrete surface shall be coated with a wet-to-dry epoxy resin, as approved by the Administrator, followed by placement of the fresh concrete before the epoxy on the interface has hardened.

17 Normal Class Concrete

This clause applies to insitu and precast concrete elements, where the Drawings specify normal class concrete.

17.1 Concrete class

The strength grade of concrete and maximum nominal aggregate size used shall be as specified on the Drawings.

17.2 Materials

17.2.1 Cementitious Materials

All cement shall comply with ATIC-SPEC SP43 and AS 3972.

Fly ash shall comply with ATIC-SPEC SP43 and AS/NZS 3582.1.

Slag shall conform to ATIC-SPEC SP43 and AS 3582.2.

Amorphous silica, including silica fume, shall comply with ATIC-SPEC SP43 and AS/NZS 3582.3.

17.2.2 Chemical admixtures

Admixtures shall conform to the requirements of AS 1478 and shall be used in accordance with AS 1379.

17.2.3 Concrete aggregate

Aggregate shall conform to AS 2758.1 and must satisfy the requirements for exposure class as specified for the concrete application.

17.2.4 Alkali reactive materials

Where aggregate is identified as having potential for alkali aggregate reaction in accordance with AS 2758.1 treatment to control the effects shall be in accordance with SA HB79.

17.2.5 Curing compounds

Curing compounds shall comply with the requirements of AS 3799 and be registered products.

17.3 Storage of materials

Materials shall be stored in such a way as to prevent damage and degradation.

17.4 Concrete mix

The Contractor shall design and produce all normal class concrete used in the Works. The use of pre-mixed concrete shall in no way lessen or remove this responsibility.

The Contractor shall ensure that the mix design is suitable for the particular application.

Concrete slump shall be nominated as appropriate for the intended application.

17.5 Batching, mixing and transport

Batching, supply and delivery of concrete shall comply with AS 1379.

17.5.1 Long distance travel and extended placement times.

Where travel times are, by necessity, longer than 90 min as listed in AS 1379 Clause 4.2.5, a procedure for long-distance travel or extended placement times shall be submitted to the Administrator for approval six weeks before concreting begins. **Milestone**

> Note that TN125 *Long distance transport and extended placement times for concrete* provides guidance on procedures for long distance travel.

Transporting dry cementitious material and aggregates together to site and then adding water is not permitted.

A trial mix shall be undertaken emulating the estimated travel time. The trial mix shall be tested, at intervals nominated by the Administrator, for:

a) Strength development (as measured by AS 1012.9).

b) Workability retention (slump, or spread, as measured by AS 1012.3).

c) Extent of reaction (concrete temperature).

The concrete performance shall be assessed as satisfactory where:

a) The strength complies with the specified performance requirements

b) The workability (slump or spread) is maintained within the acceptable tolerance limits as per AS 1379 for the nominated time frame, and

c) No increase in temperature other than expected due to ambient conditions is noted

17.6 Acceptance and rejection of plastic concrete

The consistency and workability of concrete shall be such that it can be handled and transported without segregation and can be placed, worked and compacted into all corners, angles and narrow sections of forms, and around all reinforcement.

Consistency testing shall be undertaken in accordance with AS 1379.

Acceptance and rejection of plastic concrete shall be on a batch basis and in accordance with AS 1379.

Note that AS 1379 requires a consistence test every time a sample is taken for strength testing.

17.7 Acceptance and rejection of hardened concrete

Acceptance and rejection of hardened concrete shall be on a production assessment basis in accordance with AS 1379 except as noted below. Concrete for the following applications shall be tested on a project assessment basis, where more than 25 m³ of concrete is used:

a) Signpost footings and plinths with dimension greater than 150 mm.

b) Spill through or rock grouting.

c) Kerb and channel on or alongside concrete base.

Production assessment reports in accordance with AS 1379 Clause 6.4.2 shall be submitted to the Administrator.

Note that production assessment reports are statistical summaries of concrete strength results over a nominated production interval.

Project assessment (Clause 6.5 of AS 1379) requires sampling on the project site and testing 1 sample per 50 m³ of concrete.

17.8 Defects and rectification

Where normal class concrete does not comply with the requirements of this specification, the unit or lot may, at the discretion of the Administrator, be rejected and replaced or undergo rectification.

This work shall be at the Contractor's expense.

The method of rectification shall be approved by the Administrator.

17.9 Falsework

Falsework shall conform to AS 3610.

The design and erection of falsework, the method of founding or supporting the falsework and the time, order and manner of its release shall all require approval of the Administrator. **Hold Point 10**

The Administrator’s approval of the use of completed sections of the Works as support structures for falsework shall in no way relieve the Contractor of any responsibility for the restoration or repair of any resulting damage caused by such use.

