TS 00149:1.0

Specification

Placement of Concrete

(ATS 5320-23, Ed 1.0 MOD)

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Preface

This Specification is the first issue as TS 00149. It adopts and modifies Austroads Technical Specification ATS 5320, Ed 1.0 as a TfNSW Specification.

This document sets out the requirements for the placement (including handling, compaction and finishing) and curing of special class concrete.

To enable industry preparation for the implementation of the requirements of this standard, there is a transitional period in place for the effective date of this document. This document will come into effect on 30 April 2025.

For the purposes of this document, where TfNSW has identically adopted, or adopted and modified, an ATS document as a Transport Standard, the corresponding Transport Standard should be applied.

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1. Scope

1.1 This Specification sets out the requirements for the placement (including handling, compaction and finishing) and curing of special class concrete.

1.2 It applies to both cast-in-place and precast applications.

1.3 It does not apply to extruded concrete, sprayed concrete and cast-in-place concrete piles.

1.4 The concrete must be supplied in accordance with TS 00146 and placed in accordance with this Specification.

1.5 Refer to the following specifications for additional requirements for precast and / or prestressed concrete:

TS 01738 Precast Concrete Members – (ATS 5325, Ed 1.0 MOD)

ATS 5326 Pretensioned Concrete Members

ATS 5327 Post Tensioning of Concrete

2. Referenced documents

2.1 The following documents are referenced in this Specification:

Australian Standards

AS 3610.1	Formwork for concrete Part 1: Documentation and surface finish
AS 3799	Liquid membrane-forming curing compounds for concrete
AS 5100.5	Bridge design – Part 5: Concrete

Austroads

ATS 5321	Maturity Method
ATS 5326	Pretensioned Concrete Members
ATS 5327	Post Tensioning of Concrete

Transport for NSW standards

TS 00077	Supply and Placement of Steel for the Reinforcement of Concrete – (ATS 5310-20, IDT)
TS 00079	Cementitious Patch Repair of Concrete – (ATS 5340-20, IDT)
TS 00080	Repair of Concrete Cracks – (ATS 5341-23, IDT)
TS 00145	Formwork for Concrete – (ATS 5305, ED 1 MOD)
TS 00146	Supply of Special Class Concrete – (ATS 5315, Ed 1.0 MOD)
TS 01738	Precast Concrete Members – (ATS 5325, Ed 1.0 MOD)
TS 02800.38 (T362)	Interim test for verification of curing regime – Sorptivity

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3. Definitions

3.1 The following definitions apply to this Specification:

Concrete Grey Card for Bridgeworks:	A card issued on behalf of TfNSW acknowledging the completion of appropriate training that permits the holder to carry out concrete placing activities in accordance with this specification.
Curing Period:	The period between the application of heat for accelerated curing and the stripping of the formwork from the concrete.
Delay Period:	The time between the completion of concrete placement and the application of heat for accelerated curing.
High Workability Concrete (HWC):	Concrete where the workability is such that it cannot be measured by the slump test and is instead specified by other properties, such as slump flow, viscosity and J-Ring passing ability. Distinct from Self-Compacting Concrete in that it does not self-consolidate.
Intense compaction:	Compaction of the plastic concrete using external vibrators attached to steel forms in conjunction with the use of internal vibrators.
Maturity Index:	An indicator of the development of compressive strength of concrete that is calculated from the temperature history of the concrete during the curing period. The maturity index is expressed in terms of a temperature-time factor (°C.h).
Principal's Registration Scheme:	Any scheme for the prequalification, registration or approval of products, quarries, manufacturers, suppliers and/or Professional Engineers in operation in the jurisdiction where the concrete is to be placed.
Professional Engineer:	A person who: a. is registered on any scheme of registration of engineers prescribed by legislation in the applicable jurisdiction; b. is appropriately registered or prequalified if the Principal has implemented an applicable registration or prequalification scheme; and c. satisfies at least one of the following requirements: i. is a Chartered Professional Engineer; or ii. holds a 4 year civil engineering degree from a university that is accredited under the Washington Accord and is registered in a relevant area of practice on the National Engineering Register (in Australia) or the Register of Chartered Professional Engineers (in New Zealand).

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Concrete Grey Card for Bridgeworks:	A card issued on behalf of TfNSW acknowledging the completion of appropriate training that permits the holder to carry out concrete placing activities in accordance with this specification.
Self-Compacting Concrete (SCC):	Concrete that is able to flow and consolidate under its own weight, completely fill the formwork even in the presence of congested steel reinforcement, whilst maintaining homogeneity. Also called self-consolidating concrete. Self-compacting concrete typically has higher filling and flowing abilities than high workability concrete (see above for definition of “high workability concrete”). Also called Self-Consolidating Concrete.
Temperature Matched Curing (TMC):	The process of matching the temperature of the water in a test specimen curing bath to the temperature of a concrete member, so that the test specimens in the bath are subjected to the same temperature history as the concrete member.
Wet Curing:	Curing at ambient temperature in which the concrete surface is effectively covered with water or placed in a fog room/chamber with a relative humidity exceeding 98%.

4. Quality System Requirements

4.1 The Contractor must prepare and implement a Quality Plan that includes the documentation in Table 4.1 at a minimum.

Table 4.1: Quality plan

Clause	Description of document
5.1	The number of personnel carrying out concreting operations, together with evidence of relevant training and experience.
5.2	The name, qualifications and experience of the Concreting Supervisor.
7.1	Details and / or procedures for concrete placement, compaction and finishing.
8.1, 8.4	Details and / or procedures for hot weather concreting and evaporation management on concrete slabs
9.2	Procedures / precautions to reduce differential temperature build-up
12.1	Details of the method of curing and any curing compounds for moist or membrane curing (where applicable)
15.1	Details and procedure for Temperature Matched Curing (where applicable)
19.1	Procedures for measurement and verification of tolerances

HOLD POINT 1	
Process Held	Supply and placement of concrete.
Submission Details	The Quality Plan must be submitted to the Principal at least 10 working days prior to the commencement of the supply and placement of concrete.

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5. Personnel

5.1 The Contractor must ensure that:

a. all personnel are suitably experienced, trained and qualified for the work that they are undertaking

b. a Concreting Supervisor is appointed to personally supervise the placement of concrete; and

c. At least half of the remaining crew involved in a concreting operation, must hold a hold a valid TfNSW Concrete Grey Card for Bridgeworks.

5.2 The Concreting Supervisor must:

a. Hold a valid TfNSW Concrete Grey Card for Bridgeworks and have at least 5 years of experience in concrete work and / or have qualifications for concrete placement, compaction, screeding, finishing and curing which are acceptable to the Principal;

b. be present during all stages of the pour until implementation of the curing regime; and

c. certify that all aspects of the placement, compaction, screeding, finishing and curing have been carried out in accordance with this Specification.

5.3 If requested by the Principal, at least 4 working hours prior to pouring concrete, a statement must be submitted to the Principal stating that the personnel meet the requirements of this Specification.

6. Concrete Casting Sequence

6.1 Unless shown otherwise on the Drawings, the casting sequence of box girders and voided slabs must comply with this Clause 6.

6.2 Box girders or voided slabs must comply with the following:

a. at least 7 days must elapse between the casting of adjacent segments;

b. segments incorporating a transverse diaphragm must be cast monolithically with the full cross section of the webs, floor and deck slab extending a distance of at least five metres from the face of the diaphragm; and

c. segments which do not incorporate transverse diaphragms must be either:

i. cast monolithically with the full cross section of webs, floor and deck slab; or

ii. cast in two stages with a construction joint provided between the webs and the deck slab, in which case the deck slab must be cast not later than 14 calendar days after the casting of the webs and floor slab.

