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Technical Direction – TD 00013:2023

Issue date: 15 June 2023

Effective date: 15 June 2023

Title: Clarification on placement of steel for the reinforcement of concrete – Amendments to IC-QA-B80 (TS 01733.1) QA Specification B80 *Concrete Work for Bridges*, Ed.7 Rev.6

This technical direction is issued by the Asset Management Branch (AMB) as an update to IC-QA-B80 (TS 01733.1) QA Specification B80 *Concrete Work for Bridges*, Ed.7 Rev.6.

This change is part of the national harmonisation initiative to align with Austroads technical specifications.

1 Background

TfNSW has adopted various Austroads technical specifications and published them as TfNSW specifications.

As part of the harmonisation, TfNSW has adopted ATS 5310 *Supply and Placement of Steel for the Reinforcement of Concrete* and issued as TS 00077 *Supply and Placement of Steel for the Reinforcement of Concrete – ATS 5310 Ed 1.IDT*.

TS 00077 applies to the supply, fabrication, and placement of steel (including stainless steel) reinforcement used in concrete road, marine and bridge structures, and all other incidental concrete construction.

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2 Amendment to IC-QA-B80 (TS 01733.1)

The following section in IC-QA-B80 (TS 01733.1) shall be amended as follows:

3 Section 6 Supply and fixing of steel reinforcement embedments

Delete the contents of Sections 6.1 to 6.7 in their entirety and replace with the following:

The supply and fixing of steel reinforcement and embedments shall be in accordance with TS 00077.

Authorisation:

Approved by	Director Civil Engineering Infrastructure Asset Management Branch Safety, Environment and Regulation

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TRANSPORT FOR NSW (TfNSW)

QA SPECIFICATION B80

CONCRETE WORK FOR BRIDGES

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REVISION REGISTER

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 6/Rev 0	All	Text revised to direct imperative style. Minor reformatting and editing for clarity.	GM, IC	04.04.12
	Various	Some clauses and tables re-numbered. “Cast in-situ” replaced with “cast-in-place”. “Component” and “element” changed to “member”.		
	1.3	Definitions: “Portland cements” replaced with “General Purpose cements”. Sealed curing amended to include plastic wrapping. Definition of self-compacting concrete added. Heat accelerated curing amended.		
	2.2	Name of “Cement & Concrete Users Review Group (CCURG)” updated to “Australian Technical Infrastructure Committee (ATIC)”. Requirement for taking of initial 5 kg cement sample deleted.		
	2.3.1	Use of air entraining agents clarified.		
	2.4.1	“Cl. 2.4” inserted in first paragraph. “severe exposure” classification replaced by “exposure classification C”.		
	2.4.3	Provisions for manufactured sand added.		
	Table B80.2	Tolerance on 6.7 mm sieve for 20 mm nominal size aggregate added.		
	2.5	Clause clarified.		
	Table B80.4	Amended to accord with revised RMS T363.		
	2.6	Clause on soluble salts separated into 2 sub-clauses and clarified.		

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 6/Rev 0 (cont'd)	3.2	Requirements for durability extensively modified. Concrete Durability Plan option included.		
	Table B80.6	New table on durability requirements added.		
	3.2.1	Clause deleted. Contents moved to Cl. 3.4.1.		
	3.2.2	Clause deleted. Contents moved to Cl. 3.4.2.		
	3.3	New clause for prevention of adverse effects added for clarity.		
	3.4	New clause for curing added.		
	3.4.1	Notes from Table B80.7 incorporated as second paragraph and reworded. New provisions for curing added.		
	Table B80.7	Previous Table B80.6. Heading amended. Deleted columns for "Minimum cement content" and "Maximum water/cement ratio" moved to new Table B80.6.		
	3.4.2	Sorptivity test now used to assess curing only, not durability.		
	3.5	Limits for maximum compressive strength included. Deck target strength amended.		
	3.6	Initial slump value for HRWR admixture removed. Maximum slump changed to 180 mm. "Unless otherwise approved by the Principal" added in last paragraph.		
	Table B80.8	Shrinkage limits for self-compacting concrete, slag-blended cements and exposure classification C without corrosion inhibitor added. Note clarified for precast members.		
	3.8.1	Additional conformance criteria for trial mix added in second paragraph. Tolerances clarified. Hold Point references renumbered. Additional requirement for approved concrete mix added in last paragraph.		
	3.8.2	$f_{c.max}$ added to mix design submission. Taking of initial slumps deleted for concrete containing HRWR. Mixing time prior to addition of HRWR admixture deleted. Test result for chloride resistance added.		
	3.9	Permissible admixture variation changed to 20%.		
	4.2	Aggregates to be stored SSD or wetter.		

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 6/Rev 0 (cont'd)	4.3.4	Additional items to be shown on delivery docket inserted, for better monitoring of water content.		
	4.3.5	Mixing time after addition of admixture reduced from 5 to 3 minutes.		
	4.4	Clause heading amended. Paragraph order changed. Time for checking of slumps changed from 30 to 45 minutes of adding cement or at discharge. Clauses dealing with taking of initial slumps for concrete with HRWR deleted. Additional criteria to control uniformity of concrete included in 4th paragraph. New clause on water/cement ratio added.		
	4.5	Mixing after water addition amended. Tolerances clarified.		
	5.2.3	Formwork design requirements amended.		
	5.2.4	Formwork submission requirements amended. Hold Point amended.		
	5.3.2	Term "test panel" changed to "test member" and requirements amended.		
	5.5	Construction joints for columns now to be at least 100 mm above pilecap/footing level.		
	5.6	"When left in place" added to 4th paragraph regarding use of expanded metal mesh.		
	5.7	Formwork erection requirements clarified.		
	5.8	Tolerances for slipformed parapets deleted in Table B80.11.		
	5.10	Texture and colour added to requirement for uniformity in concrete repair.		
	6.4.2	Lapped splices amended to accord with AS 3600:2009. Slipformed parapets deleted.		
	6.4.3	Link to list of RMS approved mechanical splices added.		
	6.7.2	Extensively revised. Requirements for aspros amended. Use of plastic and strip bar chairs limited.		
	6.7.3	Witness Point for cages added.		
	7.1	Concreting training by Principal deleted.		
	7.3	Witness Point amended and changed to Hold Point for precast members. Concrete Supervisor to hold Grey Card.		

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 6/Rev 0	7.4.3	Compaction requirements amended.		
(cont'd)	7.5	Cooling and covering measures on hot days after concreting added.		
	7.8	Concrete placement in water amended.		
	7.11.2.1	Deck screeding requirements amended.		
	7.11.2.5	Concrete wetting clarified. Use of finishing aids clarified. Additional option for concrete finishing added in bullet point (a).		
	7.12.1	Curing clarified.		
	7.12.2	Wet curing clarified.		
	7.12.3.2	Additional condition on application of curing compounds added in tenth paragraph.		
	Table B80.18	Lower limit on non-volatile content for all curing compounds added.		
	7.12.3.3	Sealed curing using plastic wrapping added.		
	7.12.4.1	Presetting period amended to include concrete maturity. Maximum steam curing temperature now 70°C for all exposure classifications.		
	7.13	Slipformed barriers not permitted.		
	7.14	Preparation of deck joint blockout clarified.		
	7.15	Completion of deck curing required before traffic allowed.		
	8.1	Taking of cores limited. Restoration of core holes clarified.		
	8.2	Concrete with representative compressive strength exceeding 100 MPa deemed nonconforming added.		
	Annex A2	Items added for self-compacting concrete and deck screeding using power screeds and height pins. Items rearranged in sequence. Slipformed barriers deleted.		
	Annex B1.2	Additional compliance criteria for concrete compressive strength added in first paragraph.		
	Annex C	New Witness Point for reinforcement cages added. Witness Point for precast members changed to Hold Point.		
	Annex D	New item for concrete mix designs added with other minor amendments.		

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 6/Rev 0 (cont'd)	Annex E	Tables for curing Provision B extensively amended to accord with amended durability provisions.		
	Annex F	Duplications with remainder of specification deleted. Welding of stainless steel reinforcement restricted.		
	Annex G	New annexure containing requirements for self-compacting concrete added.		
	Annex L1	Cl. 2 – minimum frequency of testing added. Cl. 2.4.3(c) – manufactured sand added. Cls. 8.2 and 8.3 – slipformed parapets deleted.		
	Annex L3	Cores to be taken as directed by Principal. Conditions for extracting core specimens from concrete and procedure for identification of rebar locations added.		
	Annex L5.1	Slipformed parapets deleted.		
	Annex M1	Nordtest Methods added. ISSA Technical Bulletin No 145 added.		
Ed 6/Rev 1	7.14	Use of flowable mortar to fill blockouts clarified.	GM, IC	27.06.12
Ed 6/Rev 2	7.1	Hold Point amended to accord with earlier statement that at least half of the concreting crew must hold a Grey Card.	GM, IC	31.08.12
Ed 6/Rev 3	7.6	Use of evaporation retarder clarified.	GM, IC	22.04.13
Ed 6/Rev 4	Global	Typos corrected.	GM, IC W Stalder	23.05.13
	5.8	Table 11 reformatted.		
	Annex M	AS 2349 (superseded) removed from list of Referenced Documents.		
Ed 6/Rev 5	5.6	Fibre reinforced cement sheets permitted for use as hidden formwork. Use of particleboard, chip board or masonite as hidden formwork prohibited.	GM, IC	10.07.13
Ed 6/Rev 6	5.2.3	References to "B204" and "B240" replaced by "B201".	DCS	27.10.17
	6.3.3, Annex F4.3	Reference to "B204" replaced by "B203".		
	Annex M	Referenced documents updated.		
Ed 6/Rev 7	6.3.3	Word "Grade" before "500L" deleted.	MCQ	27.11.17

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 6/Rev 8	1.3	Definition of "high workability concrete" added.	DCS	07.09.18
	3.6	Waiver of slump limits requirement extended to high workability concrete.		
	7.8	Clause amended to include high workability concrete for use as tremie concrete.		
	Annex A2	Section on particular bridge members for which self-compacting concrete is permitted expanded to include high workability concrete.		
	Annex D	Planning Documents updated.		
	Annex G	Annexure expanded to include requirements for high workability concrete.		
		Clauses rearranged and edited to suit. Headings added to form new sub-clauses.		
Ed 7/Rev 0	Global	Clauses rearranged and reworded to improve clarity.	DCS	29.08.19
		Exposure class C updated to C1 and C2, except where it is in relation to AS 2758.1.		
		Reference to formwork standard updated to AS 3610.1.		
	1.3	Definitions for "fitment", "Structural Engineer", and "limits of deviation" added. Definition of SCC clarified.		
	2.2	Cement types clarified, and requirements aligned with spec 3211, including representative cement grab sample.		
	2.3.2	Heading added to form new sub-clause on air entraining agent. Subsequent sub-clause renumbered.		
	2.4.1	Clarification added that where conflicting requirements occur, B80 requirements take precedence over that in AS 2758.1.		
		Conditional use of nonconforming aggregate grading deleted.		
	2.4.1, 2.4.2 (e)	Exposure class C clarified to be as per AS 2758.1.		
	2.4.2	Previous Tables 1 and 2 combined to form new Table 1 for coarse aggregates.		
	2.4.3	Fine aggregate grading revised in Table 2 (previously Table 3).		
		Individual clauses rearranged.		
	2.4.3	Notes added to Table 2 allowing for higher limits at 600 and 300 µm (for SCC and HWC) and at 75 µm.		

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 7/Rev 0 (cont'd)		MBV requirement now applicable to all fine aggregate used, not just manufactured sand as previously. Test method for MBV changed.		
	2.5.3	Table 3: AAR classifications and actions required for control of potential AAR revised. Notes added to table: – allowing use of ternary blended cements outside the limits in spec 3211. – AAR concrete prism test to be in accordance with AS 1141.60.2, instead of RMS T364 previously, and using only GP cement to prepare specimens.		
	2.6	New clause on water properties added, including new Table 4. Subsequent clauses renumbered.		
	2.7	Previously clause 2.6 on soluble salts. Individual clauses rearranged and headings re-titled.		
	2.7.1, 2.7.3	AS 1012.20.1 specified for sulfate testing.		
	3.1	1st paragraph of previous clause 3.1 merged with1st paragraph of previous clause 3.2.		
	3.2	Headings added to form new sub-clauses 3.2.1 to 3.2.4.		
	3.2.1	Upper limit of minimum 28 day compressive strength increased to 40 MPa. Use of SCC and HWC cross referred to Annex G and A2. Table 6: – Table reformatted. – Requirements now shown separately for exposure classes C1 and C2. – Upper limit of cement content increased for exposure class B1 cast-in-place concrete. – Lower limit of $f_{c.min(d)}$ reduced for exposure class A and B2 precast concrete. – New notes added and existing notes amended.		
	3.2.2	Previously sub-clause 3.3.7 on chloride ingress.		
	3.2.3	Previously sub-clause 3.3.6 on acid sulfate soils.		
	3.2.4	New sub-clause on concrete durability plan, incorporating part of previous clause 3.2, reworded.		

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 7/Rev 0 (cont'd)	3.3	Previously sub-clause 3.3.5 on cracking. Lower tiered sub-clauses renumbered.		
	3.3.2	Previously sub-clause 3.3.5.2, amended to cover restrained members.		
	3.4	Previously clause 3.3 on prevention of adverse effects in mix design, reformatted.		
		Previous sub-clauses 3.3.5.1 and 3.3.5.2 moved to clause 3.3.		
	3.5	Previously clause 3.4 on curing provision. Lower tiered sub-clauses renumbered.		
	3.6	Previously clause 3.5 on target strength.		
		Upper limit of target strength for cast-in-place deck concrete increased to 46 MPa. Exception for exposure class B2 deleted.		
	3.7	Previously clause 3.6 on slump limitations.		
	3.8	Previously clause 3.7 on shrinkage limitations.		
		Table 8 notes: Lower limit of GGBFS content specified.		
	3.9	Previously clause 3.8 on nominated mixes. Lower tiered sub-clauses renumbered.		
	3.9.1	Lead time for nominated mix details submission in Hold Point increased to 4 weeks.		
	3.9.2	New sub-clause on trial mix, incorporating parts of previous sub-clause 3.8.1.		
		Requirements for water used in trial mix specified.		
		Testing required for additional trial mix at lowest w/c ratio clarified.		
	3.9.3	Previously sub-clause 3.8.2 on submission details for new mix design.		
		Recycled water test results to be included in submission.		
	3.9.4	Previously clause 3.9 on variation to nominated mixes.		
		Limits of variation to admixture deleted and to only to be within manufacturer's recommendations.		
	4.1	Statement on nomination of $M_{control}$ deleted, to avoid repetition.		
	4.4	Previously sub-clause 4.3.4 on concrete delivery. Headings added to form new sub-clauses 4.4.1 and 4.4.2.		

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Ed 7/Rev 0 (cont'd)	4.4.3	Previously sub-clause 4.3.5 on time limit for completion of placing and compaction from time of batching.		
	4.4.4	Previously clause 4.6 on concrete temperature at point of delivery.		
	4.5	Previously clause 4.4 on slump and water/cement ratio tolerances, reworded.		
	4.6	Previously clause 4.5 on addition of water to mixed concrete batch.		
	5.1	Statement added on design and fabrication of formwork to produce specified class of finish (requirements moved to clause 9.5).		
	5.2.1	New sub-clause on formwork design, incorporating parts of previous clause 5.1, sub-clause 5.2.3 and entire sub-clause 5.2.1 and entire clause 5.4.		
	5.2.2	New sub-clause on formwork documentation, incorporating parts of previous sub-clauses 5.2.2 and 5.2.3.		
	5.2.3	Previously clause 5.2.4 on formwork documentation submission and certification.		
		Previous Tables 9 and 10 combined to form new Table 9. Clause reworded to suit.		
		Lead time specified for formwork submission in Hold Point.		
		3rd and 4th paragraph of previous clause 5.2.4 made into notes to new Table 9.		
	5.3	Previously clause 5.3.2 on test member.		
		Hold Point changed to Witness Point.		
	5.4	Previously clause 5.6. Headings added to form new sub-clauses 5.4.1 to 5.4.4. Individual clauses rearranged.		
	5.5	Previously clause 5.7 on formwork erection.		
	5.5.1	Previously sub-clause 5.7.1, incorporating parts of previous clause 5.6 and sub-clause 5.7.2.		
	5.5.2	New sub-clause on formwork at construction joints, incorporating parts of previous clause 5.5.		
	5.6	New clause on surface treatment of forms, incorporating parts of previous sub-clause 5.7.1.		
	5.7	Previously clause 5.7.2 on surveying control.		
		Previous clause 5.8 on dimensional tolerances moved to clause 9.3.		

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 7/Rev 0 (cont'd)	5.8	Previously clause 5.9 on removal of formwork. Lower tiered sub-clauses renumbered.		
	5.8.2	Previously sub-clause 5.9.2.		
		Additional factor governing minimum stripping times inserted.		
		Minimum strength before stripping for vertical surfaces increased to 15 MPa in Table 10 (previously Table 12).		
	5.9	Previously clause 7.13, on prohibition of slipforming for concrete barriers.		
	6.1.1	Previously clause 6.1, re-titled.		
		Certification requirements for reinforcement supplier clarified.		
	6.1.2	Previous sub-clause 6.2.1 on reinforcement type and grade, reworded.		
	6.1.3	Previously sub-clause 6.2.2 on protective coating of reinforcement.		
	6.1.4	New sub-clause on storage and protection of reinforcement, incorporating previous sub-clauses 6.5 and 6.6.		
	6.2	New clause on chairs and spacers, incorporating part of previous sub-clause 6.7.2. Headings added to form new sub-clauses 6.2.1 to 6.2.3.		
	6.2.1	Chairs and spacers to comply with AS/NZS 2425.		
	6.2.2	Fibre reinforced concrete chairs and spacers mandated for concrete under exposure classes C1 and C2.		
	6.2.3	Prohibited chairs and spacers clarified.		
	6.3.1	Previously part of clause 6.1.		
		Certification requirements for fabricator clarified.		
	6.3.2	New sub-clause on reinforcement fabrication, incorporating previous sub-clause 6.3.1 and parts of sub-clause 6.3.2.		
	6.3.2	Bending by heating may be approved for carbon steel reinforcement, but prohibited for stainless steel reinforcement.		
		Requirements clarified for unavoidable re-bending or straightening of bars in rehabilitation work.		

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 7/Rev 0 (cont'd)	6.3.3	New sub-clause on fabrication tolerances incorporating parts of previous clause 6.9.		
		Note added to Table 12 clarifying convention for +ve and -ve values.		
	6.4.2	Lapped splice lengths cross referred to AS 5100.		
		Previous Table 14 on splice lengths deleted.		
	6.5	Previous sub-clause 6.3.3 on welding of reinforcement.		
	6.6	Previous sub-clause 6.7.3, on assembly of reinforcement. Headings added to form new sub-clauses 6.6.1 and 6.6.2.		
	6.7.1	Previous clause 6.7.2, on support of reinforcement. Chair and spacer requirements in previous clause moved to clause 6.2.		
	6.7.2	Previously clause 6.7.5 on placement of embedments.		
		Requirements on cast-in fasteners added.		
	6.7.3	Previously clause 6.7.6, on inspection of reinforcement and embedments.		
	6.7.4	Previously clause 6.8, on cover.		
	6.7.5	New sub-clause on location and cover tolerances, incorporating parts of previous clause 6.9.		
	7.1.1, 7.1.2	New sub-clauses incorporating parts of previous clause 7.1.		
	7.1.3	Previously clause 7.7 on concreting outside daylight hours.		
	7.2	New clause on concreting personnel, incorporating parts of previous clauses 7.1 and 7.3, rearranged under 3 sub-clauses.		
	7.3	Previous clause 7.5 on weather conditions, rearranged under 3 sub-clauses.		
	7.4	Previous clause 7.9 on preparation of construction joint surfaces, rearranged under 3 sub-clauses.		
	7.5	Previous clause 7.3 on certification prior to concreting, rearranged under 2 sub-clauses.		
	7.6	Previously clause 7.4. Heading added to form new sub-clause 7.6.3. Subsequent sub-clause renumbered.		
	7.7	Previous clause 7.8 on concreting in water.		
		Bleeding and washout resistance assessment of concrete placed in water added.		

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 7/Rev 0 (cont'd)	7.8	Previously clause 7.10 on additional requirements for voided slab construction.		
	7.9	Previous clause 7.14 on concreting of deck joint blockouts. Material to be used changed to SCC from flowable mortar previously.		
	7.10	Previously clause 7.6 on moisture loss control, rearranged under 3 sub-clauses.		
	7.11.1	Previously sub-clause 7.11.2.1, re-titled to "equipment and set up".		
		Previous sub-clause 7.11.2.1 on finishing procedures moved to Annex D.		
	7.11.2	Previously sub-clause 7.11.2.3 on screeding.		
	7.11.3	Previously sub-clause 7.11.2.5 on finishing, incorporating previous sub-clause 7.11.2.4.		
		Finishing by wood floating and steel trowelling deleted.		
	7.12	Previously sub-clause 7.11.1 on screeding and finishing of other unformed surfaces.		
		Previous clause 7.15 moved to clause 9.9.		
	8	Previously clause 7.12 on curing. Lower tiered sub-clauses renumbered.		
	8.2	Previously sub-clause 7.12.3.2 on curing compounds, rearranged under three sub-clauses.		
	8.3	Previous sub-clause 7.12.2 on wet curing. Individual clauses rearranged.		
	8.4	Previously clause 7.12.3 on sealed curing. Parts of previous clause 7.12.3.2 moved to clause 8.2.		
	8.5	Previously clause 7.12.4 on heat accelerated curing. Lower tiered sub-clauses renumbered.		
	9	Previously clause 8 on conformity requirements for hardened concrete. Lower tiered sub-clauses renumbered accordingly.		
	9.1	Previously clause 8.1. Core sample requirements moved to Annex L3.		
	9.3	Previously clause 7.2 on cracking.		
		Requirements for deep cracks added.		
	9.4	Previously clause 5.8 on dimensional tolerances.		
		Table 16 (previously Table 11) reorganised under member type and reworded.		