17.10 Formwork

All formwork shall be subject to inspection and approval by the Administrator. **Hold Point 11**

Formwork shall conform to AS 3610 and provide a Class 2 AS 3610 surface finish, except as otherwise specified.

17.10.1 Supports (bar chairs and spacers)

All bar chairs and spacers shall comply with AS/NZS 2425.

17.11 Placing and compacting concrete

17.11.1 General

No concrete shall be placed in the Works until: **Hold Point 12**

a) the formwork and reinforcement have been inspected, and

b) all foreign material has been completely removed from the forms.

The Administrator may revert this Hold Point to a Witness Point.

The placing operation shall be conducted in the presence of the Administrator **Witness Point 8** and the Contractor shall give at least 24 hours notice to the Administrator of the time that placing shall start.

Fresh concrete shall be deposited within the forms as near as possible to its final location. Excessive use of vibrators and tamping rods to move the concrete along the forms shall not be permitted.

17.11.2 Compaction of concrete

Concrete shall be compacted to achieve dense and durable concrete, to the levels and tolerances specified.

17.12 Tolerances

17.12.1 General

Where tolerances for individual components and associated dimensions are not specified in the Drawings, deviations from established lines, grades and dimensions in the completed work shall not exceed the values given in this section.

Dimensions and levels shall be verified for all positions shown in the Drawings.

> Note that additional tolerances for individual products may be listed in the relevant Technical Specification.

17.12.2 Dimensional tolerances

The tolerances given in Table 17.12.2 are to ensure strength, durability and fit of cast-insitu elements.

Table 17.12.2 – Dimensional tolerances

Description	Tolerance (mm)
Cross sectional dimension of members and thickness of slabs	+ 10, - 3
Length of members, length and width of slabs:	

dimension up to 18 m dimension 18 m or over	± 6 1 in 3000
Clear cover to reinforcement	+ 10, - 5
Fitments for prefabricated elements, girder anchorages (including dimension between anchorages on adjacent piers), cored holes, handrail anchorages and other embedded items	1 in 1000 ± 5 max

17.12.3 Positional tolerances

Positional tolerances, listed in Table 17.12.3, refer to the departure of any point, plane or component of a structure from its correct position within the layout of the structure as shown in the Drawings.

Table 17.12.3 – Positional tolerances

Description	Tolerance (mm)
Level of footings	± 20
Level other than footings	± 5
Horizontal location, where tolerance on fit is not applicable	± 25

17.12.4 Relative position

Relative tolerances refer to departures from linearity or planarity in any part of the structure. Tolerances are measured as the departure of any point in a line or surface from the remainder of that line or surface.

Departure may be sudden (e.g. misfit at joint in formwork) or gradual (e.g. a wobble in the surface). Tolerance on gradual departure is the value calculated by multiplying the overall length of the line or surface under consideration by the factor given in Table 17.12.4.

Table 17.12.4 – Relative tolerances

Description	Tolerance	
	Factor	Maximum (mm)
Exposed edge: Gradual departure	0.001	-
Exposed surface: Gradual departure Sudden departure	 0.004 -	 10 3

17.13 Finishing operations

17.13.1 General

All unformed surfaces shall be finished true to line and level within the tolerances specified.

All finishing operations shall be completed prior to the application of any curing. The finishing operations shall be such as to provide a dense surface free from visible surface cracking. The concrete surface shall be reworked as necessary to eliminate plastic cracking.

17.13.2 Prevention of cracking

The Contractor shall plan and control the placing, compacting, curing and finishing operations to prevent cracking in the various concrete elements.

17.13.3 Other cast-in-place surfaces

The tops of walls, kerbs, concrete barriers, headstocks and piers shall be steel trowel finished. Other surfaces may be wood float finished.

17.13.4 Special finishes

Special finishes shall be as detailed in the Drawings.

17.14 Curing

17.14.1 General

Curing periods shall be in accordance with AS 3600 Table 4.4.

Curing shall be effected by one of the methods which follow.

17.14.2 Water curing

Surfaces shall be kept moist for the period specified by continuous spraying, ponding, wet hessian or wet sand blankets.

17.14.3 Membrane curing

Membrane curing shall be effected by application of a sprayed curing compound (refer to Clause 17.2.5) or by covering with polythene sheet.

For sprayed curing compounds, two coats shall be applied with each coat at a rate of 0.2 L/m².

17.15 Early loading

No loads including loads from backfilling shall be placed on the structure for seven days and until testing as required by the Designer indicates sufficient strength has been reached.

17.16 Removal of formwork

For cast-in-situ concrete, forms, falsework and centring shall remain in position until 72 hours has elapsed. **Hold Point 13** Precast concrete shall not be removed from the formwork or formwork stripped until 40% of f'c is attained.