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7. Placement and Compaction of Concrete

General

7.1 The Quality Plan must include details and / or procedures for the placement and compaction of the concrete. Where applicable to the work, this must include the following:

a. details of the plant and equipment to be used, including standby equipment;

b. the proposed rate of placement;

c. the number, type, frequency, capacity, spacing and method of support of the vibrators;

d. where applicable, the proposed casting sequence and, including the length of segments, the order of casting and whether segments are to be cast monolithically or in stages and certification the casting sequence by a Professional Engineer;

e. the method of placing concrete if the drop to the base of the concrete pour exceeds 2 m;

f. the method to ensure that vibration does not affect recently cast concrete;

g. setting out and level control for bridge deck pours and method of compaction adjacent to screed guides and repairs at screed guide supports vibrators (where applicable); and

h. where self-compacting concrete (SCC) and/or high workability concrete (HWC) is proposed, the actions required when a delivered batch of concrete does not have the required rheological properties.

7.2 The use of SCC and / or HWC is only permitted where specified on the Drawings or other Contract documents.

7.3 Prior to the supply and placement of cast-in-place concrete, the Contractor must verify that:

a. the formwork complies with TS 00145 (where applicable);

b. the reinforcing steel has been supplied and placed in accordance with TS 00077;

c. the concrete mix design complies with TS 00146;

d. all foreign material has been completely removed from the forms; and

e. the environmental requirements set out in Clause 8 will be satisfied.

HOLD POINT 2	
Process Held	Supply and placement of concrete.
Submission Details	Evidence of compliance with Clause 7.2 must be submitted to the Principal prior to the commencement of the supply and placement of concrete.

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7.4 The concrete must be handled, placed and compacted in such a manner as to:

a. prevent segregation or loss of materials;

b. prevent premature stiffening;

c. prevent nonconforming displacement of reinforcement, or embedments;

d. produce a dense homogeneous product which is monolithic between planned joints and/or the extremities of members, or both;

e. completely fill the formwork or excavation to the intended level, expel entrapped air, and completely surround all reinforcement, tendons, ducts, anchorages and embedments;

f. control cracking (including that caused by plastic and drying shrinkage), plastic settlement, crusting and thermal gradients;

7.5 If the concrete work is to be post-tensioned, refer to ATS 5327 for additional requirements for the placement of concrete around post-tensioning ducts, grout vents and anchorage zones.

Discharge of concrete

7.6 Plastic concrete must:

a. be deposited as near as possible in its final position and without moving or damaging reinforcing or formwork;

b. not be moved along or between the forms by the use of vibrators and tamping rods;

c. be placed continuously between specified or approved construction joints;

d. be placed in a manner which avoids segregation of the concrete;

e. not be placed against concrete which has taken its initial set (for this clause only, “initial set”, means that the concrete surface cannot be easily penetrated with a 12 mm bar using hand force); and

f. be spread in horizontal layers with the first layer not exceeding 350 mm in compacted thickness and the thickness of subsequent layers not exceeding 75 % of the length of the immersion vibrators being used.

7.7 However, for prestressed members less than 600 mm deep, the concrete must be built up to the full depth of the section and the concrete face moved forward progressively. For prestressed concrete members over 600 mm deep, this may occur in two or three passes.

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7.8 SCC and / or HWC must be placed in accordance with the procedures in the approved Quality Plan and the following (where applicable):

a. if HWC is used, sufficient compaction must be applied to ensure all spaces in the formwork or pile hole are filled but without causing segregation;

b. the distance of horizontal flow from the point of discharge into the formwork must be less than 10 m (SCC) or 3 m (HWC);

c. the rate of placement must comply with any limitation specified in the formwork design;

d. for columns and shafts, the point of discharge must initially be as close as possible to the bottom of the pour and then submerged within the concrete to a depth of at least 300 mm as the pour progresses upwards; and

e. although compaction is not normally required for SCC, apply supplementary compaction as required to ensure full filling of the formwork and achieving the required surface finish of the member.

7.9 The use of water in chutes to assist movement of concrete is not permitted. However, an initial flush of water immediately prior to commencement of concreting may be used, provided that the water is not discharged into the plastic concrete.

7.10 If placing operations necessitates a drop of more than 2.5 m, the concrete must be placed using a flexible tube reaching to the base of the formwork or another approved method approved to prevent segregation.

7.11 If an interruption to pouring greater than 45 minutes, or initial set has occurred, either a construction joint complying with Clause 11 is inserted or the laid concrete is rejected and replaced.

7.12 Pneumatic placers and concrete pumps may only be used where the approved concrete mix has been designed for this method of placement. The equipment must be positioned such that freshly placed concrete is not damaged by vibration. The initial discharge containing the cement slurry used to coat the pipeline must be discarded.

7.13 When concrete is placed and finished outside daylight hours or in any other conditions where natural light may be inadequate, the Contractor must provide adequate lighting for the placement, compaction, finishing, curing, sampling and testing, monitoring and inspection of the concrete.

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Compaction of concrete

7.14 The following conditions apply when using internal vibrators:

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

b. the number of vibrators to be used by the Contractor must be not less than one for each 10 m3 of concrete placed per hour, with a minimum of two vibrators to be provided at any time;

c. vibrators must be inserted vertically at successive positions not more than 450 mm apart and not exceeding the manufacturer's stated zone of influence;

d. vibration must continue at each position until approximately seven seconds have elapsed and air bubbles cease to emerge from the concrete;

e. vibrators must not be allowed to rest on the steel reinforcement, embedded fixtures or formwork;

f. vibrators must then be withdrawn slowly so as to avoid leaving an air or mortar ‘pocket’;

g. care must be taken to ensure that newly deposited concrete is vibrated into any fresh concrete adjacent to it to provide a homogeneous concrete mass;

h. concrete must not be vibrated to the point where segregation of the ingredients occurs; and

i. vibration must not be applied either directly to reinforcement or through the reinforcement to any concrete which has taken its initial set.

7.15 If specified in the Contract documents, concrete decks or slabs must be compacted by internal vibrators and vibrating screeds such that uniform consolidation is achieved throughout the deck and slab area.

7.16 Where intense compaction is specified, the use of external form vibrators is mandatory and must be accompanied by internal vibration. However, the Contractor may submit a proposal for the use of external vibration only, subject to being able to demonstrate that satisfactory compaction can be achieved.

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8. Environmental Limits for Concreting Operations

General

8.1 For cast in place concrete, the Quality Plan must include:

a. hot weather mitigation measures (if required);

b. procedure for monitoring the weather forecast and the weather conditions at the site for at least 3 days prior to the date scheduled for the pour and during the pour;

c. details of the instruments (including a Psychrometer and Anemometer) used to measure site temperature, humidity and wind speed to demonstrate compliance with this Clause 8, including the position of the instruments in relation to the concrete surface; and

d. for concrete slabs, the measures that will be taken to protect freshly placed concrete and prevent evaporative moisture loss during finishing operations, including details of the proposed evaporation retarding compound.