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 7/Rev 0 (cont'd)	9.5	Previously clause 5.3.1 on class of finish. Requirements shown tabulated in new Table 17.		
		Surface finish for unformed surfaces cross referred to clauses 7.11 and 7.12.		
	9.6	Previously clause 8.3 on compaction.		
		Cores taken only when directed by the Principal. Determination of unit mass clarified.		
	9.7	Previously clause 8.4 on cover deficiencies.		
	9.8	Previously clause 5.10 on repairs to surfaces.		
	9.9	Previously clause 7.15 on early trafficking of bridge decks.		
		Lead time for submission specified in Hold Point.		
	Annex A	Guidance notes for completion of Annex A added.		
		Table A.1 reformatted. Note to clause A1.3 deleted. New Table A.2 added to clause A2.1. Provision for inserting test member requirements added in Clause A4.		
	Annex C, D	Schedules updated.		
	Annex E	Requirements now shown separately for exposure classes C1 and C2.		
	Annex F.2	References for stainless steel strength grade revised.		
	Annex G	Table G.1: Notes for VSI rating and Δ Spread amended. Table G.2: Notes for VSI rating amended.		
		Slump applicability clarified in clause G6.1.		
		Photographic evidence requirement added in clauses G3 and G7.		
		Table G.3: Testing for passing ability to EN 12350-12 added. Note added to table on penetration test.		
	Annex G	Table G.4: Notes added to table.		
	Annex L1	Table revised for testing of corrosion inhibitor and MBV.		
	Annex L3	Requirements on taking of core samples expanded.		
	Annex L4	Clause revised to cover testing requirements.		
	Annex L5	Heading titles changed.		
		Part of previous clause L5.2 used as new clause L.5.3.		

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 7/Rev 0 (cont'd)	Annex L6 Annex M	Previous sub-clause L6.1.1 on identification of work lots deleted. Previous sub-clauses L6.1.2 to L6.1.5 renumbered as sub-clause L6.2 to L6.5. Previous clause L6.2 on statistical techniques deleted. Referenced Documents updated.		
Ed 7/Rev 1	5.4 Annex D	Previous clause 5.5 on construction joints reinstated. Subsequent clauses renumbered. Clause reference updated.	MCQ	03.10.19
Ed 7/Rev 2	2.4.3	% passing limit for SCC and HWC in Table 2 Note (2) corrected to "8 – 40".	MCQ	01.11.19
Ed 7/Rev 3	Global	References to "Roads and Maritime Services" or "RMS" changed to "Transport for NSW" or "TfNSW".	DCS	22.06.20
Ed 7/Rev 4	2.4.1 2.4.2 2.4.3 2.5, 2.6 2.7.1	Requirement of sample and testing of aggregate to be in accordance with AS 2758.1 added. Limits added for 75 µm and 2 µm in coarse aggregate as per AS 2758.1. Clarification added that for combined coarse aggregates, mass passing may be calculated from individual aggregate test results. Grading for fine aggregate relaxed and renamed as Envelopes "A" and "B". New performance-based grading named Envelope "C" along with acceptance criteria included. Limits added for 2 µm in fine aggregate as per AS 2758.1. Major changes to AAR control requirements. Previous method of AAR control amended and named as "deemed-to-comply approach". "Performance-based approach" for AAR control introduced. New Tables 4 and 5 added. Subsequent tables renumbered. Fig 1 and Fig 2 showing flowcharts for the "deemed-to-comply approach" and "performance-based approach" introduced. New requirements for management of AAR at quarries added. Alternative test methods for impurities in recycled water added.	DCS	17.12.20

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 7/Rev 4 (cont'd)	2.7.2	Quality records for management of recycled water is now required to be submitted to the Principal.		
	2.8.1 (b), 2.8.3	Requirements reworded to improve clarity.		
	3.2	Table B80.8 – previously Table B80.6. Entries under "Concrete Application" column now based on heat accelerated curing.		
	3.9.2	The requirement to use in trial mix same water source as that for production removed. Evidence of quality control of recycled water in batch plants now included in mix submission.		
	3.9.3	Item (a) (iii) amended to reflect the amended requirements for recycled water submission in Clause 3.9.2.		
	Annex G3.1, G7.1	Requirement for SCC test specimens to fill mould without compaction clarified.		
	Annex L1	Minimum frequency of coarse and fine aggregates amended to incorporate changes in Clauses 2.4.2 and 2.4.3.		
		New requirements included for fine aggregate grading Envelope "C".		
		Recycled water testing added.		
	Annex L2	Compaction requirements of concrete test cylinders clarified.		
	Annex M	Reference documents updated.		
Ed 7/Rev 5	Annex L1	Testing of coarse aggregate for size < 2 µm added to reflect Item (e) in Clause 2.4.2.	MCQ	03.02.21
Ed 7/Rev 6	Clause 2.4.2	Item (e) requirements of coarse aggregate percentage passing 2 µm sieve clarified		30.05.2023
	Clause 2.4.3	Item a) notes (4) amended to fine aggregate instead of 'fine and coarse aggregate'		
		Item (g) requirements of fine aggregate percentage passing 2 µm sieve clarified		
	Clause 2.5.3	AAR tests requirements clarified		
	Clause 3.2.1	Table B80.1, notes (2) statement 'For heat accelerated curing, initially cure test specimens in identical environment to concrete member, then moist cure them till testing 'is deleted		
	Clause 3.9.3 b)	Additional information added 'HWC and SCC – nominated spread flow slump'		
	Clause 3.9.3 e)	Title updated to other Test Results for Fresh and Hardened Concrete Characteristics		

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
		Additional information added 'for HWC/SCC fresh properties in accordance with Annexure G including photographic evidence'.		
	Annexure A2	Clause a) 'cast in place piles' deleted and Clause c) amended		
	Annexure A4	Title updated to 'Test members for placement and surface finish requirements'		
		Additional clause number and clause added		
	Annex L4.3	Clause amended		
	Annexure G	Table B80/G.1 and Table B80/G.2 notes updated for stability property		

Transport for NSW

QA SPECIFICATION B80

CONCRETE WORK FOR BRIDGES

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FOREWORD

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REVISIONS TO PREVIOUS VERSION

This document has been revised from Specification TfNSW B80 Edition 7 Revision 4.

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

PROJECT SPECIFIC CHANGES

Any project specific changes are indicated in the following manner:

(a) Text which is additional to the base document and which is included in the Specification is shown in bold italics e.g. ***Additional Text***.

(b) Text which has been deleted from the base document and which is not included in the Specification is shown struck out e.g. ~~Deleted Text~~.

TfNSW QA SPECIFICATION B80

CONCRETE WORK FOR BRIDGES

1 GENERAL

1.1 SCOPE

This Specification sets out the requirements for bridgeworks for:

(a) supply of all concrete, cement mortar and grout for cast-in-place and precast concrete members used in the Works;

(b) design, construction, erection and removal of the formwork;

(c) supply, fabrication and fixing of steel reinforcement and other embedded items;

(d) placing, compacting, finishing and curing of the concrete, cement mortar and grout.

1.2 STRUCTURE OF THE SPECIFICATION

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

1.2.1 Project Specific Requirements

Project specific details of work are shown in Annexure B80/A.

1.2.2 Resolution of Nonconformities

Acceptance of materials and work will be in accordance with Annexure B80/B.

1.2.3 Schedules of HOLD POINTS, WITNESS POINTS and Identified Records

The schedules in Annexure B80/C list the **HOLD POINTS** and **WITNESS POINTS** that must be observed. Refer to Specification TfNSW Q for definitions of **HOLD POINTS** and **WITNESS POINTS**.

The records listed in Annexure B80/C are **Identified Records** for the purposes of TfNSW Q Annexure Q/E.

1.2.4 Planning Documents

The PROJECT QUALITY PLAN must include each of the documents and requirements listed in Annexure B80/D and must be implemented.

1.2.5 Frequency of Testing

The Inspection and Test Plan must nominate the proposed frequency of testing to verify conformity of the item, which must not be less than the frequency specified in Annexure B80/L. Where a minimum frequency is not specified, nominate an appropriate frequency. Frequency of testing must conform to the requirements of TfNSW Q.

You may propose to the Principal a reduced minimum frequency of testing. The proposal must be supported by a statistical analysis verifying consistent process capability and product characteristics. The Principal may vary or restore the specified minimum frequency of testing, either provisionally or permanently, at any time.

1.2.6 Referenced Documents

Unless otherwise specified, the applicable issue of a referenced document, other than a TfNSW Specification, is the issue current at the date one week before the closing date for tenders, or where no issue is current at that date, the most recent issue.

Standards, specifications and test methods are referred to in abbreviated form (e.g. AS 1234). For convenience, the full titles are given in Annexure B80/M.

1.3 DEFINITIONS

The terms "you" and "your" mean "the Contractor" and "the Contractor's" respectively.

The following definitions apply to this Specification:

Cement	Material conforming to Specification TfNSW 3211, comprising cements and supplementary cementitious materials (SCMs).
Cement mortar	A mixture of cement, water and fine aggregate, with or without the addition of chemical admixtures or other materials, proportioned to produce a plastic mixture without segregation of the constituents, all of which separately and when combined conform to this Specification, with a compressive strength at 28 days not less than 40 MPa at bearings and expansion joints and 32 MPa elsewhere.
Concrete	A thoroughly mixed combination of cement, aggregates and water, with or without the addition of chemical admixtures or other materials, all of which separately and when combined conform to this Specification.
Cover	The distance between the surface of steel reinforcement and the nearest permanent surface of the concrete excluding any surface finishing material.
Curing	The control of temperature and moisture in the concrete until the concrete has developed the required properties.
Exposure Classification	Refer to AS 5100.5.
Fitment	A unit of reinforcement commonly known as a tie, stirrup, ligature or helix.
Grout	A mixture of cement and water, with or without the addition of fine sand or chemical admixtures or other materials, proportioned to produce a pourable liquid without segregation of the constituents, all of which separately and when combined conform to this Specification with a compressive strength at 28 days not less than 32 MPa when sampled and tested in accordance with Test Method TfNSW T375.

Heat accelerated curing	Curing at mechanically elevated concrete temperatures not exceeding 70°C during which time the concrete surface is protected against immature drying. Steam curing at atmospheric pressure is typical heat accelerated curing. Steam curing at high pressure (autoclaving) is excluded from this definition.
High workability concrete (HWC)	Concrete that is able to flow, consolidate and completely fill the formwork, even in the presence of congested steel reinforcement, and maintain its homogeneity with minimal compaction.
Limits of deviation (aggregate grading)	The maximum variations in percentage passing between the grading nominated for a trial mix and the actual grading during supply of that mix.
Sealed curing	Curing at ambient temperature in which the concrete surface is sealed by the retention in place of impermeable forms or by applying at least two coats of a curing compound conforming to this Specification or by using tight, fully sealed plastic wrapping.
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. Typically self-compacting concrete has higher filling and flowing abilities than high workability concrete (see above for definition of "high workability concrete").
Standard moist-curing conditions	Refer to AS 1012.8.1.
Structural Engineer	A Professional Engineer who is a Chartered Member of Engineers Australia (or equivalent) practising in the field of structural engineering. An equivalent to membership of Engineers Australia would be an Engineer registered on the National Engineering Register (NER) in the general area of practice of Structural Engineering.
Water/cement ratio	The ratio, by mass, of total free water including water contained in admixture solutions, to total cement, including all supplementary cementitious materials, in the concrete mix.
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%.

2 CONSTITUENT MATERIALS FOR CONCRETE, MORTAR AND GROUT

2.1 GENERAL

Materials for concrete, cement mortar and grout must conform to AS 1379 and this Specification.

2.2 CEMENT

Cements including supplementary cementitious materials (SCMs) used in the Works must conform to Specification TfNSW 3211.

Use only the cement types specified in Annexure 3211/A of TfNSW 3211.

Deliver to the Principal a minimum of 5 kg representative grab sample of cement to be used in the Works, in accordance with TfNSW 3211.

2.3 ADMIXTURES

2.3.1 General

Chemical admixtures, including corrosion inhibitors, and their use must conform to AS 1478.1.

Admixtures must not contain calcium chloride.

Where two or more admixtures are proposed for incorporation into a concrete mix, their compatibility must be certified by the manufacturers.

Submit details of the requirements for storage, preparation and, where relevant, mixing the admixtures.

2.3.2 Air Entraining Agent

Add an air entraining agent only when specified on the Drawings or elsewhere in the contract documents.

2.3.3 Corrosion Inhibitors

Where used, corrosion inhibitors must contain a minimum of 30% of calcium nitrite solids, and the corrosion inhibitor application rate must be such that the concrete contains a minimum of 9 kg of calcium nitrite solids per cubic metre.

Where retarders additional to those already present in the corrosion inhibitor are used to further modify the acceleration characteristics of the corrosion inhibitor, the retarders must be added to the concrete before or together with the admixture.

2.4 AGGREGATES

2.4.1 General

All aggregates used in the Works must conform to AS 2758.1 and Clauses 2.4, 2.5 and 2.6 of this Specification. Where the requirements of this Specification and AS 2758.1 are in conflict, the former will take precedence.

For concrete mixes used for construction of wearing surfaces under all exposure classifications, the durability of the aggregate used must conform to the requirements of AS 2758.1 for exposure classification C.

Sample and test aggregates in accordance with AS 2758.1.

2.4.2 Additional Requirements for Coarse Aggregate

(a) Do not use lightweight coarse aggregate;

(b) Use only graded coarse aggregate with maximum nominal sizes of 20 mm, 14 mm or 10 mm;

(c) The particle size distribution nominated in terms of the percentage passing and limits of deviation (refer Clause 1.3 for definition) must conform to Table B80.1.

Where more than one type of coarse aggregate is proposed for use in the mix, the resulting blend must conform to the requirements in Table B80.1 corresponding to the maximum size of aggregate in the blended coarse aggregate.

Table B80.1 – Coarse Aggregate –
Particle Size Distribution Requirements and Limits of Deviation

Sieve aperture	**Mass of sample passing** (%)			**Limits of deviation** (%)		
	Nominal aggregate size (mm)			**Nominal aggregate size** (mm)		
	20	**14**	**10**	**20**	**14**	**10**
26.5 mm	100	–	–	–	–	–
19.0 mm	85 – 100	100	–	±5	–	–
13.2 mm	–	85 – 100	100	±10	±10	–
9.5 mm	25 – 55	–	85 – 100	±10	±10	±10
6.7 mm	–	25 – 55	–	±10	±10	±10
4.75 mm	0 – 10	–	0 – 20	±5	±5	±10
2.36 mm	0 – 5	0 – 10	0 – 5	–	–	–

(d) The quantity passing the 75 µm sieve must not exceed 2% of the total coarse aggregate (by mass) where tested in accordance with AS 1141.11.1 or AS 1141.12;

(e) If the percentage passing 75 µm for a coarse aggregate is ≥ 1%, the material finer than 2 µm sieve must not exceed 1% of the total coarse aggregate (by mass) when tested in accordance with AS 1141.13;

(f) Where more than one type of coarse aggregate is proposed for use in the mix, the mass passing the 75 µm sieve (see item (d) above) and the 2 µm sieve (see item (e) above) may be calculated from individual aggregate test results;

(g) The maximum limit for water absorption is 2.5% except for slag aggregate where the maximum limit is 6%;

(h) Use wet strength and wet/dry strength variation tests for aggregate durability assessment in accordance with AS 2758.1 with "duplicate testing" being carried out in accordance with AS 1141.22;

(i) Durability of slag aggregate need only to conform to exposure classification B1, except for concrete mixes used for construction of wearing surfaces, which must conform to exposure classification C in accordance with AS 2758.1.

2.4.3 Additional Requirements for Fine Aggregate

(a) The particle size distribution nominated in terms of the percentage passing and limits of deviation (refer Clause 1.3 for definition) must conform to either Envelope "A" or Envelope "B" in Table B80.2 as applicable, except as permitted by item (b) following;

Table B80.2 – Fine Aggregate – Particle Size Distribution Requirements and Limits of Deviation

Sieve aperture	Mass of sample passing (%)			Limits of deviation (%)
	Envelope "A" (1)	Envelope "B" (2)	Envelope "C" (3)	
9.5 mm	100	100	Not specified	–
4.75 mm	90 – 100	90 – 100		±3
2.36 mm	65 – 95	70 – 100		±10
1.18 mm	40 – 90	50 – 90		±10
600 µm	25 – 70	30 – 80	25 – 85	±10
300 µm	8 – 35	8 – 50	8 – 55	±5
150 µm	≤ 12	≤ 12	≤ 18	±2
75 µm	≤ 3 (4)	≤ 3 (4)	≤ 6	±2

Notes:

(1) For concrete other than SCC and HWC.

(2) For SCC and HWC.

(3) Refer to item (b) of Clause 2.4.3.

(4) % passing may be taken as "≤ 5" if each type of fine aggregates proposed for use is tested as per item (f) of Clause 2.4.3, and the result obtained does not exceed 75.

(b) Fine aggregate conforming to Envelope "C" in Table B80.2 is permitted for use when the following requirements are met:

(i) The quantity of clays does not exceed 5% of the fine aggregate (by mass) and the quantity of reactive clays does not exceed 2.0% when the fine aggregate is tested by x-ray diffraction/x-ray fluorescence (XRD/XRF);

(ii) The flow time is between 21 – 27 seconds and the voids are between 38% – 44% when the combined fine aggregate is tested using Test Method TfNSW T279;

(iii) The quantity of water in the concrete mix does not exceed 190 L/m^3, unless approved otherwise;

(iv) The bleed water does not exceed 1.5% when tested in accordance with AS 1012.6, except that the maximum bleed water can be taken as 3% for concrete used in bridge decks, slabs and elements with large horizontal surfaces.

(c) Any manufactured sand used as a fine aggregate must be crushed from rock from which the aggregate is produced, and conforming to Clause 2.4, and must be non-plastic when tested in accordance with AS 1289.3;

(d) Where more than one type of fine aggregate is proposed for use in the mix, the combined fine aggregate must conform to Table B80.2. The mass passing each sieve aperture of the combined fine aggregate may be calculated from individual aggregate test results;

(e) The maximum limit for water absorption is 2.5%;

(f) For each type of fine aggregate proposed for use in the mix, when tested for methylene blue adsorption value (MBV) in accordance with Test Method TfNSW T659, the product of the MBV in mg/g and the percentage passing 75 µm sieve value (multiplied by 100) of any sample must not exceed 100;

(g) If the percentage passing 75 µm for a fine aggregate is ≥ 4%, the material finer than 2 µm sieve must not exceed 1% of the total fine aggregate (by mass) when tested in accordance with AS 1141.13. Where more than one type of fine aggregate is proposed for use in the mix, the mass passing 2 µm sieve may be calculated from individual aggregate test results (refer item (d) above);

(h) For manufactured sands, the sodium sulfate soundness when tested in accordance with AS 1141.24 must not result in a weighted average loss of more than 6% for all exposure classifications.

2.5 ALKALI-AGGREGATE REACTION (AAR)

2.5.1 General

For each source of aggregates used in the concrete:

(a) Carry out petrographic examination in accordance with Clause 2.5.2;

(b) Carry out initial investigation of AAR using the accelerated mortar bar test (AMBT) and concrete prism test (CPT), in accordance with Clause 2.5.3;

(c) Proceed with further investigation and control of AAR as required, in accordance with Clause 2.6.

Provide historical performance data on the use of the aggregates, including mix constituents (including cement type and cement content), cement alkali level, compressive strength test results, project/application details, time in service since completion, details of any damage caused by AAR and repairs undertaken.

2.5.2 Petrographic Examination

Carry out petrographic examination in accordance with ASTM C295.

Aggregates containing obviously reactive components may be eliminated without further testing. Obviously reactive components include:

(a) opaline material; acid volcanic glass;

(b) unstable silica minerals such as moderate amounts of tridymite, cristobalite and chalcedony;

(c) metamorphosed and sheared rock containing large amounts of strained quartz and microcrystalline quartz.

Avoid the use of aggregate containing potential alkali-carbonate reactive (ACR) components.

2.5.3 Assessment of AAR

Where the petrographic examination does not indicate obviously reactive components, carry out initial screening of AAR using the accelerated mortar bar test (AMBT) to AS 1141.60.1 and classify the aggregate as shown in Table B80.3.

Proceed with further testing, where applicable, in accordance with the column titled "Further Testing Using CPT" in Table B80.3 and undertake control of potential AAR in accordance with Clause 2.6.

All tests must be performed on representative samples of the aggregate. For blended aggregates, test aggregate from different sources separately.

Use only GP cement (i.e. without SCMs) to conduct the AAR tests for AMBT and CPT listed in Table B80.3, except for performance based mix designs. The GP cement must not contain fly ash mineral addition or other materials that may supress aggregate reactivity. Submit to the Principal documentation to this effect.

Table B80.3 – Classification of AAR

AMBT Expansion "*E*" (%)		AMBT Classification	Further Testing Using CPT
At 10 days	**At 21 days**		
$E < 0.10$ (1)	$E < 0.10$ (1)	Non-reactive	Not required (2).
$E < 0.10$ (1)	$0.1 \leq E < 0.3$	Slowly reactive	Carry out CPT to AS 1141.60.2 for one year, except that the cement alkali level in the concrete test sample must be 1.38% (3, 4)
$E \geq 0.10$ (1)	$E < 0.30$	Reactive	
Any value	$0.3 \leq E < 0.80$	Reactive	
	$E \geq 0.80$	Highly reactive	Do not use aggregate

Notes:

(1) For natural sands, expansion limit may be taken as 0.15%.

(2) Provided that the aggregate does not exhibit the so-called "Pessimum Effect".
If the petrographic examination of aggregates shows large amounts of amorphous silica materials, such as opaline and glassy phases, but AMBT expansion $E < 0.10$ % at 21 days, then the aggregate must be tested for "Pessimum Effect". In such cases, the aggregate must be blended with non-reactive aggregates (e.g. 20% aggregate potentially exhibiting "Pessimum Effect" and 80% non-reactive) in the mix for the AMBT.
If the expansion increases beyond the expansion of the original aggregate, then the aggregate shows the "Pessimum Effect". To determine the blending proportion, several mixes containing various proportions of the aggregate under examination must be tested.