17.17 Surface dressing of concrete

Prior to commencing concreting operations, the Contractor shall establish procedures and standards for surface dressing and repair of concrete. The standards and procedures established shall be subject to the approval of the Administrator.

Concrete surfaces shall be free of honeycombing and pockets and free of voids larger than 20 mm in lateral dimensions or 3 mm deep.

17.17.1 Formed surfaces exposed to view

Following the removal of formwork the following operations shall be carried out to the standard approved by the Administrator:

a) all fins and other unwanted projections shall be ground off to provide a smooth surface.

b) where specified in the Drawings, surfaces shall achieve the required surface finish to AS 3610.

c) where surface finish is not specified in the Drawings, a Class 2 surface finish to AS 3610 is required. Repairs shall be a **Witness Point 9**

d) non-structural elements to be covered (such as blinding concrete) shall be Class 3 surface finish to AS 3610.

17.18 Construction joints

Construction joints shown in the Drawings are mandatory.

17.19 Requirements for no-fines concrete

This clause applies to concrete produced with no fine aggregate portion.

17.19.1 Cementitious content

Limits for no-fines concrete are as per Table 17.19.1. For no-fines concrete, the water shall be the minimum amount required for cement hydration, noting that excess water will lead to cement paste not adhering to the aggregates.

Table 17.19.1 - Minimum Cementitious Contents for No Fines Concrete

Concrete Type	Minimum Cementitious Content (kg/m³)
No-fines Concrete (10 mm)	250
No-fines Concrete (20 mm)	210

No, fines concrete is not recommended for use where (potential) acid sulfate soils are present.

17.19.2 Aggregate grading

The nominal size of the single-sized aggregate for no-fines concrete shall be as shown in the Drawings. Grading limits shall be as specified in Table 17.19.2.

Table 17.19.2 – Aggregate grading for no-fines concrete

Test Sieve (mm)	Percentage Passing by Mass	
	Nom. Size 20 mm	Nom. Size 10 mm
26.5	100	-
19	85 – 100	-
13.2	-	100
9.5	0 – 20	85 – 100
4.75	0 – 5	0 – 20
2.34	-	0 – 5
0.075	0 – 2	0 – 2

17.19.3 Compaction of no fines concrete

No-fines concrete shall be rodded sufficient only to ensure the form is completely filled. It shall be screeded to the required surface level without tamping or vibrating.

17.20 Kerb and channel concrete

This clause applies to concrete produced for kerb and channel, whether manually placed or machine placed.

17.20.1 General

Kerb and channel shall be supplied in accordance with MRTS03 *Drainage, Retaining Structures and Protective Treatments* and AS 2876.

17.20.2 Compressive strength and cementitious content

The required characteristic compressive strength or minimum cementitious content will be determined by the Designer.

Appendix A: Tracking of concrete strengths

This Appendix is an example only.

Let f'c = 40 MPa f't = 47.92 MPa 0.5 (f't + f'c) = 43.96

Docket	Lot	Date Cast	28 day Cylinder 1	28 day Cylinder 2	28 day	Average (3)[1]	Average (4 wks)[2]
0001	1	1/7/2018	51	56	56		
0002	2	2/7/2018	32	35	**35**[3]		
0003	3	3/7/2018	53	55	54		
0004	4	4/7/2018	54	54	54		
0005	4	4/7/2018	**35**[4]	41	41		
0006	4	4/7/2018	40	42	41	45.3	
0007	4	4/7/2018	37	37	37	**39.7**[5]	
0008	4	4/7/2018	52	54	53	43.7	
0009	5	5/7/2018	49	54	54		
0010	6	6/8/2018	40	43	43	50.0	
0011	6	6/8/2018	44	46	45	47.3	
0012	6	6/8/2018	43	43	43	43.7	
0013	6	6/8/2018	41	41	41	43.0	
0014	7	8/8/2018	42	42	42		
0015	7	8/8/2018	50	52	51		
0016	7	8/8/2018	41	43	42	45.0	
0017	7	8/8/2018	37	41	41	44.7	
0018	8	10/8/2018	38	40	39		
0019	8	10/8/2018	43	46	46		**43.3**[6]
0020	8	10/8/2018	51	53	52	45.7	44.1

1. Resets every lot

2. Only activates when 10 samples have been tested

3. Reject Lot 2: $\sigma < 0.9\, f'_c$

4. Not a cause of rejection, cylinder is excluded

5. Reject Lot 4: $\overline{\sigma} < f'c$

6. Provide full data to Administrator for mix reassessment: $\overline{\sigma} < 0.5\ (f'c + f't)$