Hot weather concreting

8.2 If the forecast issued by the Bureau of Meteorology indicates that the ambient shade air temperature at the Site is likely to exceed 32°C (or the ambient shade air temperature actually exceeds 32°C) at any time during the concrete placement, the Contractor must implement hot weather mitigation measures. These measures must ensure that the concrete, reinforcing and formwork do not exceed the permitted maximum temperature and may include:

a. spraying reinforcement and formwork with water prior to placement of concrete;

b. spraying cold water on the concrete aggregate stockpiles at the place of manufacture;

c. the use of refrigerated water or ice in the manufacture of the concrete mix as a partial replacement of normal mix water; and

d. water mist spraying to cool the air above the placed and compacted concrete surface, provided that the water does not damage, collect or pond on the exposed concrete surfaces.

8.3 Concrete must not be placed in the Works if the temperature of any part of the formwork or reinforcement exceeds 55 °C when measured using a non-contact infrared thermometer.

Evaporation limits

8.4 When the predicted evaporation rate during the intended period of placement and finishing exceeds 0.50 kg/m²/h, measures must be taken to reduce the predicted evaporation to below this value. Contractors must submit procedures as part of the requirements in Table 4.1.

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8.5 The forecast evaporation rate must be estimated by the method specified in Clause 8.13 using the latest available data for the area from the Bureau of Meteorology and any other relevant source of data. This information must be obtained on the proposed day of construction before work commences.

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

8.7 If control measures are not successful or are impractical, concrete must not be discharged.

Evaporation retarding compound

8.8 An evaporation retarding compound must be applied to the top surface of the concrete within 10 minutes of placement and initial screeding, and any subsequent screeding or finishing operations.

8.9 Evaporation retarding compounds must:

a. primarily consist of aliphatic alcohol suitable for use on concrete;

b. be registered or approved under any Principal's Registration Scheme for evaporation retarding compounds (where applicable); and

c. be applied in accordance with the manufacturer's instructions.

8.10 Evaporative retarders do not replace curing compounds and may need several applications prior to final finishing operations in severe conditions.

Method for calculation of evaporation rates

8.11 The evaporation rate must be calculated using the following parameters, measured approximately 1.0 m above the concrete surface:

a. air temperature;

b. relative humidity;

c. concrete temperature; and

d. wind velocity.

8.12 The Contractor must submit records of these parameters and the maximum daily temperature to the Principal.

8.13 The chart in Appendix B must be used for estimating the evaporation of surface moisture from the concrete for various weather conditions as represented by the above parameters.

8.14 Any bleed water and any water that comes with the evaporation retarder must have evaporated before finishing processes proceeds.

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Protection from rain

8.15 All concrete must be placed under dry conditions. All water must be removed from the formwork before concrete is placed.

8.16 Concrete must not be poured in the rain (or if rain is imminent) unless a waterproof covering which protects all exposed surfaces of the concrete from rain and measures to prevent the inflow of water are in place.

8.17 Concrete which is exposed to rain or other precipitation within the period from placement to final set is deemed to be nonconforming.

9. Temperature Control of Large or Restrained Members

9.1 This Clause 9 only applies to a concrete member which is in one or both of the following categories:

a. A large and restrained concrete member (including crossheads, diaphragms, columns, abutments, footings and pile caps) where:

   i. the least dimension of the member exceeds 500 mm and the volume of the concrete pour exceeds 5.0 m^3; or

   ii. one or more faces of the concrete member is restrained by previously placed hardened concrete or by other external restraints.

b. A concrete member manufactured with a concrete mix containing more than 520 kg/m^3 of cementitious material or 400 kg/m3 of GP cement.

9.2 The Quality Plan must include:

a. Calculations of the temperature differential;

b. Details of the precautions to ensure that the differential temperature between the concrete core and that of the exposed concrete surface remain within the specified limits (for example: double layers of 8 mm thick closed cell foam or inner double core aluminium foil based thermal blankets); and

c. procedure for temperature monitoring and details of the placement of thermocouples.

9.3 The temperature limits in Clause 12.5 apply, unless calculations justifying a different temperature are included in the Quality Plan and the Quality Plan has been approved by the Principal.

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9.4 Temperature differential monitoring must be undertaken on at least one representative member from each of concrete member of the same dimensions and type (e.g., crosshead, diaphragm, column, abutment, footing or pile cap), provided that any required control measures to manage the differential temperature is adopted for the subsequent construction of concrete members of the same type.

9.5 Thermocouples must be placed at a range of positions within the concrete member to determine the maximum temperature and differential temperature across the section of concrete. For the purpose of measuring surface temperature, the thermocouple must be placed in the concrete approximately 30 mm from the surface and no deeper than the concrete cover to reinforcement.

9.6 For large and restrained concrete members, the following locations (at a minimum) must be monitored for temperature:

a. one at the geometric centre (core);

b. one at an upper edge;

c. two at centres of adjacent side faces (long and short side for rectangular elements, one only for circular columns).

9.7 The surface temperatures in Clause 9.6 b) and c) must be measured at the cover depth of reinforcement.

9.8 For cast-in-place piles, the temperatures in Clause 9.6 a) and c) must be measured at a depth of 2 pile diameters from the top concrete surface of the pile as poured (including an overpour). In the case of piles, the temperature sensor at the geometric centre can be installed after the completion of the pile pour.

9.9 For a concrete member manufactured with a concrete mix containing more than 520 kg/m³ of cementitious material or 400 kg/m3 of GP cement, a thermocouple must be located at the geometric centre for monitoring of the maximum temperature. For elements with concave sections, the geometric centre is the point furthest from all formwork.

9.10 The Contractor must monitor the temperature from placement for 120 hours or until the core temperature has decreased to 50 °C. Readings must be taken every 15 minutes.

9.11 A report which includes the records of the monitoring must be submitted to the Principal within 48 hours of the completion of the monitoring.

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10. Finishing of Concrete

Screeding of exposed surfaces

10.1 Immediately after placement and compaction, exposed surfaces other than decks and slabs, must be screeded off to the specified levels and finished to achieve the specified finish. Construction joints must be left rough in accordance with Clause 11.

10.2 During screeding surplus concrete must be maintained ahead of the screed to ensure full and uniform compaction to exposed concrete surfaces.

10.3 If specified in the Contract documents, concrete deck and slab surfaces must be screeded on a longitudinal direction using vibrating screeds on screeding guides. The screeding guides must be accurately set and rigidly fixed in position. Guides must be capable of sustaining construction loading without undue or permanent deflection.

10.4 Where included in the approved Quality Plan, proprietary power vibrating screeds of suitable widths may be used in narrow or constricted areas or where required by the deck and slab layout. Each new vibrating run must overlap the previous one by a minimum of 350 mm, such that uniform consolidation is achieved throughout the deck and slab area.

10.5 The proposed method of compaction adjacent to screed guides, and its proposed method and timing of repairs at screed guide supports must be included in the approved Quality Plan.

Finishing operations

10.6 All unformed surfaces must be finished true to line and level to achieve the finish specified in Clause 18 and within the tolerances specified in Clause 19.

10.7 Final finishing of exposed concrete surfaces must be carried out after all bleed water has been removed and the concrete has become sufficiently hard to support the finishing operation.

10.8 Driers (such as dry sand, cement or stone dust) must not be used to absorb free water and water must not be added to aid finishing.

10.9 The finishing operations must be undertaken to prevent cracking in the concrete surface. Any drying cracks which appear prior to initial set and before or during finishing operations must be immediately closed as required with a float.

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

10.11 The Contractor must implement adequate precautions and manage construction activities to prevent the disturbance of formwork or transmit vibrations through to recently cast concrete or projecting steel reinforcement.

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11. Construction Joints

General

11.1 The location and details of construction joints must be in accordance with the Drawings. If the Contractor proposes to insert an additional construction joint, it must submit a proposal to the Principal with certification from a Professional Engineer that the construction joint will not be detrimental to the durability or strength of the structure. The Principal is under no obligation to accept any such proposal.