(3) The cement alkali level in the test must be increased to 1.38% Na_2O equivalent by mass of cement, instead of 1.25% in the standard test, to ensure that all reactive aggregates are detected.

(4) Slowly reactive quartz gravel and gneissic granites with AMBT expansion less than 0.2 at 21 days must be tested using the accelerated concrete prism test to RILEM AAR-4, rather than the CPT to AS 1141.60.2. The cement alkali level in the RILEM AAR-4 test must be taken as 1.38% Na_2O equivalent by mass of cement.

2.6 CONTROL OF POTENTIAL AAR

2.6.1 General

Aggregates classified by AMBT as non-reactive in Table B80.3 can be used in concrete without AAR control.

Aggregates classified by AMBT as highly reactive in Table B80.3 must not be used in concrete supplied to this Specification.

Aggregates classified by AMBT as slowly reactive or reactive as described in Table B80.3 may be used in the concrete, provided that:

(a) Potential AAR is controlled using the "deemed-to-comply" approach outlined in Clause 2.6.2 or the "performance-based" approach outlined in Clause 2.6.3.

(b) Aggregates are sourced from quarries with implemented AAR quality plan in accordance with Clause 2.6.4. Submit details of the quarry's AAR quality plan.

(c) Where "performance-based" approach is used, establish and maintain a register of applications and mix details where the aggregates were used. Submit to the Principal the register details.

2.6.2 Control of AAR Using "Deemed-to-Comply" Approach

Take actions as specified in Table B80.4 for control of potential AAR.

The "deemed-to-comply" approach is illustrated in Figure B80.1.

Table B80.4 – "Deemed-to-Comply" Approach for Control of Potential AAR

AMBT Expansion "*E*" (%) at 21 Days (Table B80.3)	CPT Expansion "*e*" (%) at One Year (Table B80.3)	Actions Required
$E < 0.30$	Test is not mandatory	Use blended cement with a minimum of 25% FA or 50% BFS [(1)] in production concrete
$0.30 \leq E < 0.50$	$e < 0.03$	Use blended cement with a minimum of 25% FA or 50% BFS [(2)] in production concrete
	$e \geq 0.03$	Use blended cement with a minimum of 30% FA or 60% BFS [(3)] in production concrete
$0.50 \leq E < 0.80$ [(4)]	$e < 0.06$	
	$e \geq 0.06$	Do not use the aggregate

Notes:

(1) Ternary blended cement with a minimum of 15% fly ash (FA) and a minimum of 25% ground granulated iron blast furnace slag (BFS) is permitted. Alternatively, 15% fly ash and 5% well-dispersed amorphous silica (AS) may be used.

(2) Ternary blended cement with a minimum of 20% fly ash (FA) and a minimum of 30% ground granulated iron blast furnace slag (BFS) is permitted. Alternatively, 20% fly ash and 5% well-dispersed amorphous silica (AS) may be used.

(3) Ternary blended cement with a minimum of 20% FA and a minimum of 35% BFS is permitted.

(4) Aggregate will not be permitted for use in concrete mixes prior to the submission of AS 1141.60.2 test results.

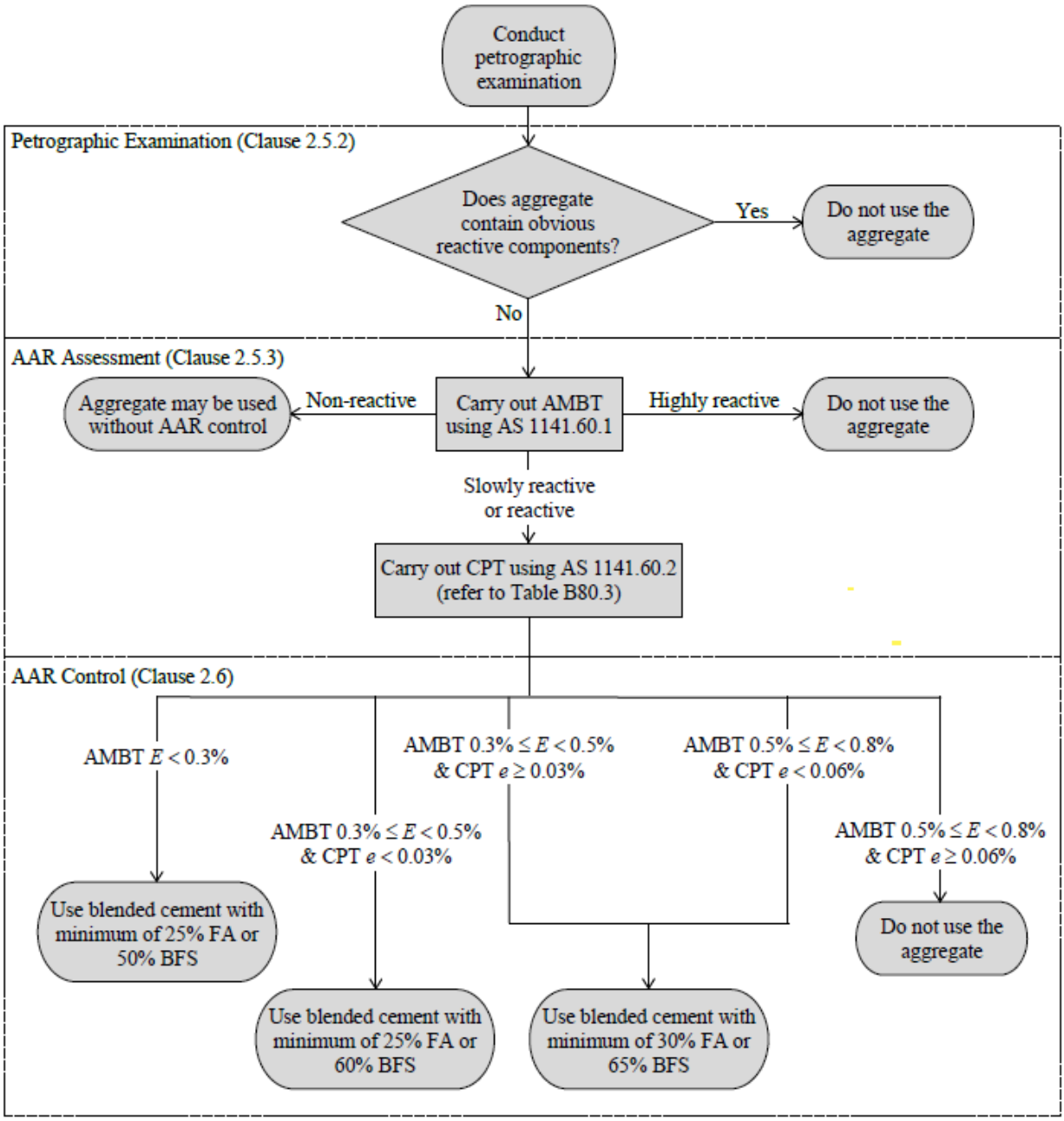


Figure B80.1 – "Deemed-to-Comply" Approach to Control AAR

2.6.3 Control of AAR Using "Performance-Based" Approach

Where the AMBT described in Table B80.3 indicates that the aggregates are slowly reactive or reactive, carry out further testing using blended cements (i.e. GP cement blended with the proposed dosage of selected SCMs) and the test methods and durations described in Table B80.5 to assess the effectiveness of the proposed mitigation to control AAR.

The results of each test in the table is taken as the average of a minimum of five (5) test specimens (i.e. 5 replicates) performed at the same laboratory. The variability in results amongst the test specimens must be in line with Clause 2.8 of SA HB-79.

Table B80.5 – "Performance-Based" Approach for Control of Potential AAR

AMBT Classification (Table B80.3)	Testing Methodology	Acceptance Limits
Slowly reactive	AS 1141.60.1 (1)	Expansion < 0.1% at 21 days
and reactive	AS 1141.60.2 (2, 3)	Expansion < 0.03% at two years

Notes:

(1) The test must be in accordance with AS 1141.60.1, except that blended cements containing the proposed SCM dosages are used in the sample mix.

(2) The test must be in accordance with AS 1141.60.2, except that blended cements containing the proposed SCM dosages are used in the sample mix and the alkali level must be 1.38% (not 1.25%) by mass of total binder (i.e. not only of the GP cement component).

(3) The accelerated concrete prism test to RILEM AAR-4 must be used instead of AS 1141.60.2 test for slowly reactive quartz gravel and gneissic granites that show AMBT expansion less than 0.2 at 21 days when tested to Table B80.3. The alkali level in the sample mix must be 1.38% (not 1.25%) by mass of total binder. The acceptable expansion must be less than 0.03% at 26 weeks.

This approach must not be used for concrete for critical applications, including:

(a) elements submerged in water or buried in soil;

(b) elements in splash zone or spray zone;

(c) members to be cured by accelerated heat curing;

(d) large concrete members (e.g. piers with cross section dimension greater than 1.0 m, abutments with length greater than 3 m, etc).

The performance-based approach is illustrated in Figure B80.2.

2.6.4 Management of AAR at Quarries

Aggregates identified as potentially reactive during petrographic examination, Test Method AS 1141.60.1 or/and Test Method AS 1141.60.2 must be regularly investigated at intervals not exceeding one year.

The quarry must establish and maintain an AAR quality plan that includes regular testing, and control measures to be implemented should the AAR limits be exceeded.

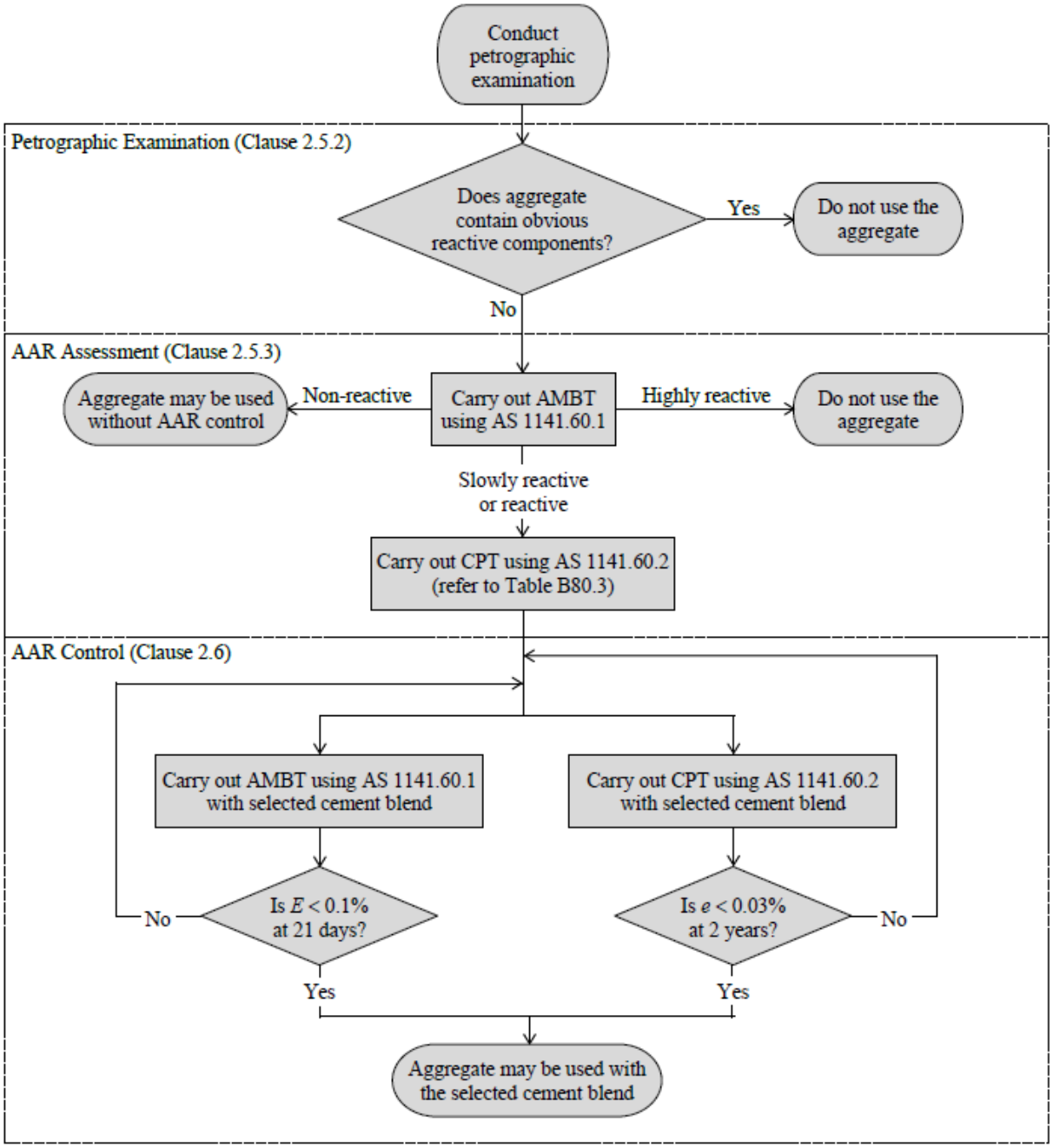


Figure B80.2 – "Performance-Based Approach" to Control AAR

2.7 WATER

2.7.1 General

Water for concrete, cement mortar and grout must comply with the requirements AS 1379 unless specified otherwise in this Clause.

Use only potable water, or water recycled from concrete plant washout pits which shows consistent conformity to the requirements of Table B80.6.

Table B80.6 – Limits for Impurities in Recycled Water

Impurity	Test Method	Concentration
Sugar	AS 1141.35	≤ 100 ppm
Oil and grease	APHA 5520	≤ 50 ppm
pH	AS/NZS 1580.505.1 or APHA 4500-H^+	> 5.0 ppm
Total dissolved solids	AS 3550.4 or APHA 2540C	≤ 1,700 ppm
Chloride as Cl	APHA 4500-Cl^-	≤ 300 ppm
Sulfate as SO_3	AS 1289.4.2.1 or APHA 4110B	≤ 350 ppm
Alkali (sodium equivalent)	ASTM C114 or APHA 3120B	≤ 1,500 ppm
Total suspended solids	AS 3550.4 or APHA 2540D	≤ 15,000 ppm

2.7.2 Production Testing and On-Going Quality Control of Recycled Water

Where recycled water is used in concrete, sample and test the water in accordance with Table B80.6 and Annexure B80/L1.

Tests must be carried out in laboratories accredited by NATA for the test, unless approved otherwise by the Principal.

Submit the test results to the Principal within four (4) weeks of the concrete delivery.

Testing of recycled water must be undertaken under a strict quality control plan which must be submitted to the Principal at the time of the concrete mix submission. The plan must provide details of how recycled water used for concrete production will remain within the limits set out in this Specification, such as control and treatment measures, and also provide details of the inspection and testing regime for quality assurance purposes.

Each plant supplying concrete under this Specification must submit records of recycled water testing at the start of production of concrete for the Contract, and at monthly intervals. These are for record purposes only and are not a substitute for a plant-specific quality control plan.

The sample for testing must be representative of the water supplied to concrete mixers. Take the sample from the pump outlet of the washout pit and agitate the sample thoroughly prior to testing.

2.8 SOLUBLE SALTS

2.8.1 Maximum Values

(a) Chlorides

The average mass of acid-soluble chloride ion per unit volume of concrete as placed must not exceed the values given in Table B80.7, when tested in accordance with AS 1012.20.1.

Table B80.7 – Maximum Values of Acid-soluble Chloride Ion Content in Concrete

Exposure Classification	Maximum acid-soluble chloride ion content (kg/m^3)			
	Unreinforced concrete	Reinforced concrete	Prestressed concrete	Grout
A	0.8	0.8	0.4	0.3
B1	0.8	0.4	0.4	0.3
B2	0.8	0.3	0.3	0.3
C1	0.8	0.3	0.3	0.3
C2	0.8	0.3	0.3	0.3
U	In accordance with Annexure B80/A1			

Note: Chloride ion content may be expressed in percentage weight of oven dried concrete.
($0.1\ kg/m^3$ ion content is approximately equivalent to 0.0042% by weight of oven dried concrete)

(b) Sulfates

The sulfate content must not exceed 3.0% for heat accelerated cured concrete or 5.0% otherwise, expressed as the percentage by mass of acid-soluble SO_3 to cement.

Determine the sulfate content by calculation by summing the sulfate content of the individual concrete constituents including water, or by testing in accordance with Clause 2.8.3.

2.8.2 Testing – Chlorides

Determine the chloride ion content by testing ground samples of hardened concrete in accordance with AS 1012.20.1.

Take the samples from a minimum 1.2 kg portion of the hardened concrete. Crush and grind the 1.2 kg of hardened concrete to a maximum size of 150 microns and then oven dry at 110ºC ± 5ºC for a minimum of one hour before taking the samples for analysis.

Analyse 5 randomly selected samples of 20 ± 0.1 grams of the ground concrete for chloride ion content.

Use the Volhard method calibrated against a concrete with known chloride content for the tests. Modify the procedure of AS 1012.20.1 and use standard solutions for the analysis that bracket the expected chloride ion concentration.

Report the chloride ion content of each of the five samples and calculate and report the average chloride content and the standard deviation of the five samples.

2.8.3 Testing – Sulfates

Determine the sulfate content of concrete by testing in accordance with AS 1012.20.1, expressing the test result as the percentage by mass of acid-soluble SO_3 to cement.

3 DESIGN OF CONCRETE MIXES

3.1 GENERAL

Design the concrete mix in accordance with this Specification, to achieve a structure service life of at least 100 years in the specified environment without significant maintenance.

Base the mix design on the anticipated conditions which will prevail at the Site so that under these conditions and after supply, placing, compaction, screeding, finishing and curing, the concrete meets all the requirements of this Specification.

3.2 DESIGN FOR DURABILITY

3.2.1 General

The concrete durability, must conform to Table B80.8 and the following:

(a) For exposure classifications A and B1, concrete made with blended cement must contain a minimum of 240 kg/m^3 of General Purpose or Shrinkage Limited cement conforming to Specification TfNSW 3211, to limit carbonation;

(b) Use blended cement containing amorphous silica only for precast concrete members. Do not use blended cement containing amorphous silica for cast-in-place concrete members;

(c) Precast concrete members in exposure classification C2 must contain a corrosion inhibitor in accordance with Clause 2.3.3, except as provided for in item (d) of this Clause or in Annexure B80/F, to limit chloride induced reinforcement corrosion;

(d) For precast concrete members requiring durability suitable for exposure classification C2 but which are not in a chloride aggressive environment, the corrosion inhibitor is not required;

(e) The water/cement ratio must not be less than 0.32 for cast-in-place concrete and 0.28 for precast concrete, to ensure cement hydration, except for cast-in-place concrete bridge decks and slabs where it must not be less than 0.40, to limit cracking;

(f) For cast-in-place concrete bridge decks and slabs, the specified minimum 28 day compressive strength, $f_{c.min(s)}$, must not exceed 40 MPa, to limit cracking;

(g) Curing equivalent to a minimum of 3 days wet curing or better must be provided to limit cracking;

(h) In addition to the above items, self-compacting concrete (SCC) and high workability concrete (HWC) must conform to the requirements of Annexure B80/G and Annexure B80/A2.

Table B80.8 – Durability Requirements for Concrete

Exposure Classification [1]	Concrete Application	Min Cement Content (kg/m³)	Max Cement Content (kg/m³)	Min w/c ratio (by mass)	Max w/c ratio (by mass)	Max chloride ingress coefficients (x 10^{-12} m²/sec) [2, 3]		$f_{c.min(d)}$ (MPa)	Actions required
						D_e	D_{nssm}		
A	Other than heat accelerated	320	400	0.40	0.56	Not applicable	Not applicable	25	Not applicable
	Heat accelerated	320	600	0.28	0.50			32	
B1	Other than heat accelerated	320	500	0.40	0.50			32	
	Heat accelerated	320	600	0.28	0.50			40	
B2	Other than heat accelerated	370	500	0.32	0.46	3.5	8.0	40	Use blended cement with minimum 25% fly ash or 50% slag [4]
	Heat accelerated	370	600	0.28	0.46			50	
C1	Other than heat accelerated	420	550	0.32	0.40	2.0	4.0	50	
	Heat accelerated	420	600	0.28	0.40			60	
C2	Other than heat accelerated	420	550	0.32	0.36	2.0	4.0	55	Use blended cement with minimum 65% slag [4]
	Heat accelerated	420	600	0.28	0.36			60	
U	All	In accordance with Annexure B80/A1							

Notes: **Min**: Minimum **Max**: Maximum **w/c**: water/cement (ratio) $f_{c.min(d)}$: Min strength for durability

D_e: Effective chloride transport coefficient to Nordtest NT Build 443 D_{nssm}: Non-steady-state migration coefficient to Nordtest NT Build 492

(1) Concrete classified under a certain exposure classification may be considered for less stringent exposure classifications, subject to Principal's approval.

(2) Continuously standard moist-cure after demoulding specimens for Nordtest NT Build 443 and NT Build 492 tests, and test at an age of 56 and 28 days respectively.

(3) Specified coefficients are based on minimum concrete cover values specified in AS 5100.5:2017 Table 4.14.3.2. If corrosion inhibitor is included, minimum cover may be reduced by 10 mm. Principal may modify the specified coefficients if concrete cover is increased.

(4) Ternary blended cement conforming to Table 3211/A.2 of TfNSW 3211 is also permitted.

3.2.2 Chloride Ingress

For the exposure classifications specified on the Drawings, the concrete mix must have resistance to chloride ingress conforming to Table B80.8. Verify the values of chloride ingress coefficients (D_e) or (D_{nssm}) on a trial mix using either of the two test methods specified. The Principal may specify which of the two test methods is to be used.

Carry out chloride ingress coefficient testing in accordance with Nordtest NT Build 443 at a concrete age of 56 days or Nordtest NT Build 492 at a concrete age of 28 days.

3.2.3 Acid Sulfate Soils

For concrete structures located in exposure classification U due to the presence of acid sulfate soils, design the concrete mix in accordance with Annexure B80/A1.