HOLD POINT 3	
Process Held	Construction joint not shown on the Drawings.
Submission Details	Certification from a Professional Engineer must be submitted to the Principal at least 3 working days prior to the placement of concrete.

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

11.3 Any point at which the placing of concrete has stopped and the concrete has taken its initial set must be treated as a construction joint.

11.4 Construction joints must be perpendicular to the principal lines of stress, and in general must not be located in regions of maximum bending or maximum shear

11.5 At horizontal construction joints along all exposed faces, dressed timber strips approximately 25 mm square must be attached to the inner face of the form, and the surface of the lower concrete lift must 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.

11.6 The surface of the joint must 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).

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11.7 The roughened surface must be cleaned of foreign matter, laitance and loose or porous material. Any projecting steel reinforcement must also be cleaned. The surface must be thoroughly moistened with water and any excess surface water removed immediately to achieve saturated surface dry condition prior to placing of concrete. Membrane-curing agents must not be applied to the surface of any construction joint.

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

11.9 Where concrete is to be poured against an existing structure, the surface of that structure must be treated as a construction joint.

11.10 Before placing new concrete against concrete which has set, the forms must be re tightened.

11.11 The placing of concrete must proceed continuously from joint to joint.

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

11.13 If a dowels joint is shown on the Drawings, it must be inserted prior to placing the surrounding concrete.

11.14 If abutting concrete surfaces are designed to not bond or bind together, the surfaces must be separated by grease or other surface coatings or insertions of bituminous impregnated felt or fibreboard as shown on the Drawings.

Construction joints in marine and other aggressive environments

11.15 Construction joints located in an Exposure Classification of C1 or C2 must be prepared as follows:

a. Immediately prior to casting concrete against the joint, the surface of the joint is prepared in accordance with Clause 11.8. The surface and any projecting steel is then 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. If practical, the concrete surface is coated with a wet-to-dry epoxy resin, as approved by the Principal, followed by placement of the fresh concrete before the epoxy on the interface has hardened. Alternatively, the construction joint is dampened with water prior to placement of concrete for a period of 4 hours before concrete placement.

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Concreting of deck joint blockouts

11.16 Where concreting of deck joint blockouts occurs after concreting of the bridge deck, and the space between the blockout and the joint components is not sufficient to place and compact concrete, fill the blockouts using SCC.

11.17 The SCC must have maximum nominal aggregate size of 10 mm, 28-day compressive strength not less than 60 MPa and drying shrinkage of not more than 500 microstrain at 3 weeks or 700 microstrain at 8 weeks.

12. Curing

General

12.1 Where moist or membrane curing is used, the Quality Plan must include full details of the method of curing and any curing compounds. Refer to Clause 13 if accelerated curing is used and to ATS 5321 if the use of the Maturity Method is proposed.

12.2 The curing of unformed surfaces of concrete must commence as soon as the concrete surface has hardened. Regardless of the curing regime adopted,contractor must wet cure all cast-in-place bridge decks and approach slabs for a minimum of 72 hours immediately after finishing operations are completed. Further curing must conform to the approved curing regime, except that the curing period, for either wet or membrane curing, may be reduced by the 72 hours elapsed during wet curing. Refer to Appendix D for curing provision.

12.3 Continuous moist or membrane curing must be in place for at least the following periods:

for Exposure Classification B2 or below: 7 days

for Exposure Classification C1 and C2: 14 days.

12.4 If formwork is removed prior to the expiration of the curing period, curing of the formed surface must commence as soon as possible and in no case more than one hour from the commencement of stripping.

Concrete temperature

12.5 Unless specified otherwise or Clause 9.3 applies, the difference in temperature between two locations within the concrete must not exceed:

a. 25 °C for Concrete Strength Grade ≥ 40 MPa and aggregate is granite or has similar thermal conductivity and specific heat.

b. 20 °C for other concrete mixes.

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12.6 The concrete temperature must not exceed the following at any stage:

a. 70 °C; or

b. a temperature approved by the Principal, which may be up to 80 °C if the Contractor can demonstrate that the level of supplementary cementitious material will prevent the occurrence of Delayed Ettringite Formation (with details provided in the Quality Plan) and the Principal has approved the Quality Plan.

Moist curing

12.7 Where moist curing is used, surfaces must be kept moist for the period specified by continuous spraying, ponding, wet hessian or wet sand blankets. The water used must conform to the requirements of AS1379 Clause 2.4.

Membrane curing (compounds)

12.8 Liquid membrane-forming curing compounds and the application rate must comply with AS 3799 and be an approved product if an applicable Principal's Registration Scheme is in place.

12.9 Where membrane curing with a compound is used, the curing compound must be applied by a pressurised sprayer to give a uniform cover in accordance with the manufacturer's instructions. The sprayer must incorporate a device for continuous agitation and mixing of the compound in its container during spraying.

12.10 The curing compound must 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 must be checked by measuring the volume of compound applied to a given area.

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

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

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

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Membrane curing (sheeting)

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

13. Accelerated Curing of Concrete

General

13.1 This Clause 13 applies if accelerated curing of concrete is used,

13.2 Unless the Contractor's facilities and equipment have been previously assessed and approved by the Principal, the Quality Plan must include:

a. Details of the proposed facilities (including drawings where appropriate);

b. For hot water curing, details of the apparatus, including inlet and outlet temperature locations and locations of water channels in moulds;

c. For steam curing, details of the enclosure and steam lines;

d. The proposed number, type and location of temperature sensors; and

e. Details of the data loggers (including the rate of data logging) and any other instrumentation.

13.3 The Quality Plan must include procedures and Inspection and Test Plans for managing each stage of the curing process and verifying conformance with this Specification.

13.4 If accelerated curing ceases prior to the curing period specified in Clause 12.3, the curing must be continued by moist or membrane curing for the specified period. The break between curing processes must not exceed 30 minutes.

Equipment

13.5 If hot water accelerated (alternatively referred to as 'radiant heat') curing is used, it must be carried out by the controlled circulation of hot water through a series of steel conduits attached externally to the steel mould that transfers the heat from the hot water uniformly to the steel mould and the concrete. A purpose built tank used for the curing of concrete test cylinders must be connected to the hot water system.

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13.6 If steam curing is used, the formwork, enclosure, supports and steam lines must be maintained in good condition and arranged so that:

a. The temperature distribution around the Precast Member is uniform;

b. Steam jets do not impinge upon any part of the concrete members, test specimens or formwork or moulds;

c. Steam delivery pipes are not attached directly to any formwork or moulds;

d. The heat is allowed to circulate freely around all sides of the units;

e. The members, including the top surface, are fully enclosed; and

f. The atmosphere within each enclosure has a minimum average relative humidity of 95% over the heating and curing cycle.

13.7 The heat control system must maintain the temperature of the steam enclosure or the hot water (as applicable) at ± 5°C of the target temperature at all times.

13.8 The Contractor must ensure that sufficient instrumentation is in place to control and digitally record the relevant temperatures in accordance with this Specification until the steam enclosure or hot water jacket has been removed.

Process control

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

13.10 The application of heat to a Precast Member by means other than steam curing or the circulation of hot water in accordance with this Clause 13 is not permitted.

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

13.12 Where steam curing is used, the enclosure must be placed immediately after the completion of concrete placement. The relative humidity within the enclosure must be validated by regular spot checks using a calibrated psychrometer.