3.2.4 Concrete Durability Plan

Alternatively, submit to the Principal for consideration a Concrete Durability Plan specific to the Works that will achieve the intent of this Clause and that will prevent the adverse effects specified in Clause 3.4.

Demonstrate in the Concrete Durability Plan a durability performance equivalent to or better than that achieved by conforming to Table B80.8 and items (a) to (h) of Clause 3.2.1.

The Concrete Durability Plan must:

(a) fully detail and quantify the effect of each factor affecting concrete durability on the Works, using field test results and supporting durability calculations;

(b) propose the measures to be taken during the Works to achieve the specified service life of the structure; and

(c) propose suitable concrete mixes for each structure and/or individual members of the Works, together with laboratory test results demonstrating conformity with the Concrete Durability Plan.

3.3 CRACKING

3.3.1 Plastic Shrinkage Cracking

Control plastic shrinkage cracking by controlling moisture loss in accordance with Clause 7.10.

3.3.2 Thermal Cracking

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.

3.4 PREVENTION OF ADVERSE EFFECTS

Design the concrete mix to prevent adverse effects arising from the following:

(a) Excessive drying shrinkage

Maximum drying shrinkage must be in accordance with Clause 3.8;

(b) Alkali-aggregate reactions

Control alkali-aggregate reactions in accordance with Clauses 2.5 and 2.6;

(c) Soluble salts

Maximum soluble salts must be in accordance with Clause 2.8.1;

(d) Inadequate compaction

Concrete compaction must be in accordance with Clauses 7.6.3 and 9.6;

(e) Cracking

Control cracking in accordance with Clause 3.3.1 for plastic shrinkage cracking and Clause 3.3.2 for thermal cracking. Maximum crack widths must be in accordance with Clause 9.3;

(f) Chloride ingress

Comply with Clause 3.2.2;

(g) Exposure to acid sulfate soils

Comply with Clause 3.2.3;

(h) Carbonation

Refer to Item (a) of Clause 3.2.1.

3.5 CURING PROVISION

The curing of the concrete must conform to either Curing Provision A – (Performance) or Curing Provision B – (Method), as specified in this Clause and Clause 8.

3.5.1 Curing Provision A – (Performance)

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 B80.9.

Table B80.9 – 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 Annexure B80/A1	

Test the effectiveness of the curing in accordance with Test Method TfNSW T362. You may carry out sorptivity testing by laboratories other than a NATA registered laboratory for this test, if approved by the Principal.

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.

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.

3.5.2 Curing Provision B – (Method)

For the exposure classifications specified on the Drawings, the curing of the concrete member must be in accordance with Annexure B80/E using one of the methods of curing specified in Clause 8.

3.6 TARGET STRENGTH FOR MIX DESIGN

Design the concrete mix to achieve a target strength $f_{c.md}$ such that:

$\mathbf{f_{c.md} \geq f_{c.min} + M_{control}}$ and

$\mathbf{f_{c.max} \leq f_{c.min} + 2.0\ M_{control}}$

where:

$\mathbf{f_{c.md}}$ is the target strength.

$\mathbf{f_{c.min}}$ is the greater of $\mathbf{f_{c.min(s)}}$ and $\mathbf{f_{c.min(d)}}$, where:

$\mathbf{f_{c.min(s)}}$ is the specified minimum 28 day compressive strength as stated on the Drawings, or elsewhere in the Specification;

$\mathbf{f_{c.min(d)}}$ is the minimum 28 day compressive strength required for durability obtained from Table B80.8.

$\mathbf{M_{control}}$ is the margin nominated for variations in strength. This margin is the measure of the level of control for the nominated plant producing the nominated mix.

$f_{c.max}$ is the maximum 28 day compressive strength permitted for the trial mix, unless otherwise approved by the Principal.

Comply with the following, unless specified otherwise on the Drawings or approved by the Principal:

(a) For cast-in-place deck concrete, $f_{c.md}$ must not exceed 46 MPa.

(b) For all other concrete, $f_{c.md}$ must not exceed 75 MPa.

(c) $M_{control}$ must not exceed 10 MPa, except when the requirement in item (a) above applies, i.e. for cast-in-place deck concrete with $f_{c.min}$ of 40 MP, $M_{control}$ must not exceed 6 MPa.

3.7 LIMITATIONS ON SLUMP

Unless specified otherwise on the Drawings, or approved by the Principal, the concrete slump of the nominated mix (nominated slump) must not exceed 180 mm.

Where a nominated slump in excess of 180 mm is proposed, demonstrate by way of a test member in accordance with Clause 5.3, that the concrete may be placed, compacted and finished without deleterious effects.

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

3.8 LIMITATIONS ON DRYING SHRINKAGE

Drying shrinkage of the concrete specimen after either of the 3 or 8 weeks' drying periods must conform to Table B80.10.

Table B80.10 – Maximum Drying Shrinkage of Concrete Specimens

Exposure classification	Maximum drying shrinkage strain (microstrain)	
	Drying period	
	3 Weeks	8 Weeks
A	570	690
B1, B2	500 (600[#]) (650[§])	630 (720[#]) (760[§])
C1, C2	430 (530[#]) (550[§]) (650*)	560 (650[#]) (670[§]) (760*)
U	In accordance with Annexure B80/A1	

Notes:

[#] For SCC or HWC.

[§] For concrete containing 30% minimum ground granulated iron blast furnace slag (by mass).

* For precast members where corrosion inhibitor is included in the mix.

Test the nominated mix for drying shrinkage in accordance with AS 1012.13.

3.9 NOMINATED MIXES

3.9.1 Submission of Nominated Mixes

Submit to the Principal details of each concrete mix and proposed curing regime, together with a certificate stating that the nominated mix, its constituents and the proposed curing regime, conform to this Specification.

Alternatively, propose a TfNSW registered mix which conforms to this Specification and is listed on TfNSW Register of Concrete Mixes available at:
http://www.rms.nsw.gov.au/business-industry/partners-suppliers/register-of-materials/concrete-mix/conform-conc-mix.pdf

HOLD POINT

Process Held:	Use of each nominated mix.
Submission Details:	At least 4 weeks prior to the proposed date for use of the concrete mix, submit to the Principal the following: (a) (i) all details in Clause 3.9.3; or (ii) mix ID and concrete mix design of a nominated mix from the Register of TfNSW Concrete Mixes; and (b) a statement stating that the mix conforms to this Specification and is suitable for its intended use.
Release of Hold Point:	The Principal will consider the submitted documents, and may carry out surveillance and audit, prior to authorising the release of the Hold Point.

3.9.2 Trial Mixes

Prepare trial mixes in accordance with AS 1012.2 using the proposed materials and mix proportions, including all admixtures.

Batch a trial mix at the highest water/cement ratio conforming to the allowable slump and water content tolerances specified in AS 1379 for the nominated mix. For mixes with a nominated water/cement ratio less than 0.40, batch an additional trial mix at the lowest water/cement ratio conforming to the allowable slump and water content tolerances. Allow for batching tolerances and anticipated variations in aggregate moisture content.

Test the trial mixes for the hardened concrete properties specified in Clause 3.9.3 (e) and report the test results.

For the additional trial mix batched at the lowest water/cement ratio, the test results of the fresh concrete properties and compressive strength need only to be reported.

From the trial mix results, nominate the water/cement ratio and slump for production. Include the nominated values on the delivery dockets.

Where recycled water is intended to be used in concrete supply, include in the trial mix submission detailed quality plan complying with the requirements of Clause 2.7.

3.9.3 Required Details for New Concrete Mix Design

The submission for a mix which is not currently listed in the Register of TfNSW Concrete Mixes must include the following details:

(a) Material Constituents

For each constituent and any individual components making up the constituent:

(i) Source;

(ii) Current test results not more than 12 months old for the characteristics and properties specified in Clause 2 for all constituents excluding recycled water;

(iii) Evidence of compliance of recycled water, where proposed for use, with the requirements of Clauses 2.7 and 3.9.2. Where concrete is to be produced from multiple plants using recycled water, provide testing documentation and quality assurance and control plans for each plant.

(b) Mix Design

(i) Constituent quantities;

(ii) Method of controlling alkali-aggregate reactions as specified in Clauses 2.5 and 2.6;

(iii) Trial mix water/cement ratio and corresponding nominated water/cement ratio;

(iv) Condition of constituents used in the mix design e.g. moisture condition of aggregates;

(v) $f_{c.min(s)}$, $f_{c.min(d)}$, $f_{c.min}$, $f_{c.md}$ and $f_{c.max}$ determined in accordance with Clause 3.6;

(vi) Applicable exposure classification(s);

(vii) Trial mix slump and corresponding nominated slump;

(viii) For concrete containing high range water reducers: final slump and reversion time;

(ix) Nominated coarse and fine aggregate particle size distributions;

(x) HWC and SCC – nominated spread flow slump.

(c) Batching, Mixing and Transport

(i) Methods of batching, mixing and transport of the concrete;

(ii) Level of control and accuracy of batching;

(iii) Level of control and accuracy of determination of the aggregate moisture content;

(iv) Margin for strength variation, $M_{control}$ and method of determining $M_{control}$;

(v) Minimum mixing time.

(d) Curing Details

(i) Curing Provision and curing regime;

(ii) Anticipated minimum and maximum ambient temperatures and relative humidity during the curing period;

(iii) For Curing Provision A only: maximum sorptivity penetration depth together with the applicable curing regime accompanied by temperature and relative humidity versus time graphs.

(e) Other Test Results for Fresh and Hardened Concrete Characteristics

(i) 28 day compressive strength in accordance with AS 1012.9 (mould the cylinders in accordance with AS 1012.8.1 using rodding only);

(ii) Drying shrinkage in accordance with AS 1012.13;

(iii) Chloride and sulfate ion contents in accordance with Clause 2.8;

(iv) Chloride ingress coefficient in accordance with Clause 3.2.2;

(v) Trial mix report in accordance with AS 1012.2;

(vi) HWC/SCC fresh properties in accordance with Annexure G including the photographic evidence.

3.9.4 Variations to Nominated Mixes

You may vary the quantities of the constituents in a nominated mix to improve the quality of the concrete, but such variations must not exceed the following limits:

(a) Cement: ±3% by mass of each constituent;

(b) Aggregates: ±5% by mass of each constituent;

(c) Water: ±3% by volume and/or mass;

(d) Admixture: within the manufacturer's recommendations.

Notify the Principal in writing and submit written details of such variations to a nominated mix before commencing production with the varied quantities.

Notwithstanding the above provisions, the varied concrete mix must:

(i) conform to Clause 3.2 for minimum cement content and maximum water/cement ratio;

(ii) not have a water/cement ratio exceeding that nominated for the concrete mix (refer to Clause 3.9);

(iii) conform to Specification TfNSW 3211 for the range of SCMs in blended cement.

If you wish to vary the quantities of the mix in excess of the above amounts, or wish to change the type or source of supply of any constituent, or vary the curing regime, submit a new nominated mix for approval in accordance with Clause 3.9, unless approved otherwise by the Principal.

4 SUPPLY OF CONCRETE

4.1 GENERAL

All concrete supplied for use in the Works must conform to the approved nominated concrete mixes.

Production and delivery of concrete to the Site or to the precasting yard must be in accordance with AS 1379 and this Specification.

Classify all concrete for use in the Works as special class designated "S" in accordance with AS 1379. Nominate the method of production assessment relevant to the plant in accordance with AS 1379.

Comply with AS 1379 Clause 4.2.1 on tolerances on batch ingredients during production.

Dispose of water, contaminants, debris, excess concrete and other materials from concrete supply operations in accordance with Specification TfNSW G36.

4.2 MOISTURE CONTENT OF AGGREGATES

Store the fine and coarse aggregates in the saturated surface dry condition or wetter prior to and during batching.

Determine the moisture content of the fine and coarse aggregates prior to concrete production for the day, and whenever conditions change, either by a moisture meter or by other similar devices or methods.

Make corrections to the mass of all aggregates and the volume of water used in the mix commensurate with the moisture content determined, so that the nominated water/cement ratio is achieved for all batches supplied for the Works.

4.3 ADDITIONAL REQUIREMENTS FOR MIXING

4.3.1 Equipment

Do not use continuous mixers.

4.3.2 Discharging of Mixer

Discharge the entire contents of the mixer before charging it with a new batch.

4.3.3 Maximum Mixing Time

Where by reason of delay it is necessary to hold a batch in the mixer, mixing may be continued for a maximum of ten minutes, except for split drum mixers where the maximum time that mixing may be continued is five minutes.

For longer delays, the batch may be held in the mixer and turned over at regular intervals, provided that the time limits specified for incorporation of the concrete into the Works have not being exceeded.

4.4 DELIVERY

4.4.1 General

Transport concrete produced at a remote central batching plant to the point of discharge by truck-mounted drum mixers conforming to AS 1379 and this Specification.

On completion of batching, continuously agitate the concrete constituents until it is thoroughly mixed. On completion of mixing, continuously agitate the concrete until it is fully discharged. The agitation speed and duration to achieve thorough mixing must be as specified by the manufacturer of the equipment.

Before discharging from a truck-mounted drum mixer, agitate the concrete on-site for a minimum of three minutes at the mixer's rated mixing speed.

4.4.2 Delivery Docket or Identification Certificate

All concrete batches delivered must be accompanied with a delivery docket or identification certificate containing the following details:

(a) Delivery docket number;

(b) Truck number;

(c) Batch number;

(d) Date and time of batching;

(e) Batch quantity;

(f) Project name;

(g) Mix type and identification;

(h) Strength grade;

(i) Nominated slump;

(j) Nominated water/cement ratio;

(k) Volume of free water in the batch;

(l) Volume of all water added after batching;

(m) Total free water in the batch;

(n) Mass of cement in the batch;

(o) Actual water/cement ratio at discharge;

(p) Time at discharge;

(q) Total quantity of the deliveries for the pour;

(r) Concrete supplier and plant details.

4.4.3 Period for Completion of Discharge, Placement and Compaction

Unless a hydration control admixture is added to the approved mix to delay hydration, place and compact the concrete within 1.5 hours from the time of batching.

Where you propose to add a hydration control admixture to the approved mix to delay hydration and extend the setting time beyond 1.5 hours, then nominate the extended setting time and it must conform to the following:

(a) Provide NATA endorsed test reports in accordance with Clause 2.3.1 proving conformity of the admixture to AS 1478.1.

(b) Soluble salt content must conform to the limits specified in Clause 2.8.

(c) Carry out trials with the mix containing the admixture prior to its use in the Works.

Assess the trials under the most adverse conditions that would most likely occur at the Site over the range of days of the pours to demonstrate that there will be no adverse effects on the plastic and hardened concrete.

Test the trials for drying shrinkage tests in accordance with Clause 3.8 and additional compression strength cylinders in accordance with Clause 9.2 taken after the addition of the second part of the admixture. Submit the trials assessment report for approval before use of the admixture.

(d) Thoroughly remix the concrete after addition of the second part of the admixture but before discharge for a minimum of three minutes at the mixer's rated speed.

4.4.4 Concrete Temperature at Point of Delivery

Do not use the concrete if its temperature at the point of discharge is less than 10°C or more than 32°C except for precast concrete members and cast-in-place piles where the minimum and maximum concrete temperatures must be 5°C and 35°C respectively.

4.5 SLUMP AND WATER/CEMENT RATIO TOLERANCES

Check and record the slump of the concrete at the point of discharge. If due to delays causing the duration measured from the time when cement is added to aggregate to exceed 45 minutes, check and record the slump again immediately prior to discharge.

Check and record the slump again when water is added to a mixed batch in accordance with Clause 4.6.

Check the slump of the concrete in accordance with AS 1379, except for the frequency of sampling which must be in accordance with Annexure B80/L.

If the measured slump is not within the specified limits, carry out one repeat test immediately from another portion of the same sample. If the value obtained from the repeat test falls within the specified limits, the concrete represented by the sample is deemed to conform; otherwise reject it.

Do not incorporate concrete into the Works if its slump is outside the specified tolerances of AS 1379.

The water/cement ratio of each batch must be within ±10% of the nominated water/cement ratio.

4.6 ADDITION OF WATER TO MIXED BATCH

Provided that a hydration control admixture has not been added to the approved mix to delay hydration, water may be added to a mixed batch of concrete prior to the commencement of discharge providing the following conditions are satisfied:

(a) Less than 45 minutes have elapsed since cement was added to the aggregate;

(b) Immediately after the addition of any water, commence mixing at a mixing speed for at least 3 minutes, and for such additional time as may be necessary to re-establish uniformity of the mix;

(c) The total quantity of water added is not more than 9 kg/m^3, and the nominated water/cement ratio plus 10% tolerance and maximum water/cement ratio in Table B80.8 is not exceeded;

(d) The quantity of water added is measured and submitted with the delivery docket;

(e) The slump of the concrete is checked after the water has been added, in accordance with Clause 4.5.

Once discharge of a batch has commenced, do not add further water to that batch.

4.7 PRESENCE OF CORROSION INHIBITOR IN FRESH CONCRETE

Where the corrosion inhibitor is included in the nominated mix, determine the presence and quantity of the calcium nitrite within the fresh concrete in accordance with Test Method TfNSW T371. The frequency of sampling must be in accordance with Annexure B80/L.

5 FORMWORK

5.1 GENERAL

Formwork, including all temporary supporting members, must conform to AS 3610.1 and this Specification.

Design and construct the formwork to produce concrete with the Class of finish specified in Clause 9.5 unless stated otherwise in Annexure B80/A4 or the Drawings.

With the exception of Clauses 5.1, 5.2, 5.5, 5.6 and 5.9, Clause 5 does not apply to formwork for precast concrete members cast at off-site precasting yards.

5.2 FORMWORK DESIGN, DOCUMENTATION AND CERTIFICATION

5.2.1 Formwork Design

Design the formwork to account for all load cases in accordance with AS 3610.1. The design and details must also account for stream flow, traffic impact, flooding, ground conditions, effect of post-tensioning and any other applicable conditions.

Where formwork is intended for re-use, allow in the design for the deterioration of the materials following their use and handling.

Supplement the foundation investigation for the bridge design with additional foundation information, if necessary, to complete the formwork design.

Design any steel girders used for support and all associated bolted or welded splices in accordance with AS 5100.6. All welded splices must be full penetration butt welds conforming to Specification TfNSW B201.

Formwork for concrete intended for composite action with a member previously constructed must be designed to be supported only from that member, and in such a manner that placing of concrete in the formwork or any other construction loads does not produce separation or differential movement between the member and the formwork.

Formwork for cross girders may be supported off the substructure.

Apply the requirements of TfNSW Q for the design control of temporary structures to the design of formwork.

5.2.2 Formwork Documentation

Project documentation must conform to AS 3610.1.

State clearly on the formwork drawings all relevant formwork construction requirements including design assumptions, foundation preparation, footing details and precamber diagrams. The formwork drawings must be sufficiently comprehensive and clearly presented so that erection and inspection can be carried out without reference to any other documentation.

Supply of all bolts and other fasteners, and their installation must conform to Specifications TfNSW B240 and TfNSW B201 respectively.

5.2.3 Submission and Certification Requirements

The submission of formwork documentation and certification must be in accordance with Table B80.11 under the relevant risk category.

When design certification of formwork is required in Table B80.11, the certification must state that the design of the formwork and the formwork documentation conform to AS 3610.1 and this Specification. Where multiple systems are combined to create the formwork, the design certification must cover the full extent of formwork used, including any interfaces and any required bracing and stiffeners.

The certification for erected formwork must state that the formwork has been erected in accordance with either the formwork documentation for risk category A, or the certified design for risk categories B and C, as applicable.

When certification by an Engineer is required by Table B80.11, nominate a Structural Engineer who is experienced in the design and erection of formwork of at least similar complexity.

HOLD POINT	(Does not apply to category A formwork)
Process Held:	For category B formwork – placing of reinforcement. For category C formwork – erection of formwork.
Submission Details:	For category B formwork – at least five working days before commencement of placing of reinforcement, For category C formwork – at least ten working days before commencement of erection of formwork, submit to the Principal your formwork documentation and Engineer's design certification in accordance with Clause 5.2.
Release of Hold Point:	The Principal will consider the submitted documents prior to authorising the release of the Hold Point. Where the Principal has concerns about the adequacy of the formwork documentation or certification, the Principal may order an independent verification of the formwork design at your expense before releasing the Hold Point.

When changes are proposed to the certified design or erected formwork, (re-)submit the documentation and certification in accordance with Clause 5.2.

5.3 TEST MEMBERS

Produce test members to demonstrate the suitability of a concrete mix for the Works where required under Clause 3.7, or if specified in Annexure B80/A4 or on the Drawings.

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.

WITNESS POINT	(If test members are required)
Process to be Witnessed:	Placement of concrete for the test member.
Submission Details:	At least two working days' notice in writing of the proposed placement of concrete for the test member. Thereafter, give the Principal the opportunity to inspect the constructed test member.

Table B80.11 – Submission and Certification Requirements for Formwork

Risk Category	Bridge Members	Formwork documentation	Design certification		Erected formwork certification	
		Time of submission	by	Time of submission	by	Time of submission
A (Low Risk)	(a) Abutments, pilecaps, footings, piers, columns and walls, with heights < 3 m (b) Members not included in either category B or category C	NA	NA	NA	Contractor	In accordance with Clause 7.5 (**Hold Point**)
B [1] **(Moderate Risk)**	(a) Abutments, pilecaps, footings, piers, columns and walls, with heights ≥ 3 m and ≤ 6 m (b) Headstocks > 3 m off the ground (c) Decks and off-ground slabs with maximum thickness ≤ 600 mm	Prior to placing reinforcement	Engineer	Prior to placing reinforcement (**Hold Point**)	Contractor	
C [2] **(High Risk)**	(a) Abutments, pilecaps, footings, piers, columns and walls, with heights > 6 m (b) Parapets (c) Decks and off-ground slabs with maximum thickness > 600 mm (d) Concrete box girders (e) Any member for which SCC or HWC is proposed (f) Job specific bridge members listed in Annexure B80/A3	Prior to erecting formwork	Engineer	Prior to erecting formwork (**Hold Point**)	Contractor for parapets, Engineer for all other members	

Notes: NA: Not Applicable

(1) For bridges over or adjacent to railways and/or roads conveying more than 5,000 vehicles/day in any lane, formwork for the members listed under category B must conform to the submission requirements of category C.