13.13 If hot water curing is used, it must be continuously applied for the duration of the curing period. Unformed exposed concrete surfaces must be covered or kept wet with a relative humidity exceeding 98% at all times to minimise evaporation from the surface of the concrete mass. Curing covers must be heat insulated to prevent surface heat loss during hot water curing and designed to prevent moisture loss from the finished concrete surface.

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13.14 The concrete temperatures must be measured for a period of 48 hours after concrete placement or until temperatures at the centre of the largest cross section have dropped to 5°C below the peak temperature, whichever occurs first. The concrete temperature must not exceed the temperature specified in Clause 12.6.

13.15 When the minimum amount of accelerated curing in accordance with clause 13.20 has not been achieved, curing of the element must be continued by one or a combination of methods specified in accordance with Clause 12. The curing must recommence within 30 minutes of the removal of the forms.

Delay period

13.16 Unless specified otherwise in the Contract documents, the Delay Period (t) in hours must be calculated as follows:

t = K / T

where

T = concrete temperature (°C) after finishing,

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

13.17 If the ambient air temperature during casting is less than 23°C, a small amount of heat may be used during the Delay Period to maintain the concrete at the temperature at which it was placed, but the surface temperature of the concrete member must not exceed 30°C.

13.18 The Delay Period must not exceed 3 hours, unless wet curing is applied in the interim period prior to heat application.

13.19 Notwithstanding Clause 13.18, if any cracking of the concrete occurs due to the premature application of heat, the Delay Period must be extended for future members to prevent a reoccurrence of the cracking.

Curing period

13.20 The application of heat must be such that the enclosure temperature or hot water temperature is raised at a linear rate not exceeding 24°C/h and the rise must not exceed 6°C in any 15 minute interval. Any further temperature rise within the curing period must be at the same rate.

13.21 Unless specified otherwise in the Contract documents, the Curing Period must not be less than:

a. The time at which a Maturity Index of 350°C.h is achieved; or

b. the time at which 70% of the specified characteristic concrete compressive strength is achieved.

13.22 After the cessation of the application of heat, the drop in temperature in the steam enclosure or hot water jacket must not exceed 30°C per hour.

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13.23 For all types of concrete member, the steam enclosure or hot water jacket must not be removed until the surface temperature of the member has cooled to within 30°C of the ambient air temperature.

13.24 For pretensioned concrete members, the transfer of prestress may be performed when the design concrete transfer strength has been achieved.

Temperature variation

13.25 At any time during the curing cycle, the temperature differential within the curing system must not exceed 10°C for a cumulative period for 30 minutes when measured as follows:

Where hot water curing is used: The difference between the inlet water temperature and the outlet water temperature.

Where steam curing is used: Between any two locations in a single bed / enclosure (Refer Table 14.3).

14. Concrete Temperature Monitoring

General

14.1 Where temperature of a concrete member is monitored for accelerated curing or for Temperature Matched Curing, the temperature must be recorded continuously or at intervals not exceeding 5 minutes. Unless specified otherwise, the monitoring must commence at the completion of the concrete pour and continue for a period of 48 hours or until temperatures have dropped to 10°C below the peak temperature, whichever occurs first.

14.2 Thermometers and recording devices must maintained in good condition and calibrated in accordance with the manufacturer’s instructions.

14.3 The standard rate of temperature monitoring set out in Table 14.3 applies, unless the Principal has approved a reduced rate of monitoring.

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Table 14.3: Location and minimum number of temperature monitoring points

Element	Location	Standard Rate	Reduced Rate
Prestressed piles	Core	1 per element	1 per bed
	Surface	1 per element	1 per bed
	Steam enclosure or hot water (1)	≤ 6 m apart	1 per pile
Prestressed decks and girders	Core	1 per element (2)	1 per bed
	Surface	1 per element (2)	1 per bed
	Steam enclosure or hot water (1)	≤ 6 m apart	≤ 20 m apart
Precast Elements (continuous enclosure) (3)	Core	≤ 10 m apart	1 per bed
	Surface	≤ 10 m apart	1 per bed
	Steam enclosure or hot water (1)	≤ 10 m apart	≤ 20 m apart
Precast Elements (individual enclosures) (4)	Core	1 per element	1 per batch (largest element)
	Surface	1 per element	1 per batch (largest element)
	Steam enclosure or hot water (1)	1 per element	1 per element

Notes:

(1) Where hot water curing is used, the water temperature must be measured at the inlet and outlet.

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

(3) Typically panels.

(4) Typically culverts.

14.4 To seek approval for a reduced rate of monitoring to apply, the Contractor must be able to demonstrate that the curing is carried out in accordance with this Specification and achieves consistent and even temperatures. Any approval for reduced monitoring will 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. Where a Principal's Registration Scheme applies, the approval will be granted under that scheme.

14.5 Thermometers and recording devices must not be disturbed or moved in any way until after the completion of curing.

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Temperature monitoring locations

14.6 Where the core temperature of a Precast Member is measured, the temperature sensor must be positioned at:

a. the geometric centre of the member's largest concrete cross-section; or

b. the centre of mass of the largest concrete volume.

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

14.8 Where the surface temperature of a Precast Member is measured, the temperature sensor must be placed in the concrete at a position which is between 30 mm and 50 mm inside the external concrete surface. It must not be deeper than the concrete cover to reinforcement.

14.9 For Precast Members with continuous cross sections along the length (for example, prestressed piles and panels) temperatures must be recorded evenly along the length.

14.10 Temperature sensors must not be in direct contact with any steel that may affect the temperature recorded by the sensor.

14.11 For steam curing, the temperature sensitive part of each thermometer must be positioned under the steam cover so that the thermometer records the minimum temperature under that cover.

14.12 For hot water curing, at a minimum, the temperature of the inlet and outlet pipes must be measured. Where the hot water jacket consists of more than one section, temperature monitoring must be undertaken for each section.

Reporting

14.13 All temperatures recorded throughout the curing process must be recorded and included a report submitted to the Principal. This includes:

a. concrete temperatures;

b. temperatures within the enclosure (where steam curing is used);

c. the temperature at the inlet and outlet for each section of the hot water jacket and the difference in temperatures (where hot water curing is used);

d. temperatures recorded in the TMC tank (where applicable); and

e. ambient air temperature at the time of removal of enclosures (if applicable) and striping from the mould.

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15. Temperature Matched Curing

15.1 Where TMC is used, the Quality Plan must include:

a. procedure or details of the methodology for undertaking TMC; and

b. the period of monitoring.

15.2 Temperature Matched Curing (TMC) must be undertaken as follows:

Steam curing: Placing the test specimen cylinders within the steam enclosure or by submerging the test specimen cylinders in a TMC tank water which is controlled by monitoring of the Precast Member temperature in accordance with Clause 15.3 c).

Hot Water Curing: Submerging the test specimen cylinders in a TMC tank. The temperature of the tank may be controlled either by the outlet hot water temperature or by monitoring of the Precast Member temperature in accordance with Clause 15.3 c).

15.3 Where a TMC tank is used to cure the test specimen cylinders:

a. the temperature of TMC tank must be controlled to within –10°C and +2°C of the temperature of the Precast Member;

b. at the time of placing the cylinders into the TMC tank, the tank temperature must be the same as the temperature of the Precast Member at the time of placement;

c. the TMC tank temperature must be monitored using a thermocouple to ensure it matches the temperature 100 mm below the surface of the member; and

d. tank temperatures must be monitored and recorded in accordance with Clause 14.13.