(2) When a formwork assembly for members listed under category C will be used more than once, submission for any subsequent use after its initial use needs only to conform to the requirements of category A, if approved by the Principal.

5.4 CONSTRUCTION JOINTS

5.4.1 Locations

Locate construction joints as shown on the Drawings.

If you require construction joints at locations other than those shown on the Drawings, submit details of the proposed locations together with your formwork documentation. Any such construction joints must be perpendicular to the longitudinal axis of a member.

Unless shown otherwise on the Drawings, do not locate construction joints in salt or brackish water from 1.0 m below minimum low water to 1.0 m above maximum high water tide levels.

Locate construction joints at the base of columns or walls at least 100 mm above the tops of the footings or pile caps.

5.4.2 Additional Requirements for Construction Joints on Visible Surfaces

Form construction joints on visible faces by using suitably dressed timber beading, or by other means, so that the joints are straight and regular.

5.5 FORMWORK MATERIALS

5.5.1 General

Forms for exposed concrete surfaces must be either plywood conforming to AS/NZS 2271 or steel plate conforming to AS/NZS 1594.

Forms for surfaces which will be completely enclosed or permanently hidden below the ground may be of rough sawn or dressed timber, fibre reinforced cement sheets, plywood or steel. Do not use particleboard, chipboard or masonite for such purpose.

Where shown on the Drawings, use dressed timber for exposed concrete surfaces instead of plywood or steel plate.

5.5.2 Plywood Forms

Fabricate plywood forms from panels having uniform widths of not less than 1 m and uniform lengths of not less than 2 m, except where the dimensions of the member formed are less than these minimum panel dimensions.

5.5.3 Use of Expanded Metal Mesh

Do not use expanded metal mesh as permanent formwork (i.e. formwork which is left in place), including for the purpose of forming construction joints.

5.5.4 Use of Rigid Foamed Plastic Material

Where indicated on the Drawings, narrow spaces between concrete faces may be formed by the use of suitable rigid foamed plastic material (such as polystyrene or similar).

The foamed plastic material must have sufficient rigidity to prevent appreciable deformation during concreting, but must not present significant resistance to the expected relative movement of the adjacent concrete faces in the finished structure.

Unless otherwise stated on the Drawings, this material may be left in the finished concrete.

The foamed plastic material may be attached to either the forms or the previously cast concrete surfaces, but any adhesive used must be of a type which will not dissolve or otherwise damage the plastic material.

Take measures to prevent the foamed plastic material from being damaged by fire, petroleum products, or any other solvents, before the concrete has hardened.

5.6 FORMWORK ERECTION

5.6.1 General

Erect the formwork strictly in accordance with the certified formwork documentation and Drawings.

Erect the formwork to achieve the specified dimensions, levels and alignment of the completed Works within the tolerances specified in Clause 9.4. Make allowance for the deflections of the formwork which may occur before and during concreting.

Erect plywood panels with the grain of the outer plies perpendicular to the studding or joists.

Erect all form panels in a neat and symmetrical pattern.

Make the joints in formwork mortar-tight, to prevent slurry loss and consequent honeycombing.

Items such as dowel bars, tie rods, etc which pierce the formwork through sealed penetrations may be permitted.

5.6.2 Formwork at Construction Joints

At horizontal construction joints where the formwork for the pour above the joint is anchored to the hardened concrete below the joint, pre-tighten the form anchor bolts against the face of the supporting concrete, to prevent the formwork from separating from the supporting face under the pressure of fresh concrete.

At vertical construction joints in cast-in-place superstructure, place continuous supports directly under the formwork at the joint location. The method of providing and fixing these supports must prevent the formwork from separating from the hardened concrete of the previous pour when fresh concrete is placed against it.

5.7 SURFACE TREATMENT OF FORMS

Treat the interior surface of the formwork and any removable items to prevent adhesion of the concrete. Commercial quality form release agents, oil or grease may be used for this purpose, provided that the treatment on formwork against surfaces to be exposed is of a type that will not stain or discolour the concrete surface.

Apply the treatment in accordance with the manufacturer's instructions. Spread the treatment uniformly in a thin film and remove any surplus prior to placing the concrete. In the case of unlined timber forms, thoroughly wet the timber before treating.

Do not soil any reinforcement, tendons, and embedments when applying the treatment. If any reinforcement is soiled, clean it thoroughly.

Do not use treatments where concrete surfaces are to receive an applied finish, unless otherwise approved by the Principal. Use only treatments which are compatible with the curing compound to be applied, so that its adhesion to the concrete is not affected.

5.8 SURVEYING CONTROL

Control all survey activities in accordance with Specification TfNSW G71.

Carry out all necessary investigations and calculations to ensure that the estimated deflections of the formwork during concreting are reliable for the erected formwork and actual site conditions.

Maintain records for the checking and verification of the following items at each listed location:

(a) As planned

(i) the designed characteristic (level, dimension etc) at that point on the structure as shown on the Drawings;

(ii) the calculated or estimated deflection/settlement of the formwork prior to and during concreting;

(iii) the target characteristic for the formwork (allowing for deflection/settlement); and

(iv) the specified tolerance on final location of the structure at that point.

(b) As measured

(i) the characteristic as set out;

(ii) the characteristic as verified;

(iii) the difference between the verified value and the target value; and

(iv) the magnitude of any out of tolerance measurement (i.e. the amount by which the measured difference exceeds the specified tolerances).

5.9 FORMWORK REMOVAL

5.9.1 General

Remove formwork in such a way and at such a time as to achieve the specified characteristics, prevent damage to the old or recently placed concrete, and maintain safety at all stages of removal.

Unless specified otherwise, do not apply superimposed loads to any part of the structure until the design concrete strength stated on the Drawings has been achieved.

5.9.2 Minimum Stripping Times

Unless specified otherwise, the minimum stripping time is the longest of the times governed by the following:

(a) curing in accordance with Clause 3.5;

(b) the time required to achieve the concrete compressive strength in Table B80.12;

(c) the time required to achieve the concrete compressive strength in Table 4.4.1(A) of AS 5100.5 for the appropriate exposure classifications.

Table B80.12 – Required Compressive Strength for Stripping of Formwork

Member and Surface	Minimum Concrete Compressive Strength
Cast-in-place members:	
Vertical surfaces	15 MPa
Underside of horizontal surfaces	0.80 $f_{c.min(s)}$
Other surfaces	A compressive strength as approved by the Principal
Precast concrete members:	
All surfaces	A compressive strength as approved by the Principal

Determine the concrete compressive strength by testing representative test cylinders cured under the same conditions as the concrete in question. Provide on-site charts of the temperature and relative humidity in the concrete in the member and the compression test cylinders to prove that the curing of each is the same.

5.10 SLIPFORMING OF BARRIERS

Do not construct concrete barriers by slipforming.

6 SUPPLY AND FIXING OF STEEL REINFORCEMENT AND EMBEDMENTS

This Clause applies to all steel reinforcement and embedments, whether on site or in a precasting yard off-site, except where specified otherwise for stainless steel in Annexure B80/F.

6.1 STEEL REINFORCEMENT MATERIAL

6.1.1 Certification

The steel reinforcement material must be certified by the Australasian Certification Authority for Reinforcing and Structural Steels (ACRS) for conformity of the reinforcement production and processing to the requirements of AS/NZS 4671.

The manufacturer, and any supplier involved in the supply, must implement and maintain a quality management system in accordance with AS/NZS ISO 9001.

6.1.2 Reinforcement Type and Grade

Reinforcement must be of the type and grade specified on the Drawings, and conforming to AS/NZS 4671.

Plain bars or wire may be used for fitments.

6.1.3 Protective Coatings

Unless specified otherwise, do not use reinforcement with protective coatings, including epoxy coating.

6.1.4 Storage and Protection

Protect the reinforcement against corrosion, contamination and damage prior to and during concrete placement.

Support the reinforcement above the surface of the ground and protect it from damage and deterioration due to exposure.

The surface condition of reinforcement at the time of concreting must be such that its bond to the concrete or its performance in the member is not impaired.

6.2 CHAIRS AND SPACERS

6.2.1 General

Chairs and spacers must comply with AS/NZS 2425 unless specified otherwise in this Specification.

The smallest chair or spacer dimension must not be less than the specified concrete cover, and the largest dimension must not exceed 1.8 times the cover.

6.2.2 Permitted Chairs and Spacers

Use concrete chairs or spacers that are manufactured from machine mixed concrete. The strength and durability of concrete bar chairs and spacers must be the same or better than the concrete member in which they are placed.

Use fibre reinforced concrete chairs and spacers in concrete members located in exposure classifications C1 and C2.

Individual plastic bar chairs may be used only for precast and cast-in-place concrete members located in exposure classification A, B1 or B2 and for enclosed internal surfaces not exposed to view.

6.2.3 Prohibited Chairs and Spacers

Do not use chairs and spacers which are produced on site.

Do not use carbon or stainless steel wire bar chairs of any type, or pieces of timber, or coarse aggregate or broken concrete or bricks, to support the reinforcement.

6.3 FABRICATION OF REINFORCEMENT

6.3.1 Certification

Unless approved otherwise by the Principal, the reinforcement fabricator must be certified by the Australasian Certification Authority for Reinforcing and Structural Steels (ACRS) for fabricating reinforcement in accordance with AS 5100.5.

The fabricator must implement and maintain a quality management system in accordance with AS/NZS ISO 9001.

6.3.2 Fabrication – General

Fabricate reinforcement to the shape and dimensions shown on the Drawings and within the tolerances given in Clause 6.3.3.

Bend steel reinforcement bars by cold bending around pins of adequate size without impact or damage to the bar.

The nominal internal diameter of a bar bend or hook is the external diameter of the pin around which the reinforcement is bent. The diameter of the pin must be not less than the value determined from Table B80.13.

Table B80.13 – Internal Diameter of Bar Bend and Hooks

Item	Type of Bar	Minimum Internal Diameter of Bend
(a)	Normal bends	
	Fitment bars: Grade 250 and wire Grade 500	$3d_b$
	Fitment bars: Grade 500	$4d_b$
	Bars other than in (b) and (c) below	$5d_b$
(b)	Bends designed to be straightened or subsequently re-bent	
	$d_b \leq 16$ mm	$4d_b$
	$d_b = 20$ and 24 mm	$5d_b$
	$d_b \geq 28$ mm	$6d_b$
(c)	Bends in reinforcement which are epoxy coated or galvanized either before or after bending, and for stainless steel	
	$d_b \leq 16$ mm	$5d_b$
	$d_b \geq 20$ mm	$8d_b$

Note: d_b = nominal diameter of bar or wire

The Principal may approve bending of carbon steel reinforcement by heating, provided that the heating is carried out in a workshop under a controlled environment.

Before its first use, submit the heating procedure to the Principal for approval. The procedure must include adequate measures for applying uniform heat not exceeding 450°C, for a period not exceeding two minutes, to and beyond the portion to be bent. Do not cool heated bars by quenching.

Do not bend stainless steel reinforcement or Class L reinforcement by heating.

Do not re-bend or straighten bars already bent-within 20 bar diameters of the previous bend.

Where re-bending or straightening of bars on site is inevitable, such as in rehabilitation work, submit your proposed procedure to the Principal for approval before its first use. Include in the procedure details of tools to be used and the method for controlling the heating if applicable. Do not re-bend any bar more than once.

Bars partially embedded in concrete may be field bent provided that the bending conforms to the above requirements and the bond of the embedded portion is not impaired as a result of the bending.

6.3.3 Fabrication Tolerances

Fabrication tolerances must be as shown in Table B80.14.

Table B80.14 – Reinforcement Fabrication Tolerances

Type of Reinforcement	Tolerances [1] (mm)
Bar and mesh used for reinforcement	
Overall dimension for lengths up to 600 mm	–25, +0
Overall dimension for lengths over 600 mm	–40, +0
Overall offset dimension of a cranked column bar	–0, +10
Bar and mesh used for fitments	
Overall dimension for deformed bar and mesh	–15, +0
Overall dimension for plain round bar and mesh	–10, +0

Note:

[1] Positive value indicates amount by which cover may exceed specified thickness, and negative value indicates amount by which cover may be reduced below specified thickness.

6.4 SPLICING OF REINFORCEMENT

6.4.1 Location of Splices

Splice reinforcement only at the locations shown on the Drawings.

Additional splices or splices at other locations are at your expense and constitute a change in design detail for which you must first obtain the approval of the Principal.

6.4.2 Lapped Splices

Securely wire together the ends of bars forming a lapped splice in at least two places unless the splice is welded.

The length of lapped bar splices must conform to the requirements of AS 5100.5.

For bars in structural elements built using slipforming, increase the length of lap splices by 30%.

For bars in lightweight concrete members, increase the length of lap splices by 30%.

For galvanised or epoxy-coated bars, increase the length of lap splices by 50%.

A lapped splice for welded wire mesh must be made so that the two outermost transverse wires of one sheet of mesh overlap the two outermost transverse wires of the sheet being lapped.

6.4.3 Mechanical Splices

Use mechanical splices only at the locations shown on the Drawings and use only TfNSW approved types. Details of TfNSW approved mechanical splices can be found at:
http://www.rms.nsw.gov.au/business-industry/partners-suppliers/documents/tenders-contracts/listofapprovedbridgecomponentssystems.pdf

Install mechanical splices in accordance with the manufacturer's instructions.

6.5 WELDING OF REINFORCEMENT

Tying of reinforcement is preferred over welding.

All welding must conform to Specification TfNSW B203 and the bar manufacturer's recommendations. Welding includes any welding used to assemble reinforcing cages (refer Clause 6.6) or for temporary attachments.

Load bearing welds for lifting and transport of prefabricated reinforcement cages must be designed by a suitably qualified person with extensive experience in the design, welding and handling of prefabricated cages, taking into account the static and dynamic loadings and any stress reversals that may occur during lifting, moving and transport.

Welded splices must be tested and must meet the specified tensile strength of the parent metal. Testing must be carried out by a laboratory with appropriate NATA registration.

Do not field weld Grade 500L reinforcement. Where Grade 500L is shop welded, demonstrate that the weld procedure does not result in the loss of ductility.

Do not carry out welding of reinforcement in assemblies or cages after prestressing tendons have been placed within the assemblies or cages.

6.6 ASSEMBLY OF REINFORCEMENT

6.6.1 General

Secure reinforcement in place by tying or tack welding. Tie wire must be annealed steel wire having a diameter of not less than 1.2 mm. Perform tack welding in accordance with Clause 6.5.

Where there are 2 or more layers of reinforcement crossing each other laterally, tie bars at all intersections, except where the spacing is less than 300 mm in any direction, in which case tie only alternate intersections.

Wire ties must have a clear cover equal to that shown on the Drawings for the bar being tied, less the diameter of the tie wire. Projecting ends of ties must not encroach into the concrete cover.

Stiffen the reinforcement where necessary to ensure that the specified dimensional tolerances of Clause 9.4 and the clear cover for the reinforcement are achieved.

6.6.2 Lifting and Transport of Prefabricated Cages

Show on the shop drawings the design location of lifting and transport support points for prefabricated reinforcement cages, and mark these locations indelibly on the cage during fabrication. Show the lifting requirements on a drawing on durable material, attached to the cage prior to lifting. The load bearing welds must conform to Clause 6.5.

Submit to the Principal one copy of all prefabricated reinforcement cage shop drawings showing the size, type and location of load bearing welds, lifting and support points and lifting requirements. The person who designed the load bearing welds must certify the shop drawings.

WITNESS POINT	(For prefabricated reinforcement cages)
Process to be Witnessed:	Assembly, lifting and transport of cages.
Submission Details:	At least two working days' notice of intention to transport cages to the Works. Prior to the proposed transport date, submit to the Principal a Certificate of Conformity in respect of load bearing weld sizes and locations, and conformity of finished welds, together with drawings and checklists.

6.7 PLACING AND FIXING OF REINFORCEMENT AND EMBEDMENTS

6.7.1 Support of Reinforcement

Support the reinforcement and hold it clear of the formwork or blinding concrete by using individual concrete chairs and spacers complying with Clause 6.2, or by suspension using mild steel fitments that do not encroach into the cover.

Install the chairs or spacers at sufficiently close spacing, to ensure that the specified cover is maintained during concreting, and crushing of the chairs or spacers or encroachment into the cover does not occur.

Continuous bar chairs must:

(a) not be more than 350 mm in length;

(b) not be placed on a continuous straight line;

(c) only be used in SCC or HWC in conformity with Annexure B80/G; and

(d) have at least 25% voids within the enclosed perimeter of the bar chair side elevation, with a minimum gap between the formwork and the underside of the bar chair in the voids of 1.5 times the maximum nominal aggregate size in the concrete mix.

Reinforcement for cast-in-place decks over precast girders or planks may be supported on the exposed reinforcement of the girders or planks.

6.7.2 Placement of Embedments

Plan in detail the placement of embedments such as stressing anchorages, bearing attachment plates, form ties and hole formers in their final locations.

In addition to the tolerance requirements of this Specification, install post-tensioning ducts and void formers in accordance with Specifications TfNSW B113 and TfNSW B170 respectively.

Supply and install cast-in fasteners as specified on the Drawings.

Do not substitute cast-in fasteners shown on the Drawings with fasteners installed after concrete casting, such as chemical or mechanical anchors.

6.7.3 Inspection of Placed Reinforcement and Embedments

Locate all fitments and embedments with sufficient accuracy to prevent any misfit or misalignment between mating components.

Verify by inspection the placement of the reinforcement, the soundness of any associated welding, and the fixing of embedments prior to the placed reinforcement and/or embedments becoming inaccessible.

6.7.4 Cover

Fabricate, bend and place the reinforcement to provide the cover shown on the Drawings, within the tolerances given in Clause 6.7.5.

6.7.5 Reinforcement Location and Cover Tolerances

Tolerances for location of reinforcement not controlled by cover are as shown in Table B80.15.

Table B80.15 – Reinforcement Location Tolerances

Reinforcement location	Tolerances (mm)
Ends of reinforcement	±50
Spacing (s) of bars in walls/slabs, and of fitments in beams and columns	±15, or ±0.1s whichever is the greater

Cover tolerances are as shown in Table B80.16.

Table B80.16 – Cover Tolerances

Reinforcement location	Tolerances [1] (mm)
Formed surfaces [2]	–5, +10
Unformed finished surfaces	–5, +10
Slabs cast on ground	–10, +20
Footings cast against ground	–20, +40
Cast-in-place piles without permanent steel casing	–20, +40

Notes:

(1) Positive value indicates amount by which cover may exceed specified thickness, and negative value indicates amount by which cover may be reduced below specified thickness.

(2) Concrete cast against a blinding concrete layer is considered as formed.

You must achieve the tolerances for cover, irrespective of all other dimensional tolerances in the fabrication and casting of concrete members.

7 PLACING, COMPACTING, AND FINISHING OF CONCRETE

7.1 GENERAL

7.1.1 General

Place, compact, finish and cure (refer Clause 7) the concrete in such 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 to the intended level, expel entrapped air, and surround all reinforcement, tendons, ducts, anchorages and embedments;

(f) provide the specified finishes;

(g) control cracking, including that caused by plastic and drying shrinkage, concrete slumping, plastic settlement, crusting and thermal gradients.

7.1.2 Environmental Measures

Dispose of water, contaminants, debris, excess concrete and other materials from concrete placing, compaction, finishing and curing operations in accordance with TfNSW G36.

7.1.3 Working Outside Daylight Hours

When concrete is placed and finished outside daylight hours or in any other conditions where natural light may be inadequate, provide adequate lighting for the work including finishing and inspection.

7.2 CONCRETING PERSONNEL

7.2.1 General

For concrete pours other than precast members cast off-site, include in the PROJECT QUALITY PLAN the name of the Concrete Supervisor with details of qualifications and experience in concreting work.

7.2.2 Concrete Supervisor

The Concrete Supervisor must hold a TfNSW Bridgeworks Concreting Grey Card and have suitable and acceptable TAFE or equivalent qualifications for concrete placement, compaction, screeding, finishing and curing and must be present during all stages of the pour until implementation of the curing regime.

The Concrete Supervisor must certify that all aspects of the placement, compaction, screeding, finishing and curing have been carried out in accordance with your procedures submitted in accordance with Annexure B80/D.

7.2.3 Concreting Crew

In addition to the Concrete Supervisor, at least half of the remaining crew involved in a concreting operation, must hold a TfNSW Bridgeworks Concreting Grey Card.

HOLD POINT	(TfNSW Bridgeworks Concreting Grey Card)
Process Held:	First concrete pour in the Works.
Submission Details:	At least two weeks prior to the first concrete pour, submit to the Principal the names of the personnel who will be involved in bridgeworks concreting operations; which of these persons hold a TfNSW Bridgeworks Concreting Grey Card; and corresponding evidence of this. At least four working hours prior to pouring concrete, submit to the Principal a statement stating that at least half of the personnel who will be involved in bridgeworks concreting operations hold a TfNSW Bridgeworks Concreting Grey Card.
Release of Hold Point:	The Principal will verify that at least half of the personnel who will be involved in the bridgeworks concreting operations hold a TfNSW Bridgeworks Concreting Grey Card prior to authorising the release of the Hold Point.

7.3 TEMPERATURE AND RAIN

7.3.1 General

Continuously measure and record the concrete temperature and air temperature at the point of concrete placement.

The concrete temperature prior to placement must conform to Clause 4.4.4.

7.3.2 Ambient Temperature

Unless the Principal approves special precautions, do not place concrete other than that for cast-in-place piles if the air temperature in the shade is:

(i) below 5°C;

(ii) predicted to be below 5°C in the 24 hours after placement; or

(iii) above 38°C.

For cast-in-place concrete piles, do not place concrete if ice exists on pile casings, embedments, steel reinforcement or in pile holes.

On hot days, special precautions to reduce the concrete temperature may include:

(a) watering the aggregate stockpiles;

(b) use of refrigerated water in the mix;

(c) water mist spraying to cool the air provided that the water does not collect or pond on the exposed concrete surfaces.

On hot days, cool reinforcement by providing covers and wetting down prior to concrete placement to prevent flash setting of concrete coming into contact with the reinforcement.

On cold clear nights, take precautions against cooling of exposed surfaces by loss of heat by radiation that may cause frost damage, such as by providing insulation on the concrete surface.

7.3.3 Rain

Do not place concrete during rain or when rain appears imminent unless a waterproof covering is provided to the exposed surfaces of the concrete.

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

7.4 PREPARATION OF CONSTRUCTION JOINT SURFACES

7.4.1 Roughen Surface

Deliberately roughen the surface of concrete at construction joints to a pronounced profile with a surface roughness not less than 3 mm. Remove loose aggregate particles and laitance.

7.4.2 Clean and Wet Surface

Prior to placing the adjoining concrete, remove all loose material and clean the surface of the construction joint and the projecting reinforcement. Saturate the concrete surface with water conforming to Clause 2.7, and remove all excess water.

7.4.3 Remove Salt and Other Contaminants

In marine or aggressive environments, remove salt or other contaminants from the joint surface and reinforcement using water applied at high pressure. Provide temporary openings in formwork to allow the washing water to be removed.

7.5 CERTIFICATION PRIOR TO CONCRETING

7.5.1 Concreting of Precast Concrete Members Cast Off-Site

HOLD POINT	(For precast concrete members cast off-site)
Process Held:	Commencement of production of precast members for the Works.
Submission Details:	At least two working days prior, submit to the Principal checklists for verifying conformity of the nominated concrete mix, formwork, reinforcement, embedments and other relevant details.
Release of Hold Point:	The Principal will consider the submitted documents and may carry out further surveillance and audit, prior to authorising the release of the Hold Point.

7.5.2 All Other Concreting

HOLD POINT	(For concrete other than precast concrete members cast off-site)
Process Held:	Each placement of concrete in the Works.
Submission Details:	At least two working days prior to each concrete placement, submit to the Principal a pour specific method statement detailing: (a) delivery rate; (b) placement method and rate; (c) equipment on standby. At least 4 working hours prior to commencement of placing concrete (unless otherwise permitted by the Principal), submit to the Principal a Certificate of Conformity, endorsed by the Concrete Supervisor, in respect of formwork, reinforcement, embedments and screeding guide rails or height pins. This certificate must be accompanied by verification checklists and other details showing conformity to this Specification.
Release of Hold Point:	The Principal will consider the submitted documents and may carry out further surveillance and audit, prior to authorising the release of the Hold Point.

7.6 CONCRETE PLACING AND COMPACTION

7.6.1 General

Before commencing placing of concrete, remove all loose tie wire, dirt, wood chips, hardened concrete or mortar, and all other foreign matter from within the forms.

Continuously monitor the placement and compaction of the concrete during each pour. Provide access and lighting as necessary to permit adequate monitoring.

Where necessary, place and compact concrete in discrete layers.

7.6.2 Placing Concrete

Do not place concrete in water except as provided for in Clause 7.7.

Remove all free water from areas where concrete is to be placed in the dry and provide suitable cofferdams or other means to stop any inflow of water.

Carry out concreting in one continuous operation between the ends of members and/or construction joints. Place concrete in such manner as to prevent the occurrence of cold joints.

Do not place fresh concrete against concrete that has taken its initial set, except at properly formed construction joints.

Supply the concrete at a rate that ensures that all the concrete in the forms is kept plastic until placed in its final position and compacted, and so that no cold joints are formed. Provide sufficient equipment and personnel to maintain the adopted rate of concrete placement.

Place concrete only from a height from which segregation cannot occur. Ensure conformity to this requirement through the use of suitable tremie pipes, chutes or other similar equipment.

7.6.3 Equipment

Internal vibrators must be of the rotary out-of-balance type, with a minimum diameter of 50 mm and operating frequency between 130 Hz and 200 Hz. Use smaller diameter vibrators for compaction of thin or narrow members or spaces or for compaction around dense reinforcement or as otherwise required. Check the vibrators prior to the concrete pour to ensure they are in proper working order.

The number of working internal vibrators and motors in use for compacting concrete during a concrete pour must not be less than one for each 10 cubic metres of concrete placed per hour, with a minimum of two. The number of standby vibrators and motors must be not less than one quarter of the number of vibrators and motors in use, with a minimum of one.

7.6.4 Compaction

Compact concrete immediately after placing using internal and/or external vibration to expel all entrapped air. Carry out vibration in a regular and systematic manner to ensure that the concrete is thoroughly compacted. Apply vibration to the full depth of each layer and extend into the top 100 mm of the underlying layer. Do not vibrate concrete to the point where segregation occurs.

Insert internal vibrators vertically at spacings not exceeding 350 mm to liquefy the concrete so that all entrapped air escapes. Leave the vibrator in place until the air bubbles cease breaking the surface, then withdraw slowly to prevent pockets forming. Do not allow vibrators to rest on the reinforcement.

In regions of closely spaced horizontal reinforcement, full compaction of the concrete must be achieved directly beneath the closely spaced horizontal reinforcement prior to encasing that reinforcement with concrete.

7.7 PLACING IN WATER

Unless otherwise specified on the Drawings or permitted by the Principal, do not place concrete in water.

Concrete for cast-in-place piles may be placed in water. For cast-in-place piles, use the tremie method in accordance with the appropriate piling specification, and using either SCC or HWC.

Concrete placed in water must be assessed for bleeding and washout resistance using Bauer Filtration test method described in CIA Z17. The test results must meet the requirements of Table B1 of CIA Z17.

Do not place concrete in water having a temperature below 5°C.

7.8 PLACING FOR VOIDED SLAB CONSTRUCTION

Voided slab construction comprises a cast-in-place deck slab having multiple formed longitudinal voids.

Carry out the placing of concrete in voided slabs in at least three stages as follows:

(a) to the bottom one third of the voids;

(b) to the top of the voids; and

(c) to the finished level.

The percentage of the total area covered by any one stage must be such that no concrete has reached its initial set before the overlying concrete is placed.

7.9 CONCRETING OF DECK JOINT BLOCKOUTS

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.

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.

Aggregate for the concrete must conform to Clause 2.4.

Prepare the blockout surfaces for concreting strictly in conformity with Clause 7.4.

7.10 CONTROL OF MOISTURE LOSS

7.10.1 General

When placing concrete into forms, take appropriate measures to restrict the evaporation of water from the concrete surface and to prevent the incidence of plastic shrinkage cracking.

Submit procedures for the restriction of the evaporation rates to less than 1 kg/m^2/hour as part of the requirements of Annexure B80/D.

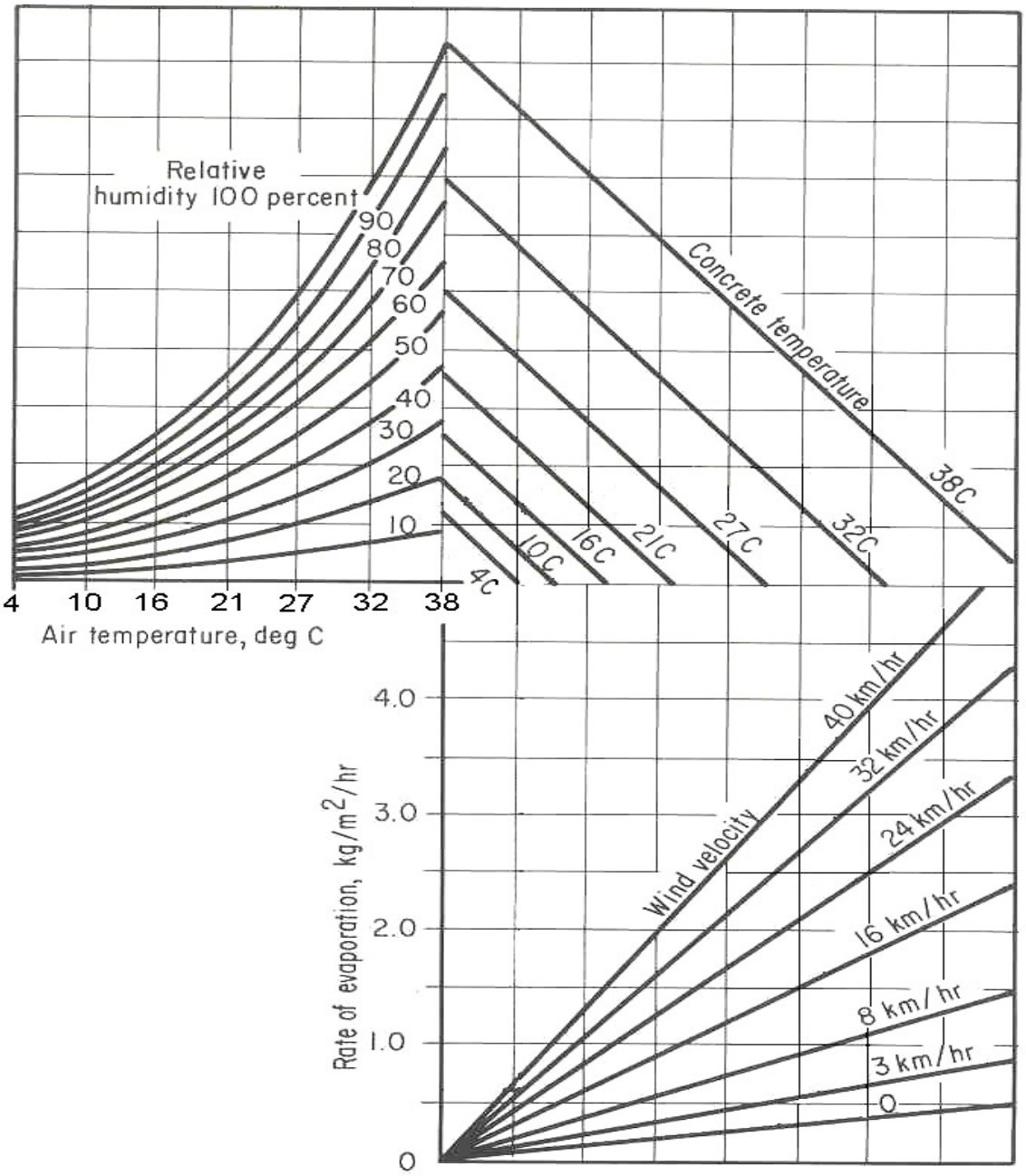
7.10.2 Evaporation Retarder

If an evaporation retarder is used to restrict the evaporation of water, apply it in a fine uniform spray. Any subsequent operations on the concrete must not incorporate the evaporation retarder into the unset concrete.

7.10.3 Rate of Evaporation

You may use Figure B80.3 as a guide for assessing the rate of evaporation.

***Figure B80.3 – Evaporation from Concrete Freshly Placed on Site**



The graph shows the effects of air temperature, relative humidity, concrete temperature and wind velocity together on the rate of evaporation of water from freshly placed and unprotected concrete.

Example – with:

- air temperature at 27°C;
- relative humidity at 40%;
- concrete temperature at 27°C; and
- a wind velocity of 26 km/hr;

the rate of evaporation would be 1.2 kg/m^2/hr.

To determine the evaporation rate from the graph, enter the graph at the air temperature (in this case 27°C), and move vertically to intersect the curve for relative humidity encountered – here 40%. From this point, move horizontally to the respective line for concrete temperature – here 27°C. Move vertically down to the respective wind velocity curve – in this case interpolating for 26 km/hr and then horizontally to the left to intersect the scale for the rate of evaporation.

* Source of figure: ACI Committee 305, 1999, "Hot weather concreting (ACI 305R-99)", American Concrete Institute, Farmington Hills, Michigan, USA, p 5.

7.11 SCREEDING AND FINISHING OF DECK AND APPROACH SLAB SURFACES

7.11.1 Equipment and Set Up

For all types of deck and approach slab surfaces, whether concrete, asphalt or bitumen-sealed, screed the surface using vibrating screeds set on screeding guide rails.

Where approved by the Principal or stated in Annexure B80/A5, you may screed decks and approach slabs using power vibrating screeds operated by experienced personnel and height pins, provided that the concrete strips between height pins are placed and compacted at the same time as the concrete between strips.

Set screeding guide rails entirely above the concrete surface unless they are removed on completion of screeding and before commencement of finishing. Make screeding guide rails sufficiently rigid to ensure that the finished deck surface levels and concrete cover values conform to the Drawings.

Support screeding guide rails and height pins, where permitted by the Principal, independently of the underlying reinforcement. Attachments to forms must either be of durable sacrificial non-corrosive materials compatible with concrete or be capable of being completely removed from the deck after final screeding.

When setting screeding guide rails or height pin markings, make due allowance for take-up of formwork, deflections on removal of formwork, construction of subsequent stages of superstructure, deflection of girders, prestressing of the superstructure and any other factors which may change the deck levels during the construction of the bridge.

Height pin spacings both longitudinally and laterally must be equal to the length of the vibrating screed or three (3) metres, whichever is the lesser.

7.11.2 Screeding

Place and compact the concrete in accordance with Clause 7.6. If a power vibrating screed is used, bring the surface to the required level with a vibrating screed operating at a frequency of at least 100 Hz.

Ensure that the consolidation process is uniform throughout the deck area, including areas adjacent to the screeding guide rails or height pins, during final placement, redistribution and compaction of the top layer of deck concrete prior to or during screeding. Keep sufficient surplus concrete in front of the screed to ensure full and uniform compaction to the deck surface.

You may carry out supplementary floating to bring fines to the surface.

Remove all parts of screeding guide rails or the top parts of height pins after final screeding and compact the disturbed areas to provide the concrete cover shown on the Drawings, within the tolerances given in Clause 6.7.5.

7.11.3 Finishing

After screeding, protect the surface so that only excess bleed water is removed and no drying out of the surface occurs at any location. The control of moisture loss must conform to Clause 7.10 .

Do not carry out finishing until after the concrete has become sufficiently hardened to support the finishing operation. Complete all repairs to the concrete at the screeding guide rails and supports or height pin locations prior to the commencement of finishing.

Continue to protect the surface from drying out in accordance with Clause 7.10 during finishing and texturing.

Do not pour water onto the surface during finishing, but apply water mist sprays or aliphatic alcohols to prevent the concrete from drying out.

Provided they are not deleterious to the concrete surface, you may use approved proprietary finishing aids in adverse conditions. Apply the finishing aid without working it into the surface when the concrete sheen is about to disappear.

Unless otherwise specified on the Drawings or approved by the Principal, provide the surface finish by sweeping the surface transversely with a stiff-bristled yard broom, or using a suitable mechanical grooving device, to produce a uniformly roughened surface texture.

The texture depth of the surface must not be less than 0.90 mm when measured in accordance with Test Method TfNSW T240.

When cracks appear before or during finishing, rework the concrete using vibrators as required where initial set has not yet occurred, and refinish the surface in accordance with the above.

Commence curing without any delay, on completion of the finishing operation at any location.

7.12 SCREEDING AND FINISHING OF ALL OTHER UNFORMED SURFACES

Compact and tamp unformed surfaces to bring a layer of fines to the surface, and screed the surface to the specified levels.

Finish with a wooden or “magnesium” float to form an even uniform surface.

Leave construction joints rough in accordance with Clause 7.4.

When cracks appear before or during finishing, rework the concrete, using vibrators as required, where initial set has not yet occurred and refinish the surface with a wooden or “magnesium” float.

Commence curing without any delay, on completion of the finishing operation at any location.

8 CURING

8.1 GENERAL

For all types of curing regimes, protect the concrete surface from extreme heat or cold and maintain at a temperature not less than 5°C throughout the curing period.

Apply curing methods and periods in accordance with the approved curing regime submitted under Clause 3.9.3.

Regardless of the curing regime adopted, 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 sealed curing, may be reduced by the 72 hours elapsed during wet curing.

8.2 CURING COMPOUNDS

8.2.1 Quality Management System

The curing compound supplier must have in place a quality management system conforming to AS/NZS ISO 9001 as a means of ensuring that the product conforms to this Specification.

8.2.2 Material

Curing compounds must conform to AS 3799 for the Classes and Types specified in Table B80.17.

Table B80.17 – Classes and Types of Curing Compounds

Description of curing compound	Class (1)	Minimum non-volatile content (2)	Type (1)
Wax-based (Wax emulsion)	A	30%	1-D
Resin-based (Hydrocarbon resin)	B	30%	
Waterborne emulsions	Z	30%	

Notes:

(1) In accordance with AS 3799.

(2) In accordance with AS 1580.301.1.

The curing compound must be such that no evidence of the curing compound remains on any concrete surface exposed to view after a period of six (6) months from the date of application of the compound.

8.2.3 Certification

For each curing compound proposed for use in the Works, provide a Certificate of Conformity from the supplier, supported by test certificates from a laboratory with appropriate NATA registration, certifying that the curing compound conforms to this Specification.

This Certificate of Conformity must relate only to the formulation on which the tests were made and must be valid for not more than three years from the date of issue. The test certificates must report the non-volatile content, the efficiency index and the density and must provide a reference for the infrared spectrum as determined in accordance with Test Method TfNSW T1005.

For each batch delivered, provide a Certificate of Uniformity from the supplier, supported by uniformity testing on non-volatile content, density, viscosity and infrared spectroscopy in accordance with AS 3799. The Certificate of Uniformity must state that the same formulation has been used for the batch as is represented by the Certificate of Conformity.

Sample and test at a rate of not less than one test per 3000 litres, or part thereof, supplied.

8.3 WET CURING

Apply wet curing:

(a) to unformed surfaces immediately after the completion of all finishing operations;

(b) to formed surfaces immediately after the removal of the forms.

Keep the concrete surfaces completely covered with canvas, hessian, geofabric with plastic sheeting, or other suitable materials and continuously wet.

When used on vertical surfaces, keep these cover materials effectively wrapped and in place for the whole curing period.

Water used for curing must conform to this Specification and be not more than 10°C cooler than the concrete surface.

Wet curing must not cause staining of the formed surfaces producing a nonconforming finish.

8.4 SEALED CURING

8.4.1 By Retention of Formwork

Keep in place all parts of the formwork used for members cured under the sealed curing regime.

Where it is proposed to strip part of or all the formwork before the curing period is completed, apply a curing compound or wet curing to the stripped members for the remainder of the curing period.

8.4.2 Using Curing Compounds

Curing compound used must comply with Clause 8.2.

Do not use wax emulsion on deck surfaces.

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

Apply the curing compound using a fine spray at the rate stated on the Certificate of Conformity, or at a rate of 0.2 litres/m^2 per coat, whichever is the greater. Check the application rate by calculating the amount of curing compound falling on felt mats, each approximately 0.25 m^2 in area, placed on the concrete surface.

Apply the curing compound in two coats at the full rate to form a continuous membrane over the whole concrete surface.

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.

Apply the curing compound to unformed surfaces immediately after completion of all finishing operations, and to formed surfaces within half an hour of the removal of formwork from the section.

Maintain the curing membrane intact after its initial application, for the curing period nominated. Make good any damage to the curing membrane by respraying the affected areas.

8.4.3 Using Plastic Wrapping

As an alternative to curing compounds, carry out sealed curing using tight, fully sealed plastic wrapping to prevent moisture loss from the concrete surface. Make good any damage to the wrapping by repairing the affected areas.

8.5 HEAT ACCELERATED CURING

8.5.1 General

Heat accelerated curing must conform to the following:

(a) At the end of the presetting period (i.e. the interval between placing the last concrete and commencement of heat application), the concrete maturity must not be less than 50°C.hrs, and the time elapsed must not be less than two hours or more than five hours, unless wet curing is applied during the presetting period.

(b) Keep unformed exposed concrete surfaces wet with a relative humidity exceeding 98% at all times after the presetting period and until the completion of the heat curing. Provide evidence of this to the Principal.

(c) The rate at which the temperature of the concrete increases must not exceed 24°C per hour.

(d) The maximum temperature of the concrete during and after the application of heat must not exceed 70°C for all concrete exposure classifications.

(e) After completion of curing, allow the concrete to cool gradually and evenly. Do not expose the concrete to the surrounding environment or operate on it in any way until the temperature at the surface of the concrete has fallen to within 40°C of the ambient temperature.

(f) Record maximum and minimum temperatures and temperature variations with time using a suitable thermograph taking reading at intervals not exceeding 15 minutes.

(g) For Curing Provision B only, keep the concrete at a temperature not less than 50°C and for such a period to attain a concrete maturity not less than 350°C.hours.

8.5.2 Steam Curing – Additional Requirements

Use distribution pipes to assist in the uniform distribution of heat. Arrange the distribution pipes in such a manner and/or protect the concrete members in such a way that steam will not be blown directly against the concrete, or cause uneven heating of the members at any point.

Keep the enclosing arrangements sufficiently airtight during the whole period of steam curing to prevent the entry of cool air at any time.

Cure the associated concrete test cylinders by placing the cylinders within the enclosure in a position adjacent to the lower face of the structural units they represent. Locate the cylinders midway between steam entry points and at least half the width of the structural unit from these points. Do not place the cylinders on top of the structural units or on the steam jet lines or in line with any steam jets.

9 PROPERTIES OF HARDENED CONCRETE AND DIMENSIONAL REQUIREMENTS

9.1 GENERAL

The methods and frequencies of sampling and testing of concrete for compressive strength, compaction, cover and other properties during the progress of the work must be in accordance with Annexure B80/L.

Do not take cores in concrete bridge decks or other bridge members without the Principal's approval.

Use non-destructive tests to investigate concrete of observed or suspect quality, and take cores only to confirm findings of nonconforming concrete as approved by the Principal.

9.2 COMPRESSIVE STRENGTH

Determine the compressive strength of the concrete in accordance with Annexure B80/L Clause L4.

For the purpose of this Clause, the Representative Concrete Strength (RCS) is defined as either the age adjusted strength of concrete cylinders or, when applicable, the age adjusted strength of cores cut from the Works.

Concrete will be considered to be nonconforming where the RCS is less than $f_{c.min}$ determined in accordance with Clause 3.6. Refer to Annexure B80/B for resolution of nonconformities.