15.4 Where the test specimen cylinders are placed in a steam enclosure for curing, all test specimen cylinders must:

a. be placed adjacent to the lower face of the structural units which they represent;

b. be placed midway between heat input points and must be distant at least half the width of the structural unit from these input points;

c. not be placed on top of the structural units;

d. not be placed on the steam lines; and

e. not be placed directly in line with any steam jet.

15.5 At intervals not exceeding 6 months, or whenever there is a change to the curing equipment, one additional test specimen incorporating a temperature sensor, embedded centrally, must be cured in the same conditions as the other specimens to verify that the actual temperature in the specimen matches that in the Precast Member.

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16. Removal of Formwork and Loading of the Structure

16.1 For cast in place concrete, the forms, falsework and centring must remain in position until the times stated below have elapsed after completion of concreting:

a. Soffits: 7 days

b. Side forms: in accordance with Table 16.1.

Table 16.1: Retention of side forms

Exposure classification	Minimum form retention time (hours)	Minimum form retention time if early stripping is approved under Clause 16.2 (hours)
A	48	48
B1, B2	72	48
C1, C2	120	72

16.2 The Contractor may submit a proposal to the Principal for the times specified for early stripping times specified in Table 16.1 to apply, subject to achievement of 70% of the specified characteristic strength (i.e. the strength specified on the Drawings) and compliance with Clause 12 regarding concrete temperatures.

WITNESS POINT 1	
Process	Removal of formwork.
Notification	Notification of the formwork removal (and commencement of curing where required) must be submitted at least 2 working days prior to the commencement of formwork removal.

16.3 Longer formwork retention times may be required in some cases to comply with differential temperature compliance requirements (refer Clause 12.5).

16.4 In addition, the curing requirements of Clause 12 apply to the newly exposed surfaces within one hour of stripping the forms.

16.5 For precast concrete, refer to TS 01738 for formwork removal times.

16.6 Where the timing for the removal of formwork and / or early loading of the structure is based on compressive strength, sufficient test cylinder(s) must be prepared, cured and tested in accordance with TS 00146.

16.7 Construction activities must be planned and managed such that the formwork and concrete are not affected by vibration.

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16.8 Forms must be removed with care, without hammering and wedging, and in a manner which must not damage the concrete or disturb the remaining supports. Centres must be lowered gradually and uniformly in such a manner as to avoid over-stressing in any part of the structure.

16.9 Loads which may cause damage to the work must not be placed on or against any part of the structure.

16.10 Where shown on the Drawings, steel reinforcement must be left projecting for the purpose of bonding on subsequent work. The bars must not be disturbed during the specified period for curing of the concrete or be loose in the concrete.

16.11 Continuity bars must be positioned within 3 mm of the positions shown on the Drawings. The relative deviation of any two bars cross sections, taken at right angles to the longitudinal centreline of the unit over the projecting length of bar, must not exceed 3 mm.

16.12 Concrete must not be loaded until 7 days has elapsed from placement of all elements within the load path, including foundations and base slabs, and 70% of the specified characteristic strength has been obtained.

16.13 Loads which may cause damage to the work must not be placed on or against any part of the structure. Fill material must not be placed against concrete within 14 days of concrete placement.

16.14 The Contractor may submit a proposal to the Principal to apply loading earlier than specified in this Clause 16. Any such proposal must include structural calculations and certification from a Professional Engineer that the early loading will not damage the concrete member.

HOLD POINT 4	
Process Held	Early loading of the structure.
Submission Details	Calculations and certification from a Professional Engineer that the proposed early loading will not damage to concrete member must be submitted to the Principal at least 10 working days prior to the application of the loading.

17. Cracking of Concrete

17.1 The Contractor must plan and control the placing, compacting, curing and finishing operations of the concrete to prevent cracking.

17.2 At the end of the curing period, the concrete must not have cracks of width greater than 0.05 mm, measured at the concrete surface. At 28 days after placement or later, the concrete must not have cracks of width greater than 0.1 mm, measured at the concrete surface. Identify any such cracks as nonconformity. Identify any cracks regardless of their width, which extend through the full thickness of a concrete member or in the opinion of the Principal extend beyond the concrete cover, as nonconformity. The Principal may request you to take cores at the location of the cracks to determine their depths. Measure their widths and map all cracks

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identified as nonconforming. Submit to the Principal the crack maps, together with your proposed remedial actions to rectify the nonconformities, and corrective actions to prevent recurrence.

17.3 The Contractor must carry out a visual inspection for cracking of the concrete surface no earlier than 28 days after concrete placement and submit a report to the Principal which records the presence of absence of cracks on each surface.

17.4 Any cracks identified must be measured for conformity with Clause 17.2. Measurement may be by using a plastic strip gauge with fixed width lines or a hand-held optical comparator fitted with a microscope and suitable measuring scale. Live / active cracks may be measured with the use of overlapping upper and lower plastic plates bonded across the crack or steel studs bonded across the crack and movement measured with a Demec gauge or similar device.

17.5 If any cracks exceed the values in Clause 17.2 the Contractor must:

a. undertake an assessment of the cracked concrete structure (prepared by a technical specialist with a minimum of 5 years practical experience in the diagnostic assessment and investigation of concrete structures) to evaluate the influence of cracks on the load bearing capacity, serviceability and durability;

b. establish the cause(s) of the cracks, crack width, the moisture condition of the crack and whether a crack is active or inactive;

c. prepare a crack repair procedure / plan; and

d. repair the cracks in accordance with TS 00080 so that the specified durability of the concrete is achieved.

HOLD POINT 5	
Process Held	Repair of cracks
Submission Details	A crack repair procedure or plan must be submitted to the Principal at least 3 working days prior to the commencement of the crack repair.

Plastic Shrinkage Cracking

17.6 Control plastic shrinkage cracking by controlling moisture loss in accordance with Clause 8.1 d.

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Thermal Cracking

17.7 Thermal cracking is usually aggravated in large volume concrete members. Control thermal cracking by using blended cement containing fly ash or blast furnace slag, or by chilling the mix water or by insulating the concrete member. Limit the temperature of all concrete members following concrete placement to a maximum of 70°C. Model the effects of temperature increase from cement hydration in large members or/and in members that are externally restrained during production and curing. Measure adiabatic temperature rise of concrete mixes, as required.

18. Surface Finish

Formed surfaces

18.1 Unless specified otherwise, formed concrete surfaces must comply with the Class of finish shown in Table 18.1.

Table 18.1: Class of surface finish (as defined in AS 3610.1)

Structure member	Beyond 1 km from coast	Within 1 km from coast
Precast girders and piles surfaces	Class 2	Class 2
Deck soffit between precast girders	Class 2	Class 2
Piers, abutment and retaining wall surfaces exposed to view	Class 2	Class 2
Other external surfaces, including soffits of precast planks	Class 2	Class 2
Internal and permanently hidden surfaces	Class 3	Class 3

18.2 If a Class 2X surface finish is specified in the Contract documents, it means a surface finish conforming to Class 2 of AS 3610.1, except that the blowholes requirement is relaxed to that for Class 3 (refer Figure B3 of AS 3610.1).

18.3 Where bagging is used to rectify aesthetic blemishes (if permitted), it must be carried out by the following procedure:

a. Produce a plastic grout mix consisting of equal parts of cement and fine sand passing a 0.6 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.

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

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

18.4 The exposed surface of any repaired area must have a texture and colour which is uniform with the colour and texture of the surrounding concrete.

18.5 For HWC or SCC mixes construct test member(s) in accordance with Appendix C.

Unformed surfaces

18.6 Unless specified otherwise:

a. decks and approach slabs must have a broomed finish;

b. other slabs must be finished with a power trowel fitted with rotating steel floats;

c. the tops of walls, kerbs, concrete barriers, headstocks and piers must be steel trowel finished; and

d. other surfaces may be wood float finished.

18.7 Where a broomed finish is specified, the concrete surface must be broomed in a direction at right angles to the bridge centre line with a stiff-bristled broom not less than 400 mm wide or using a suitable mechanical grooving device to produce a uniformly roughened surface texture with an average depth of not less than 0.9 mm.

18.8 Refer to TS 01738 for other surface finishes applicable to Precast Members.

Damage to the concrete surface

18.9 Where the surface of the concrete is damaged and the surface may be repaired to meet the requirements for surface finish without affecting the durability of the concrete, the repair must be carried out in accordance with TS 00079 or TS 00080 as appropriate. Epoxy materials must not be used for the patch repair of concrete.

Drilling of holes in concrete members

18.10 Drilling or coring of holes in concrete members is not permitted unless shown on the Drawings.

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19. Dimensional Tolerances

19.1 The Quality Plan must include details and / or procedures for measuring of the concrete work to demonstrate compliance with the tolerances specified in this Clause 19.

19.2 The Contractor must:

a. measure each concrete member in such a way that every dimension can be checked against the specified tolerances;

b. record all measurements, and

c. tabulate the specified dimensions, actual dimensions, tolerances and identify any nonconformances in a report which is submitted to the Principal.

HOLD POINT 6	
Process Held	Any subsequent work on cast-in-place concrete or the incorporation of a precast member into the Works
Submission Details	A report of the actual dimensions of the concrete member must be submitted to the Principal prior to any subsequent work on cast-in-place concrete or the incorporation of a precast member into the Works

19.3 Fitments and embedments must be located with sufficient accuracy to prevent any misfit or misalignment between mating components.

19.4 The soffits of arches, box girders, beams and deck edges must be continuous curves or straight lines as shown on the Drawings, free from all visible irregularities.

19.5 The deviation between the specified position / dimensions and the finished concrete work must not exceed the lesser of the tolerances specified in AS 5100.5 and the tolerances set out in Tables 19.5 a) and b) (where applicable). Refer to TS 01738 and ATS 5326 for the dimensional tolerances applicable to precast concrete members (non-pretensioned) and pretensioned concrete members respectively.

Table 19.5 a): General tolerances

Item	**Tolerance (mm)**
Placing of reinforcement	± 5
Placing of post tensioning sheathing	± 5

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Table 19.5 b): Tolerances for cast in place concrete

Item	Tolerance (mm, unless shown otherwise)
1) Footings	
Plan dimensions: Formed footings and pile caps	–15 to +50
Plan dimensions: Unformed footings (when approved)	0 to +150
Thickness: < 300 mm	–5 to +25
Thickness: > 300 mm	–10 to +50
Top of footing or pile cap reduced level	–25 to +25
Departure from the plan position in any direction	± 50
2) Variation in cross section of columns, piers, pier and abutment crossheads, slabs, walls, bridge barriers, beams and similar parts (excluding deck slabs and end posts):	
< 3 m	–5 to +15
> 3 m	–10 to +25
3) Variation of cross section of end posts	–5 to +5
4) Deck	
Thickness of deck slabs (excluding allowance for correction of camber or hog)	0 to +10
Deck surface reduced level	–10 to +10
5) Deck joints	
Width of slot	–3 to +3
6) Variation from vertical or specified batter of columns, piers, walls, handrail posts and arrises	
Unexposed concrete	10 mm in 2.5 m (1/250)
Exposed concrete	5 mm in 2.5 m (1/500)
7) Variation from grades indicated on drawings for railings, kerbs and arrises	2.5 mm in 2.5 m (1/1000)
8) Reduced level of tops of pier and abutment crossheads and piers	
With pedestals	–10 to +10
Without pedestals	–5 to +5
Difference in level across width of crosshead	± 5
9) Bearing pedestals:	
Reduced level	–2.5 to +2.5
Variation from grade across the width of individual pedestals must not exceed	1 in 200
Deviation from flat surface	+1.0 to –1.0

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Item	Tolerance (mm, unless shown otherwise)
10) Departure from plan position at any level:	
Columns, piers, walls, pier and abutment crossheads, beams, slabs, kerbs, railing and other similar parts	± 25
Relative displacement of adjoining members must not exceed	± 10
11) Departure from alignment	
Rows of columns, faces of piers or walls	± 10
Handrails, faces of handrail posts, kerbs	± 5
12) Maximum allowance for irregularities in exposed concrete surfaces	
Sections less than 1 m in dimension when measured with a straightedge across the dimension of the section	± 2.5
Sections greater than 1 m in dimension when measured with a straightedge across the dimension of the section, except that when sections are greater than 2.5 m in dimension, a 2.5 m straightedge must be used	± 5
13) Irregularities in railings	2.5 mm in 2.5 m
14) Slab surface finish	5 mm in 2.5 m

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Appendix A Summary of Hold Points, Witness Points and Records

A.1 The following is a summary of the Witness Points/Hold Points that apply to this Specification and the Identified Records that the Contractor must submit to the Principal to demonstrate compliance with this Specification.

Clause	Hold point	Witness point	Identified Records
4.1	Supply and placement of concrete.		Quality Plan
7.2	Supply and placement of concrete		Verification that the formwork, reinforcing and concrete comply with the specified requirements
8.12			Weather records
9.11			Report of concrete temperature measurements for large and restrained members
11.1	Proposal for additional Construction Joint		Certification from a Professional Engineer
14.13			Report of concrete temperature records during curing
16.1		1. Removal of formwork	
16.14	Proposal for early loading of the structure		Calculations and certification from a Professional Engineer
17.3			Report of visual inspection for cracks
17.5	Repair of cracks		Crack repair procedure or plan
19.2	Any subsequent work on cast in situ concrete or incorporation of a precast member into the Works		Report of the actual dimensions of the concrete member
Annexure E	Early Trafficking of Bridge Decks		Submit the ‘strength versus age’ relationship of concrete, with supporting test results, and evidence of completion of curing