Any concrete with the RCS exceeding 100 MPa must be identified as nonconforming.

9.3 CONCRETE CRACKING

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 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.

9.4 DIMENSIONAL TOLERANCES

The formed and unformed surfaces of hardened concrete must have the dimensions shown on the Drawings within the tolerances stated in Table B80.18, for both cast-in-place and precast concrete members.

Where there is a conflict, the dimensional tolerances stated in Specifications TfNSW B110 and TfNSW B115 take precedence over that in this Specification.

Table B80.18 – Dimensional Tolerances for Formed and Unformed Surfaces

Item	Member	Tolerance (mm)
(a)	**Footings and Pilecaps**	
	Deviation in **plan dimensions**	
	Formed	–10, +50
	Unformed (footings only)	–0, +150
	Deviation from **plan position** in any direction	50
	Deviation in **thickness**	
	Thickness < 300 mm	–5, +25
	Thickness ≥ 300 mm	–10, +50
	Deviation in **top surface level** (reduced level)	–25, +25
(b)	**Columns/Piers and Headstocks**	
	Deviation in **plan dimensions**	
	Any cross sectional dimension < 3 m	–5, +15
	Any cross sectional dimension ≥ 3 m	–10, +25
	Deviation from **plan position** (at any level) in any direction	25
	Deviation from **alignment of row of members**	10
	Deviation from **vertical or specified batter**	
	Unexposed concrete	12 mm in 3 m ($^1/_{250}$)
	Exposed concrete	6 mm in 3 m ($^1/_{500}$)
	Deviation in **top surface level** (reduced level)	
	With pedestals	–10, +10
	Without pedestals	–5, +5
	Difference in **top surface level** across width of member	5
(c)	**Pedestals and Bearing Pads**	
	Deviation in **top surface level** (reduced level)	–2.5, +2.5
	Deviation from design **grade** across individual units	1 in 200
	Top surface **flatness**	+1.0, –1.0
	Deviation of **bearing pads centreline** from plan position	5
(d)	**Decks Slabs**	
	Deviation (1) in **thickness**	–5, +15
	Deviation (1) in **deck surface level** (reduced level)	–10, +5
	Deviation (2) in **surface flatness** in any direction	3 mm in 3 m ($^1/_{1000}$)
	Deviation in **deck joint slot width**	–3, +3

Item	Member	Tolerance (mm)
(e)	**Kerbs and Barriers**	
	Deviation in **dimensions**	–2.5, +2.5
	Deviation from **plan position** (at any level)	25
	Deviation in plan from **straight or curved horizontal alignment**	5 mm in 3 m ($^{1}/_{600}$)
	Deviation from design **grade**	3 mm in 3 m ($^{1}/_{1000}$)
	Deviation from **vertical or specified batter**	
	Unexposed concrete	12 mm in 3 m ($^{1}/_{250}$)
	Exposed concrete	6 mm in 3 m ($^{1}/_{500}$)
	Deviation in **height** above deck slab	–5, +10
	Step anywhere on top or side surface	5
	Front face **flatness**	3 mm in 3 m ($^{1}/_{1000}$)
	Relative **displacement** between adjoining members	10
	Deviation in **barrier end posts dimensions**	–5, +5
(f)	**Walls**	
	Deviation in **plan dimensions**	
	Any cross sectional dimension < 3 m	–5, +15
	Any cross sectional dimension ≥ 3 m	–10, +25
	Deviation from **plan position** in any direction	25
	Deviation from **alignment**	10
	Deviation from **vertical or specified batter**	
	Unexposed concrete	12 mm in 3 m ($^{1}/_{250}$)
	Exposed concrete	6 mm in 3 m ($^{1}/_{500}$)
	Relative **displacement** between adjoining members	10
(g)	**All other members**	
	Deviation in **plan dimensions**	
	Any cross sectional dimension < 3 m	–5, +15
	Any cross sectional dimension ≥ 3 m	–10, +25
	Deviation in **plan position** (at any level) in any direction	25
	Deviation from **vertical or specified batter**	
	Unexposed concrete	12 mm in 3 m ($^{1}/_{250}$)
	Exposed concrete	6 mm in 3 m ($^{1}/_{500}$)
	Relative **displacement** between adjoining members	10

Item	Member	Tolerance (mm)
(h)	**Irregularities in exposed concrete surfaces**	
	Any side dimension < 1 m	2.5 (3)
	Any side dimension ≥ 1 m	5 (3, 4)

Notes:

(1) After allowing for camber or hog, and variations in design loads and their effects.

(2) After allowing for superelevation and vertical curvature or grade.

(3) Deviation measured using straight edge.

(4) When side dimension > 3 m, use 3 m long straight edge.

9.5 SURFACE FINISH

The surfaces of hardened concrete must comply with the Class of finish shown in Table B80.19, unless otherwise stated in Annexure B80/A4 or the Drawings.

Table B80.19 – Class of Surface Finish

Structure Member	Class of Surface Finish (1)	
	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 2X (2)	Class 2
Piers, abutment and retaining wall surfaces exposed to view	Class 2X (2)	Class 2
Other external surfaces, including soffits of precast planks	Class 2	Class 2
Internal and permanently hidden surfaces	Class 3	Class 3

Notes:

(1) As defined in AS 3610.1.

(2) Class 2X is the surface finish conforming to Class 2 except that the blowholes requirement is relaxed to that for Class 3 (refer Figure B3 of AS 3610.1).

The surface finish of unformed surfaces must conform to Clauses 7.11.3 and 7.12.

9.6 COMPACTION

When directed by the Principal, determine the relative compaction of concrete as the percentage ratio of the unit mass of the sample cores to the unit mass of the representative cylinders for the concrete area from which the cores are cut. Determine the unit mass in accordance with Annexure B80/L Clause L5.

The relative compaction must be at least 98%.

Identify any concrete failing to meet this requirement as nonconforming.

9.7 COVER

When required by the Principal, carry out a cover measurement survey of reinforced and precast concrete members in accordance with Clause L6 of Annexure B80/L.

Identify any concrete members not meeting the specified concrete cover as nonconforming. Mark on the members and map the nonconforming locations.

Identify and report to the Principal all individual cover survey results with less than 75% of the specified cover, together with the cover map and your proposed remedial actions to rectify each nonconformity.

9.8 REPAIRS TO FORMED SURFACES

Detail in the PROJECT QUALITY PLAN your procedure, including materials, for repairing minor surface imperfections including porous spots, shallow honeycombing, rough areas, and blowholes which are nonconforming with the specified Class. The procedure must be approved by the Principal.

Carry out repairs promptly using the approved method and materials so that a general uniform appearance, texture and colour is achieved.

9.9 EARLY TRAFFICKING OF BRIDGE DECKS

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.

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.

Carry out in-place strength assessment in accordance with Clause 9.2 at a frequency to suit your 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.

HOLD POINT

Process Held:	Early trafficking of concrete bridge deck.
Submission Details:	At least 2 working days prior to commencement of early trafficking, submit the "strength versus age" relationship of concrete, with supporting test results, and evidence of completion of curing.
Release of Hold Point:	The Principal will consider the submitted documents, prior to authorising the release of the Hold Point.

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

ANNEXURE B80/A – PROJECT SPECIFIC REQUIREMENTS

Refer to Clause 1.2.1.

A1 MEMBERS IN EXPOSURE CLASSIFICATION U

NOTES TO TENDER DOCUMENTER: (Delete this boxed text after customising Annexure B80/A)

Complete the tables below under Annexures A1.2 and A1.3 by deleting whichever is not applicable or filling in the required details.

A1.1 General

Concrete members in exposure classification U must conform to Specification TfNSW B80 for the base exposure classification and the additional requirements contained in this Annexure.

A1.2 Base Exposure Classification

The base exposure classification, nature of exposure and concrete isolation requirements are stated in Table B80/A.1 or on the Drawings.

Concrete quality, cover and other durability requirements for the base exposure classification must conform to those specified for the corresponding exposure classification of AS 5100.5.

Where full isolation of concrete surface from the aggressive environment is mandatory, include details of the proposed isolation method with the concrete mix design submission.

Table B80/A.1

Parameters	Requirement
Base exposure classification	B1 / B2 / C1 / C2
Nature of exposure	Acid sulfate soil / Soft or running water / Other
Full isolation of concrete surface from aggressive environment	Mandatory / Optional / Not required

A1.3 Additional Requirements

Cement:

Aggregate:

Admixtures:

Curing Provision:

Others:

A2 USE OF SELF-COMPACTING CONCRETE OR HIGH WORKABILITY CONCRETE

Refer to Clause 3.2.

You may use SCC or HWC for placement of the following bridge members:

(a) Precast concrete members manufactured under controlled conditions.

(b) Cast-in-place concrete members with an intricate shape and/or heavily congested reinforcement or other specific applications warranting a high degree of workability (subject to Principal's approval).

Comply with the following clauses for the project specific concrete type and requirements.

A2.1 Self-Compacting Concrete

Refer to Annexure B80/G.

NOTES TO TENDER DOCUMENTER: (Delete this boxed text after customising Annexure B80/A)

List here concrete members where SCC must/may be used.

Fill in below the required maximum nominal size of coarse aggregate, and complete Table B80/A.2 by filling in the required nominated values.

The maximum nominal size of coarse aggregate is ….. mm

The fresh properties of the concrete must be in accordance with Table B80/A.2.

Table B80/A.2 Project Specific Fresh Properties

Property	Test Method	Project Specific Criteria	Nominated Value
Filling ability	ASTM C1611	Slump flow spread [(1)] (mm)	
Stability	ASTM C1611	VSI rating (max)	
	EN 12350-11	Sieved portion (max) (%)	
	ASTM C1712	Penetration (max) (mm)	
Passing ability	ASTM C1621	Δ Spread (max) (mm)	
	EN 12350-12	Δ Height (max) (mm)	

Note:

(1) With a tolerance of ±50 mm.

A2.2 High Workability Concrete

Refer to Annexure B80/G.

NOTES TO TENDER DOCUMENTER: (Delete this boxed text after customising Annexure B80/A)

List here concrete members where HWC must/may be used.

Fill in below the required maximum nominal size of coarse aggregate.

The maximum nominal size of coarse aggregate is ….. mm

A3 FORMWORK CATEGORY C

Refer to Clause 5.2.3.

A4 TEST MEMBERS FOR PLACEMENT AND SURFACE FINISH REQUIREMENTS

Refer to Clause 3.7.

Construct test member(s) in accordance with Clause 5.3 and Clause G4.

Refer to Clause 9.5

Surface finish to be assessed on the same test member.

NOTES TO TENDER DOCUMENTER: (Delete this boxed text after customising Annexure B80/A)

Delete this clause in its entirety and replace the heading with "Not Used" if test members are not required.

A5 DECKS AND APPROACH SLABS FOR HEIGHT PINS SCREEDING

Refer to Clause 7.11.

ANNEXURE B80/B – RESOLUTION OF NONCONFORMITIES

Refer to Clause 1.2.2.

Nonconforming work and materials will be rejected, unless accepted with the specified deductions in accordance with this Annexure.

B1 COMPRESSIVE STRENGTH

B1.1 Cores

If the 28 day compressive strength of reinforced or unreinforced concrete as indicated by test specimens fails to reach the specified minimum 28 day compressive strength, submit to the Principal a request for testing specimens cut from the completed Works.

For prestressed work, the request must be accompanied by a certificate from a Structural Engineer who is experienced in the design of prestressed concrete structures. The certificate must state that the proposed coring will not be detrimental to the prestressed concrete member.

B1.2 Conformity of Concrete

Concrete where the RCS is less than $f_{c.min}$ (refer to Clause 3.6) or greater than 100 MPa is nonconforming.

Where the RCS is less than $f_{c.min}$ but greater than or equal to 90% of $f_{c.min}$, the concrete represented may be accepted by the Principal at the Principal's discretion. In such cases, and when the concrete is accepted by the Principal, the schedule rate for the nonconforming concrete will be reduced by the amount shown in Table B80/B.1.

Any deduction arising from deficiencies in concrete strength, as calculated from Table B80/B.1, apply to the proportion of the pour represented by the deficient result.

In the case of precast members, the "schedule price" in Table B80/B.1 is taken to mean one half of the priced unit rate for the members.

Table B80/B.1 – Deductions for Understrength Concrete

Deficiency in strength below $f_{c.min}$	Deduction
≤ 5%	2% of the schedule price for each 1% (or fraction thereof) deficiency in strength.
> 5%, ≤ 10%	10% of the schedule price for the first 5% deficiency plus 5% of the schedule price for each 1% (or fraction thereof) deficiency in strength in excess of 5%.

ANNEXURE B80/C – SCHEDULES OF HOLD POINTS, WITNESS POINTS AND IDENTIFIED RECORDS

Refer to Clause 1.2.3.

C1 SCHEDULE OF HOLD POINTS AND WITNESS POINTS

Clause	Type	Description
3.9.1	Hold	Nomination of concrete mix, including submission of all details for new concrete mixes.
5.2.3	Hold	Submission of formwork documentation and design certification.
5.3	Witness	Placement of concrete for test members.
6.6.2	Witness	Assembly, lifting and transport of prefabricated reinforcement cages.
7.2.3	Hold	Submission of names of personnel involved in concreting operations and evidence that at least half of them hold a TfNSW Bridgeworks Concreting Grey Card.
7.5.1	Hold	Submission of checklists for verifying conformity of the nominated concrete mix, formwork, reinforcement and embedments for precast concrete members cast off-site.
7.5.2	Hold	Submission of Certificate of Conformity of formwork, reinforcement and embedments for concrete other than precast concrete members cast at off-site locations.
9.9	Hold	Early trafficking of concrete bridge deck.

C2 SCHEDULE OF IDENTIFIED RECORDS

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

Clause	Description of Identified Record
3.9	Submission of nominated mixes
3.9.4	Variations from nominated mixes
7.5.1	Certificate of Conformity in respect of formwork, reinforcement, embedments and other relevant details or precast concrete members cast at off-site locations
8.2.3	Certificate of Conformity of curing compound

ANNEXURE B80/D – PLANNING DOCUMENTS

Refer to Clause 1.2.4.

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

Clause	Description of Document
2.3.3	Procedures for addition of corrosion inhibitors
3.9	All concrete mix designs and trial mix reports
3.3.2	Methods to prevent thermal cracking
4.4.3	Details of set retarding admixture to delay hydration, and procedures for trialling their use
5.3	Details of design and construction of test members
5.9.2	Details of methods used to determine formwork stripping time other than by direct testing of representative cylinders
6.3.2	Procedure for re-bending or straightening bent bars on site, if permitted
6.5	Procedure for welding reinforcement and design of load bearing welds in reinforcement cages
6.7.2	Method for placing embedments
7.2	Name, qualifications and experience of the Concrete Supervisor for concrete pours other than precast members cast off-site Names of personnel for carrying out concreting operations, together with evidence of relevant training and experience
7.6	Method of concrete delivery Method for placing concrete, including placing rates for varying pour sizes Procedures for compaction including vibrator spacing and sequence to ensure full compaction of concrete member
7.10	Procedures for controlling moisture loss
7.11	Procedures for screeding and finishing, including details of method of fixing and removing screeding guide rails or height pins
7.11.3	Procedures for deck finishing, which must include the details under Clause D2 below.
8	Curing methods and curing periods
8.5	Verification of conformity of a proposed heat accelerated curing method with Specification requirements
9.8	Approved procedure for repair of minor surface imperfections
Annex G6.1	Procedures for supply and placement of SCC
Annex G6.1	Procedures for supply and placement of HWC
Annex L6	Name, qualifications and experience of technicians for concrete cover survey

D2 Finishing Procedures

The finishing procedures referred to in Annexure B80/D must include:

(a) evidence including previously obtained survey results that the finishing method will produce decks conforming to this Specification and a statement that non-conforming results will be included;

(b) type and rate of proposed evaporation retarders if any;

(c) details of proposed finishing aids;

(d) method of compaction of concrete adjacent to the guide rails;

(e) details including drawings of screeding guide rails or height pins and method of attachment to forms;

(f) method and timing of repairs at guide rail supports or height pins;

(g) timing for checking of profile using a straight edge;

(h) type and size of allowances to be made for screeding guide rails or height pin marks for profile adjustments in accordance with Clause 7.11.1.

ANNEXURE B80/E – CURING PROVISION B

Refer to Clause 3.5.2.

For the exposure classifications specified on the Drawings, the curing regime applied under Curing Provision B must be in accordance with Tables B80/E.1 (wet), B80/E.2 (sealed) and B80/E.3 (heat accelerated).

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.

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

Abbreviations Used in Tables B80/E.1, B80/E.2 and B80/E.3:

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

✓ Applicable. Curing Provision B may apply for this case

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

Table B80/E.1 – Wet Curing

Exposure classification	Curing period (days)		
	SL cement	Blended cement containing BFS and/or FA	Blended cement containing AS
A	7	7	×
B1	7	7	×
B2	×	14	7
C1	×	14	7
C2	×	14	7
U	In accordance with Annexure B80/A1		

Table B80/E.2 – Sealed Curing

Exposure classification	Curing period (days)	
	SL cement	Blended cement containing BFS and/or FA
A	7	7
B1	7	7
B2	×	×
C1	×	×
C2	×	×
U	In accordance with Annexure B80/A1	

Table B80/E.3 – Heat Accelerated Curing

Exposure classification	Permissibility of curing	
	SL cement	Blended cement containing BFS and/or FA and/or AS
A	✓	✓
B1	✓	✓
B2	×	✓
C1	×	✓
C2	×	✓
U	In accordance with Annexure B80/A1	

ANNEXURE B80/F – STAINLESS STEEL REINFORCEMENT

Refer to Clause 6.

F1 GENERAL

The relevant requirements of this Specification apply to the supply, fabrication, transport, storage, assembly and fixing of stainless steel reinforcement, except where modified by this Annexure.

F2 DURABILITY

Where stainless steel reinforcement is used in members in exposure classification C2, a corrosion inhibiter is not required.

F3 SUPPLY

F3.1 Quality Management System Requirements

The reinforcement material supplier must be certified by the UK Certification Authority for Reinforcing Steels for the production of stainless steel reinforcement materials.

F3.2 Materials

Stainless steel reinforcement must be deformed bars, deformed wire or welded wire mesh.

Stainless steel reinforcement must be strength grade B500 in accordance with Table 8 of BS 6744:2016 and conform to designation 1.4362, 1.4429, 1.4436 or 1.4462 to BS 10088 (as identified by Table 5 of BS 6744:2016).

F4 FABRICATION AND ASSEMBLY

F4.1 Fabrication

The reinforcement fabricator must implement and maintain a quality management system in accordance with AS/NZS ISO 9001.

Tools for fabricating stainless steel reinforcement must not have been used and must not be used for other materials. Tools and processes for cutting stainless steel must not reduce the strength of the stainless steel reinforcement or cause contamination with grease, oil, iron or other steels.

Contamination of stainless steel by carbon steel, iron, dust etc or any other material can adversely affect mechanical properties or corrosion resistance of stainless steel and must be always avoided.

Consumables such as paint markers, grinding and cutting discs must be suitable for stainless steel.

Tools and workshop previously used in carbon steel reinforcement fabrication must be thoroughly cleaned to the satisfaction of the Reinforcement Manufacturer, Contractors, and Principal.

F4.2 Bending

Before commencement of bending, the tools used for bending stainless steel must be thoroughly cleaned to prevent contamination from other materials (e.g. carbon steel). The workshop and tools

used for bending must be inspected by the Reinforcement Manufacturer, Contractor and Principal to ensure their cleanliness. Do not heat the stainless steel reinforcement when bending.

Do not field bend bars with diameters greater than 20 mm.

F4.3 Welding

Welding of stainless steel is discouraged. You may carry out welding of stainless steel only when permitted by the Principal in writing.

All welding for stainless steel reinforcement must comply with Specification TfNSW B203 and the following:

(a) Weld stainless steel reinforcement only in a welding shop set up for the purpose. Any such facility must maintain conditions that prevent any contamination of the stainless steel and any consumables and allow proper welding;

(b) Store, condition and handle all consumables in accordance with the bar manufacturer's recommendations;

(c) Welding procedures and consumables must comply with the bar manufacturer's recommendations. Welds to be 100% visually examined and comply to Category 2B to AS 1554.6 Table 6.1. Assess defects in accordance with AS/NZS 1554.6 Table 6.3.2 Class B'. 10% of the welds that are welded by each welder and for each WPS used in the fabrication are to be examined by liquid penetrant testing. Examine the welds using dye penetrant or magnetic particle examination methods. Treat arc strikes as defects and repair by grinding and confirm by visual examination. Principal reserves the right to ask for liquid penetrant examination of the repaired arc strike. Surface cleaning after welding must be carried out in accordance with AS/NZS 1554.6 Cl. 6.2.3(a), (b) or (c);

(d) Demonstrate that the weld does not result in the loss of ductility and corrosion resistance. Test welds in accordance with AS 1554.3 Clause 7.1 and Table 7.2;

(e) Keep the weld area clean and free of any contamination;

(f) Clean and passivate completed welds by stainless steel wire brushing and pickling to finish Category II to AS 1554.6 Table 6.2.1. Pickling compounds must be chloride free.

F4.4 Splicing

Manufacture mechanical splices for stainless steel reinforcement from stainless steel conforming to designation 1.4362, 1.4429, 1.4436 or 1.4462 to BS 10088 (as identified by Table 5, BS 6744:2001).

F5 ASSEMBLY

Secure reinforcement in place by tying or tack welding. Tie wire with stainless steel wire having a diameter of not less than 1.2 mm. Wire used to tie stainless steel must conform to designation 1.4362, 1.4429, 1.4436 or 1.4462 to BS 10088 (as identified by BS 6744:2001).

Perform tack welding in accordance with Clause F4.3.

ANNEXURE B80/G – SELF-COMPACTING CONCRETE AND HIGH WORKABILITY CONCRETE

G1 GENERAL

G1.1 Applicability

The relevant requirements of this Specification apply to the design, supply, delivery, placement and curing of SCC or HWC, except where modified by this Annexure.

Use SCC or HWC only for the specific bridge members listed in Annexures B80/A2.1 and A2.2 respectively.

G1.2 Mix Requirements

Where SCC or HWC is proposed, choose the mix composition and proportions carefully to satisfy project specific performance requirements, taking into account the placement method, and the worst possible case arising from the variability in the batching of the mix constituents.

SCC and HWC, when placed in water, must be adequately stable and cohesive to avoid segregation and wash-out.

G1.3 Slump Flow Spread

For SCC or HWC, where “slump” is specified in this Specification other than in this Annexure or Clause 4.5 (refer to Clause G6.1), use “slump flow spread” instead.

G2 PERFORMANCE REQUIREMENTS

Unless stated otherwise in Annexure B80/A2.1, the fresh properties of SCC must conform to Table B80/G.1.

The fresh properties of HWC must conform to Table B80/G.2.

Table B80/G.1 – Fresh Properties of SCC

Property	Test Method	Criteria	Notes
Filling ability	ASTM C1611	Slump flow spread: 550 – 800 mm	Nominated slump flow spread must be a value between 600 mm and 750 mm with a maximum tolerance of ±50 mm
Stability	ASTM C1611	VSI rating: 0 (1)	Submit the photographic evidence VSI rating > 0 and < 2 may be acceptable during concrete supply
	EN 12350-11	Sieved portion: ≤ 15 %	Required during trial mixing
	ASTM C1712	Penetration: ≤ 10 mm	Penetration depth ≤ 15 mm may be acceptable depending on the type of concrete pour
Passing ability	ASTM C1621	⊿ Spread: ≤ 50 mm	Complete test within 6 minutes of ASTM C1611 to harmonise results
	EN 12350-12	⊿ Height: ≤ 15 mm	Difference between height at centre and mean height just outside J-ring. Required during trial mixing.
Viscosity	ASTM C1611	T_{500}: 2 – 5 seconds	Gives indication on consistency between batches

Note:

(1) For VSI rating of "0", there must be no evidence of segregation or bleeding. Reflective shine caused by high range water reducing agents, particularly during cold weather, is not to be interpreted as water sheen on the concrete mass. The photographs shown in Figure B80/G2.1 below are examples of VSI rating of "0".

Table B80/G.2 – Fresh Properties of HWC

Property	Test Method	Criteria	Notes
Filling ability	ASTM C1611, as modified by Clause G3.2	Slump flow spread: 350 – 550 mm	All mixes. Nominated slump flow spread must be a value between 425 mm and 475 mm with a maximum tolerance of ±75 mm.
Stability		VSI rating: 0 (1)	All mixes. Submit the photographic evidence.
Viscosity		T_{350}: 1 – 5 seconds	Use a stop watch during trial mixing. Estimate seconds during production by calibrated counting, e.g. 1001, 1002, 1003.
Slump	AS 1012.3.1	≥ 200 mm	Required during trial mixing only.

Note:

(1) For VSI rating of "0", there must be no evidence of segregation or bleeding. Reflective shine caused by high range water reducing agents, particularly during cold weather, is not to be interpreted as water sheen on the concrete mass. The photographs shown in Figure B80/G2.1 below are examples of VSI rating of "0".

Figure B80/G2.1 – Examples of VSI Rating of "0"

G3 TRIAL MIXES

G3.1 Self-compacting Concrete

Where SCC is trialled, submit:

(a) Slump flow spread and corresponding nominated slump flow spread instead of slump, using a slump cone in the inverted position;

(b) Time to 500 mm slump flow spread, T_{500}, and corresponding nominated T_{500} range;

(c) Visual stability index (VSI) rating with photographic evidence and nominated VSI value;

(d) Passing ability values and corresponding nominated passing ability values;

(e) Static segregation percentage and corresponding nominated static segregation percentage;

(f) Penetration depth and corresponding nominated degree of static segregation resistance.

When moulding test specimens or filling the slump cone for testing relevant concrete, entirely fill the mould without mechanical or manual compaction.

G3.2 High Workability Concrete

Where HWC is trialled, submit:

(a) Slump flow spread and corresponding nominated slump flow spread, using a slump cone in the inverted position;

(b) Time to 350 mm slump flow spread, T_{350}, and corresponding nominated T_{350} range using a slump cone in the inverted position;

(c) Visual stability index (VSI) rating with photographic evidence and nominated VSI value;

(d) Slump, using a slump cone in the upright position.

When moulding test specimens or filling the slump cone for testing relevant concrete fresh properties, entirely fill the mould or the slump cone and compact the concrete using five consolidation strokes with a standard tamping rod.

G4 TEST MEMBERS

Where a test member is required under Clause 5.3, it must 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.

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

G5 FORMWORK DESIGN

Where placement time is less than 1.5 hours, design the formwork, including support and fixing systems, for full hydrostatic concrete pressure.

Where greater times for placement are proposed, determine the rate of stiffening of the concrete under the conditions for placement by experiment and design the formwork accordingly.

G6 SUPPLY, DELIVERY, PLACEMENT AND CURING

G6.1 General

Implement rigorous production control for all operations, especially of adding water and admixtures during concrete batching and delivery.

High-range water reducers may be added to adjust deformability or flowability on site at a dosage determined and agreed prior to full production.

Do not add water to the mixed batch while in transit. The Principal may permit the addition of water on site if an approved procedure of stringent control and recording of the total amount of water is in place, the amount of water added does not exceed the limits specified in Clause 4.6 and conformity with the criteria in Tables B80/G.1 and B80/G.2 is verified by re-testing after the addition of water.

Include the following additional details on the concrete batch delivery dockets:

(a) nominated spread and accepted range for slump flow spread, instead of nominated slump;

(b) instructions for adding admixtures on site to adjust workability;

(c) slump reversion time where the concrete is used for piling.

Apply the requirements of Clause 4.5 to ensure that concrete fresh properties are maintained at the time of concrete discharge. For SCC or HWC, where “slump” is specified, use “fresh properties” instead.

Include in the PROJECT QUALITY PLAN the procedures for achieving the required level of control for supply, delivery, placement, supplementary compaction and curing of SCC or HWC, including the action required when a delivered batch of concrete does not have the required rheological properties.

For columns and shafts, to prevent segregation, keep the point of discharge initially as close as possible to the bottom of the pour to limit the free fall height, and keep the point of discharge submerged within the concrete to a depth of at least 300 mm as the pour progresses upwards.

Where compaction is required for complex forms or thin members with congested reinforcement, commence placement from the lowest point of the formwork and progress to the highest point, and apply compaction only as required to achieve the specified concrete finish and properties.

Commence curing as soon as practicable and keep exposed surfaces moist to minimise the risk of surface crusting and shrinkage cracking.

G6.2 Self-Compacting Concrete

Keep the distance of horizontal flow less than 10 m or within the limitations demonstrated by the test member. Do not exceed the rate of placing specified in the formwork design for the placement conditions.

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.

G6.3 High Workability Concrete

For horizontal members, keep the point of discharge just above the surface of the discharged concrete and keep the extent of horizontal flow less than 3 metres or within the limitations demonstrated by the test member. Do not exceed the rate of placing specified in the formwork design.

Apply adequate compaction as required to ensure all spaces in the formwork are filled but without segregation.

G7 MINIMUM FREQUENCY OF TESTING

G7.1 Self-compacting Concrete

Prepare concrete test samples as specified in Clause G3.1.

The minimum frequency of testing during supply and delivery of SCC must conform to Table B80/G.3.

Provide photographic evidence of the VSI ratings.

Table B80/G.3 – Minimum Frequency of Testing for SCC

Characteristic Analysed	Test Method	Minimum Frequency of Testing
Supply and delivery		
Passing ability, J-ring slump flow differential	ASTM C1621 EN 12350-12	Initial batch
Stability, penetration depth	ASTM C1712	Initial batch and every fourth batch thereafter (1)
Filling ability, slump flow spread	ASTM C1611	One per batch of concrete
Viscosity, T_{500}		
Stability, VSI rating		

Note:

(1) Penetration test may be waived if the stability test results of the initial and subsequent batches show VSI = 0.

G7.2 High Workability Concrete

Prepare and compact the concrete test samples and the slump cone, and measure the slump flow spread and the time of flow to 350 mm as specified in Clause G3.2.

The minimum frequency of testing during supply and delivery of HWC must conform to Table B80/G.4. Provide photographic evidence of the VSI ratings.

Table B80/G.4 – Minimum Frequency of Testing for HWC

Characteristic Analysed	ASTM Test Method	Minimum Frequency of Testing
Supply and delivery		
Filling ability, slump flow spread [(1)]	ASTM C1611, as modified by Clause G3.2	One per batch of concrete
Viscosity, T_{350}		
Stability, VSI rating		

Note:

(1) Where the slump flow spread of delivered HWC batch exceeds 550 mm, the concrete may be accepted if the VSI rating is maintained as "zero" and the stability is further assessed in accordance with ASTM C1712 showing penetration ≤ 10 mm and the passing ability is further assessed in accordance with EN 12350-12 showing a Δ Height ≤ 15 mm.

ANNEXURES B80/H TO B80/K – (NOT USED)

ANNEXURE B80/L – TESTING PROCEDURES

Refer to Clause 1.2.5.

L1 MINIMUM FREQUENCY OF TESTING

Clause	Characteristic Analysed	Test Method	Minimum Frequency of Testing
	Supply and Delivery of Concrete		
2	All test reports specified in Clause 2	As specified in Clause 2	At start of project and yearly thereafter
2.3	Each chemical admixture – sample and store for 6 months at batch plant	AS 1478.1 Appendix A	At start and every two months during production
2.3.3	Quantity of calcium nitrite in fresh concrete only where corrosion inhibitor is specified	TfNSW T371	Two tests per 25 m^3 or part thereof
2.4.2 (c)	Particle size distribution of coarse aggregate – deviation from nominated particle size distribution	AS 1141.11.1	One per week or one per 400 tonnes
2.4.2 (d)	Particle size < 75 µm	AS 1141.11.1 or AS 1141.12	One per week or one per 400 tonnes
2.4.2 (e)	Particle size < 2 µm	AS 1141.13	One per week or one per 400 tonnes
2.4.3 (a) or (b)	Particle size distribution of fine aggregate – deviation from nominated particle size distribution (including particle size < 75 µm)	AS 1141.11.1 and AS 1141.12 (as relevant)	One per week or one per 400 tonnes
2.4.3 (b)	Fine aggregate – for Envelope "C" only:		
	Quantity of clays	XRD/XRF	One per 10000 tonnes
	Flow time	TfNSW T279	As directed by the Principal
	Bleed water in concrete	AS 1012.6	As directed by the Principal
2.4.3 (g)	Fine aggregate – Material < 2 µm	AS 1141.13	
	Manufactured and unwashed natural sand		One per 1000 tonnes
	Washed natural sand		One per 5000 tonnes
2.4.3 (f)	Fine aggregate – Methylene Blue Value	TfNSW T659	One per 10000 tonnes
2.4.3 (h)	Manufactured sand – Sodium sulfate soundness	AS 1141.24	One per 4000 tonnes
4.5	Slump (1)	AS 1012.3.1	One per batch of concrete
	Recycled Water		
2.7	Water testing	Refer to Clause 2.7.2	

Clause	Characteristic Analysed	Test Method	Minimum Frequency of Testing
	Hardened Concrete		
9.2	Compressive strength 28 days	AS 1012.8 AS 1012.9	
	Mass (unreinforced) concrete		One pair per 50 m^3 or part thereof
	Reinforced concrete		One pair per 25 m^3 or part thereof
	Prestressed concrete		One pair per 15 m^3 or part thereof
9.2	Compressive strength for other purposes	AS 1012.8 AS 1012.9	One pair per pour or more as required by the Contractor
9.6	Relative compaction of concrete	AS 1012.12.2 Annexure B80/L5	As directed by the Principal
9.7	Concrete cover	Annexure B80/L6	As and when directed by the Principal.

Note:

(1) For concrete containing a high range water reducer, requirements for test method and minimum frequency of testing must be applied to both initial and final slump.

L2 MOULDED CYLINDERS

Moulded concrete specimens must be standard cylinders moulded in accordance with the requirements and procedure of AS 1012.8.1 using rodding only. Fill and rod HWC specimens as described in Clause G 3.1. Fill SCC specimens without rodding (refer to Clause G 3.2).

L3 CORE SAMPLES

When directed by the Principal, take core specimens using a core drill, and wet pre-treat and cure the specimens in accordance with AS 1012.14.

The number of cores must be as directed by the Principal.

Select coring locations to avoid reinforcement and wheel paths, and where possible take cores in areas that will subsequently be covered with concrete.

Do not cut through steel reinforcement when extracting core specimens. Prior to coring, identify the steel reinforcement positions by carrying out a cover meter survey at representative locations. Do not test any cores which contain reinforcement; instead replace them with cores cut at new locations.

Scabble and clean core holes and restore using a concrete mix with graded aggregates with a maximum nominal aggregate size of 10 mm and of the same quality as the material from which the core was cut. Place, finish and cure the concrete in such a manner so as to produce no visible cracks.

The surface of the restored hole must be similar to the surrounding surface in texture and colour.

L4 COMPRESSIVE STRENGTH

L4.1 Moulded Cylinders

The compressive strength of the concrete represented by a pair of specimens moulded from one concrete batch tested in accordance with AS 1012.9, is the average strength of the two specimens unless the two results differ by more than 10% of their average, in which case the higher result must be taken as the strength of the concrete.

L4.2 Core Samples

The compressive strength of the concrete represented by the cut cores tested in accordance with AS 1012.9, is the average strength of the individual core test results after their correction for the length to diameter ratio as applicable.

The compressive strength of core specimens overrides the strength of moulded concrete specimens.

L4.3 Adjustment for Age of Specimen

Should any specimen or core be tested more than 28 days after moulding or placement, the equivalent 28 day strength is the test strength divided by the age factor given in Table B80/L.1. Age adjustment factors are given for concrete made with Shrinkage Limited and Blended cements. For intermediate ages, the factor must be determined on a pro-rata basis.

Table B80/L.1 – Factors for Age of Specimens

Age of specimen at time of test (days)	Age factor	
	Shrinkage Limited cement	Blended cement
28	1.00	1.00
56	1.08	1.19
112	1.14	1.33
224	1.22	1.42
365 or greater	1.25	1.45

L5 COMPACTION

L5.1 Preparation of Core Samples

Take cores in the deck and elsewhere only as directed by the Principal. The locations of the cores, which are subject to the agreement of the Principal, must be selected to clear any reinforcement or other embedments.

Test specimens for determining the relative compaction of concrete must be cores of nominal diameter 75 mm, cut in accordance with the requirements of Clause L3 except that the minimum concrete age for coring must be:

(a) four (4) days from May to December inclusive; or

(b) two (2) days from December to April inclusive.

Within two (2) hours of coring, place the cores either in a tank of lime saturated water or in individual plastic bags which are sealed to prevent water loss and stored in the shade.

Do not subject cores to temperatures which are in excess of the ambient temperature or 28°C, whichever is the higher; or less than 10°C.

L5.2 Unit Mass of Representative Concrete

Determine the unit mass of the representative cylinders at an age of between four (4) and seven (7) days in accordance with AS 1012.12.2 and the following conditions:

(i) Testing of the representative cylinders must be in the saturated surface-dry condition without dressing of voids, in accordance with Test Method TfNSW T368; and

(ii) The unit mass for a pair of representative cylinders must be the average of the two results unless they differ by more than 20 kg/m^3, in which case the higher result must represent the unit mass of the pair.

L5.3 Unit Mass of Cores

Determine the unit mass of the cores and report all results in accordance with AS 1012.12.2 and the following:

(a) assess cores in accordance with TfNSW T368 for excessive voids and, if warranted, dress voids prior to testing;

(b) wet conditioning in AS 1012.12.2 Clause 6(c) may be extended from 24 hours to 3 days;

(c) the concrete age at testing must be between three (3) and seven (7) days;

(d) the full depth of the core must be tested except that:

  (i) non-concrete materials such as bitumen must be removed, and

  (ii) up to 20 mm of concrete may be removed from each end of the core;

(e) report the height and diameter of the core, as tested; and

(f) round individual results for unit mass to the nearest 10 kg/m^3 in accordance with AS 1012.12.2.

The unit mass of the cores is the average of the test results (rounded to the nearest 10 kg/m^3) unless they differ by more than 20 kg/m^3, in which case the lower result applies.

L6 COVER

L6.1 Testing

Carry out concrete cover survey at the frequency requested by the Principal and in accordance with this Clause.

L6.2 Exclusion from Cover Testing

Portions of a concrete bridge member or product that will be covered by subsequent concreting operations may be excluded from cover survey.

L6.3 Personnel

Include in the PROJECT QUALITY PLAN the name(s) of the technician(s) with details of qualifications and experience in concrete cover surveys. The technician(s) must have a proven record in the use of cover meters and must conduct all stages of the survey.

L6.4 Reports

Concrete cover survey reports must be provided to the Principal within 5 working days of the Principal's direction.

L6.5 Cover Meters

Checks must be made to confirm that cover meters are properly calibrated before and during use to give average site accuracy readings on single bars within ± 15% and a maximum error of ± 5 mm.

ANNEXURE B80/M – REFERENCED DOCUMENTS

Refer to Clause 1.2.6.

TfNSW Specifications

TfNSW G36	Environmental Protection
TfNSW G71	Construction Surveys
TfNSW Q	Quality Management System
TfNSW B110	Pretensioned Precast Concrete Members
TfNSW B113	Post-Tensioning of Concrete
TfNSW B115	Precast Concrete Members (Not Pretensioned)
TfNSW B170	Supply and Installation of Void Formers
TfNSW B201	Steelwork for Bridges
TfNSW B203	Welding of Reinforcing Steel
TfNSW B240	Steel Fasteners
TfNSW 3211	Cementitious Materials, Binders and Fillers

TfNSW Test Methods

TfNSW T240	Road Surface Texture Depth (Sand Patch)
TfNSW T279	Flow Time and Voids Content of Fine Aggregate by Flow Cone
TfNSW T362	Interim Test for Verification of Curing Regime – Sorptivity
TfNSW T368	Dressing of Voids in Concrete Specimens and Unit Mass Adjustment for Embedded Steel
TfNSW T371	Determination of Calcium Nitrite Quantity in Fresh Concrete (Test Strips)
TfNSW T375	Sampling and Testing of Grout
TfNSW T659	Methylene Blue Adsorption Value of Road Construction Material
TfNSW T1005	Recording the Infrared Spectrum of Materials

Australian Standards

AS 1012	Methods of testing concrete (multiple parts)
AS 1141	Methods for sampling and testing aggregates (multiple parts)
AS 1289	Methods of testing soils for engineering purposes (multiple parts)
AS 1289.3.2.1	Soil classification tests – Determination of the plastic limit of a soil – Standard method
AS 1289.4.2.1	Soil chemical tests – Determination of the sulfate content of a natural soil and the sulfate content of the groundwater – Normal method
AS 1379	Specification and supply of concrete
AS 1478.1	Chemical admixtures for concrete, mortar and grout – Part 1: Admixtures for concrete

AS/NZS 1554	Structural steel welding
AS/NZS 1554.3	Part 3: Welding of reinforcing steel
AS/NZS 1554.6	Part 6: Welding stainless steels for structural purposes
AS 1580	Paints and related materials – Methods of test
AS 1580.301.1	Non-volatile content by mass
AS/NZS 1580.505.1	pH of water-based paints
AS/NZS 1594	Hot-rolled steel flat products
AS/NZS 2271	Plywood and blockboard for exterior use
AS/NZS 2425	Bar chairs in reinforced concrete – Product requirements and test methods
AS 2758.1	Aggregates and rock for engineering purposes - Concrete aggregates
AS 3550.4	Methods for the analysis of waters – Determination of solids – Gravimetric method
AS 3610.1	Formwork for concrete – Specifications
AS 3799	Liquid membrane-forming curing compounds for concrete
AS/NZS 4671	Steel reinforcing materials
AS 5100	Bridge design
AS 5100.5	Part 5: Concrete
AS 5100.6	Part 6: Steel and composite construction
AS/NZS ISO 9001	Quality management systems – Requirements

British Standards

BS 6744	Stainless steel bars for the reinforcement of and use in concrete – Requirements and test methods
BS 10088	Stainless steels – List of stainless steels
BS EN 12350-11	Testing fresh concrete – Part 11: Self-compacting concrete – Sieve segregation test
BS EN 12350-12	Testing fresh concrete – Part 12: Self-compacting concrete – J-ring test

ASTM Standards

C114	Standard Test Methods for Chemical Analysis of Hydraulic Cement
C295	Standard Guide for Petrographic Examination of Aggregates for Concrete
C1611	Standard Test Method for Slump Flow of Self-Consolidating Concrete
C1621	Standard Test Method for Passing Ability of Self-Consolidating Concrete by J-Ring
C1712	Standard Test Method for Rapid Assessment of Static Segregation Resistance of Self-Consolidating Concrete Using Penetration Test

Nordtest Methods

NT Build 443	Concrete, Hardened: Accelerated Chloride Penetration

NT Build 492	Concrete, Mortar and Cement-Based Repair Materials: Chloride Migration Coefficient from Non-Steady-State Migration Experiments

Concrete Institute of Australia

CIA Z17	Recommended Practice – Tremie Concrete for Deep Foundations

American Public Health Association

APHA 2540C	Solids – Total Dissolved Solids dried at 180°C
APHA 2540D	Solids – Total suspended Solids dried at 103-105°C
APHA 3120B	Metals by plasma emission – Inductively coupled plasma (ICP) method
APHA 4110B	Determination of anions by ion chromatography – Ion Chromatography with Chemical suppression of eluent conductivity
APHA 4500-Cl^-	Cl^- – Chloride
APHA 4500-H^+	H^+ – pH Value
APHA 5520	Oil and grease

RILEM Test Method

AAR-4	Detection of Alkali-Reactivity Potential in Concrete – Outline guide to the use of RILEM methods in assessments of aggregates for potential alkali-reactivity Standard Test Methods for Chemical Analysis of Hydraulic Cement