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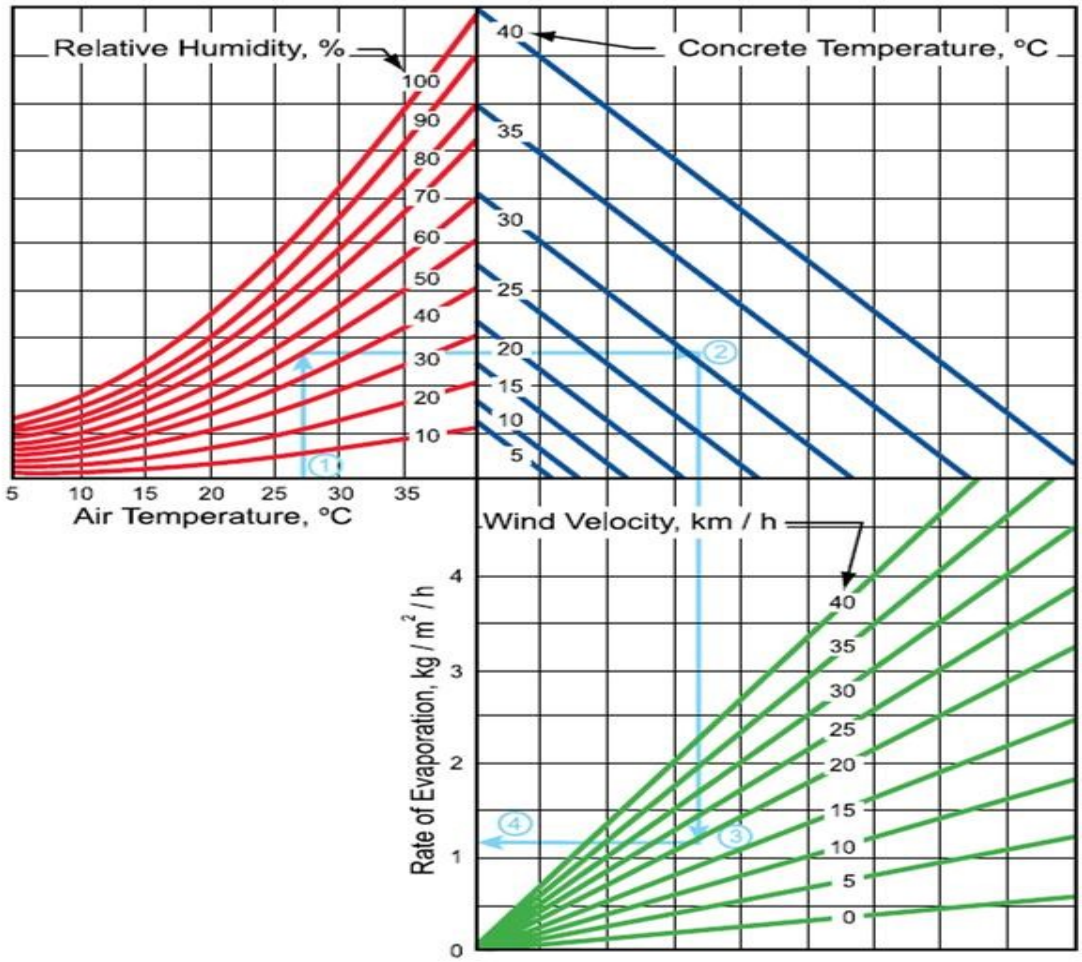
Appendix B Chart for Estimation of Water Evaporation Rate



For example – with:

- air temperature at 27°C;
- relative humidity at 50%;
- concrete temperature at 30°C; and
- a wind velocity of 20 km/hr;

the rate of evaporation would be 1.2 kg/m2/hr.

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

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Appendix C Test Members For HWC Or SCC

C.1 Where a nominated slump in excess of 180 mm is proposed, demonstrate by way of a test member in accordance with Annexure C.

C.2 Unless approved otherwise by the Principal, the above limitations on slump may be waived only for SCC or HWC.

C.3 Produce test members to demonstrate the suitability of a concrete mix for the Works where required under this clause, or if specified on the Drawings.

C.4 When test members are required, they must be designed and constructed in accordance with AS 3610.1 for test panels. The method of constructing the test members must effectively simulate the formwork, reinforcement layout and concreting operations to be applied in the Works.

C.5 Where a test member is required, conform to the following:

a. For columns, the test member must consist of a column not less than the height of the column in question or 6 m, whichever is less, with similar corner detailing and steel reinforcement layout.

b. For other members, replicate the most complex part of the member.

C.6 Cut the concreted test member as directed by the Principal to demonstrate that segregation has not occurred.

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Appendix D Curing Provision

D.1 The curing of the concrete must conform to either Curing Provision A – (Performance) or Curing Provision B – (Method), as specified in this Annexure and Specification.

Curing Provision A – (Performance)

D.2 For the exposure classifications specified on the Drawings, the effectiveness of the curing of the concrete used in the works must be in accordance with Table D1.

Table D1 – Effectiveness of Curing Provision A

Exposure classification	Maximum sorptivity penetration depth (mm)	
	Shrinkage Limited cement	Blended cement
A	35	35
B1	25	25
B2	N/A	20
C1	N/A	8
C2	N/A	8
U	In accordance with project specific requirements	

D.3 Test the effectiveness of the curing in accordance with TS 02800.38. Sorptivity testing may be carried out by laboratories other than a NATA registered laboratory for this test, if approved by the Principal.

D.4 Verify the maximum sorptivity penetration depth on a trial mix using the method and duration of curing (“curing regime”) proposed for use on the Works.

D.5 At the trial mix stage, the curing of the sorptivity test specimen must be identical to that proposed for the concrete member. At the construction stage, the curing of the concrete member must be identical to that of the sorptivity test specimen. Provide charts of the curing temperature and humidity versus time to verify that the required curing has been achieved.

Curing Provision B – (Method)

D.6 Refer to Clause 12 and 13.

D.7 For the exposure classifications specified on the Drawings, the curing regime applied under Curing Provision B must be in accordance with Tables D2, D3 and D4 (heat accelerated).

D.8 For formed surfaces, the wet curing period counts only from when the formwork is removed within 48 hours of completion of concrete placement and the surface is immediately wet cured.

D.9 Concrete made with blended cement containing amorphous silica must be wet cured only.

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Abbreviations Used in Tables D2, D3 and D4:

SL denotes Shrinkage Limited cement

BFS denotes ground granulated iron blast furnace slag blended cement

FA denotes fly ash blended cement

AS denotes amorphous silica blended cement

Y Applicable. Curing Provision B may apply for this case

N Not applicable. Curing Provision B does not apply for this case

Table D2 – Wet Curing

Exposure classification	Curing period (days)		
	SL cement	Blended cement containing BFS and/or FA	Blended cement containing AS
A	7	7	N
B1	7	7	N
B2	N	14	7
C1	N	14	7
C2	N	14	7
U	In accordance with TS 00146 Annexure C1		

Table D3 – Sealed Curing

Exposure classification	Curing period (days)	
	SL cement	Blended cement containing BFS and/or FA
A	7	7
B1	7	7
B2	N	N
C1	N	N
C2	N	N
U	In accordance with TS 00146 Annexure C1	

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Table D4 – Heat Accelerated Curing

Exposure classification	Permissibility of curing	
	SL cement	Blended cement containing BFS and/or FA and/or AS
A	Y	Y
B1	Y	Y
B2	N	Y
C1	N	Y
C2	N	Y
U	In accordance with TS 00146 Annexure C1	

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Appendix E Early Trafficking of Bridge Decks

E.1 Provisions for early trafficking of bridge decks must be in accordance with TS 00149 and the following requirements.

E.2 Strictly control trafficking of bridge decks to prevent damage to new and curing concrete. Non-essential traffic must not access the deck until the specified 28 day compressive strength of the concrete is reached or the curing is completed, whichever occurs later.

E.3 Control access by essential traffic as follows:

a. Equipment not exceeding 0.5 tonnes in weight may access the deck after 50% and before 75% of the specified 28 day compressive strength of the deck concrete is reached;

b. Other equipment must not access the deck until 75% of the specified 28 day compressive strength of the deck concrete is reached, as follows:

   i. Maximum axle loads: 5.0 tonnes single, 8.0 tonnes tandem, 9.0 tonnes triaxle;

   ii. (Tracked vehicles: maximum 15 tonnes/m^2 pressure over the track area, providing the concrete is protected from surface damage.

E.4 Carry out in-place strength assessment in accordance with Clause 9.2 at a frequency to suit the construction program. All concrete placed using the same concrete mix for which the strength versus age relationship has been determined may be assumed to have the same strength versus age relationship providing the placement and air temperatures are similar. Otherwise, adjust the strength for the actual temperatures at the Site based on maturity methodology.

E.5 Make good any damage arising from early trafficking of the bridge deck at your expense.

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