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Technical Direction – TD 00021:2023

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Title: Clarification on placement of steel for the reinforcement of concrete – Amendments to IC-QA-NB80 (TS 01733.3) *Guide to QA Specification B80 – Concrete Work for Bridges*, Ed.3 Rev.0

This technical direction is issued by the Asset Management Branch (AMB) as an update to Specification Guide NB80 IC-QA-NB80 (TS 01733.3) *Guide to QA Specification B80 – Concrete Work for Bridges,* Ed.3 Rev.0.

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 Amendments to IC-QA-NB80 (TS 01733.3)

The following section in IC-QA-NB80 (TS 01733.3) 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 embedment's 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 NEW SOUTH WALES (TFNSW)

SPECIFICATION GUIDE NB80

GUIDE TO QA SPECIFICATION B80
CONCRETE WORK FOR BRIDGES

REVISION REGISTER

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 1/Rev 0		Initial issue	GM, IC	24.07.07
Ed 1/Rev 1		Document reference number changed from NG80 to NB80	GM, IC	15.03.10
Ed 2/Rev 0		Updated to accord with B80 Ed 6/Rev 2	GM, IC	07.11.12
Ed 2/Rev 1	Global	References to “Roads and Maritime Services” or “RMS” changed to “Transport for NSW” or “TfNSW” respectively.	DCS	22.06.20
Ed 3/Rev 0		Updated to accord with B80 Ed 7/Rev 6	MCQ	30.05.23

GUIDE TO QA SPECIFICATION B80
CONCRETE WORK FOR BRIDGES

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IC-QA-NB80

VERSION FOR:
DATE:

Clause

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FOREWORD

TFNSW COPYRIGHT AND USE OF THIS DOCUMENT

Copyright in this document belongs to the Transport for New South Wales.

The Guide is not a contract document. It has been prepared to provide readers with guidance on the use of the specification.

The text of the base specification is shown in this Guide in shaded format.

The commentary on the intent of the specification, with guidance as to how it can be interpreted on a construction site, is shown in *italic font* below the specification clause to which it refers.

BASE SPECIFICATION

This document is based on RMS QA Specification B80 Edition 7 Revision 6.

SPECIFICATION GUIDE NB80

GUIDE TO QA SPECIFICATION B80 CONCRETE WORK FOR BRIDGES

NOTES ON GUIDE NB80

N.1 AIM OF B80

To produce concrete which has the required properties of strength and durability, within a QA contract context, for a price which represents a reasonable trade-off between initial cost and long term performance.

Concrete is a composite engineering material comprised of a mixture of hydraulic cement, water, aggregate and admixtures that when freshly mixed is a thixotropic fluid. Because the water reacts chemically with the cement, a chemical reaction called hydration commences about 90 minutes after mixing. The rate of hydration is dependent on the temperature of the concrete mix. As time passes the fluid concrete stiffens and loses workability and sets about 5 or 6 hours after mixing, depending on the concrete temperature. The now hardened concrete gains strength with time, with the hydration react ion ceasing if the concrete dries out.

The steel reinforcement in reinforced concrete gives the structural member its tensile strength that, when combined with concrete's compressive strength, density and alkalinity, results in a strong, ductile, tough and durable engineering material, providing that the supply, delivery, placement and compaction of the concrete are carried out in such a manner that its designed long-term engineering properties are achieved.

TFNSW needs good bridge concrete to:

- *Keep road and bridge maintenance workers and road users safe;*
- *Obtain durability for longer structure life;*
- *Obtain good bridge deck ride quality and skid resistance;*
- *Minimise costs of maintenance works and associated traffic restrictions and road closures;*
- *Give aesthetic appeal to its bridges; and*
- *Provide value from the large-scale expenditure of taxpayer monies.*

B80 is not a document that can just be filed away when constructing bridges for TFNSW. All bridges contain concrete somewhere in the structure, and the only common ground between the Contractor and the Agency is the Contract Documents of which B80 forms a part. Without the Contract Documents nothing can be agreed in either the contractual or technical context.

N.2 HISTORY

B80 Ed 7/Rev 5 is the latest revision to TFNSW QA Specification Concrete Work for Bridges.

This document has been around since early Department of Main Roads (DMR) days, when all bridgeworks were constructed by direct control, because the private sector was not able to supply the required skills. As such, the document at that time was very prescriptive in nature.

With the advent of contracting out the construction of bridgeworks the document evolved, and gained an emphasis on the contractual relationship between Contractor and Principal's Representative – who acted for the Principal.

When adoption of Quality Assurance in contracts managed by the Roads and Traffic Authority, NSW (RTA) came about as a result of a Federal Government policy decision, the document gained its QA format in 1991, and was identified as B80 Edition 1.

In 1992, concrete specifiers within the RTA were forced into a situation where durability as well as strength of concrete was becoming a prime concern, especially for bridges on the coast. In response to those concerns, the specification was revised in an attempt to attain durable as well as strong concrete. That document was B80 Edition 2, which was in use from the end of 1992 to 1994. The interim test selected for the indirect assessment of a particular concrete's durability was the CSIRO's sorptivity test (now RMS T362). This test measures the depth of penetration of water into a concrete block after a set period of immersion. A number of test results for concrete produced from the contracts in which Edition 2 had been used were gathered, and tabulated to assess the effectiveness of the sorptivity test, which was really a test of the effectiveness of a curing regime.

With Edition 2 having achieved its purpose, in response to requests from the concrete and contracting industries for B80 to be made easier to use and administer, Edition 3 was produced in 1994 within RTA's Technology and Engineering Contracts Branches, with extensive input from industry and academia.

The revised specification attempted to address, among other matters, the maturing QA system, and the continuing rapid changes in concrete technology and knowledge becoming increasing available.

Since Edition 3 was produced, the specification has been revised a number of times in response to drivers such as materials supply issues, e.g. manufactured sand, evolutions in concrete and related technologies, e.g. admixtures, and construction issues, e.g. cracking of bridge decks.

Edition 5 and its revisions addressed issues causing concern and included provisions to prevent cracking of bridge decks, controls on use of super-workable concrete for precasting operations and requirements for training of bridge concreting crews and supervisors.

Edition 6 was issued to align B80's durability provisions with more recent developments in this area, particularly the use of Nordtest test methods to address more comprehensively the issue of chloride induced corrosion, and includes a new annexure following field trials that offers more scope for the use of self-compacting concrete. The opportunity has also been taken to simply/clarify a number of other provisions in the specification.

Edition 7 was issued to reflect changes to exposure class C as it was further broken down into C1 & C2. This edition also include option to adopt performance based testing for mitigating AAR risk in concrete this was based on discussions with industry. Further relaxation of fine aggregate grading and performance based Envelope C is introduced.

N.3 INFORMATION/TRAINING ON GOOD CONCRETING PRACTICE

Cement Concrete & Aggregates Australia (CCAA): www.concrete.net.au

Concrete Institute of Australia (CIA): www.concreteinstitute.com.au

Cement & Concrete Services: www.cementandconcrete.com

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.

The scope of B80 is the supply, delivery, placement, and compaction, screeding, finishing and curing of all concrete for bridgeworks, including pre-cast elements. It contains the requirements for formwork for both in-situ and precast elements. However, not all the clauses relating to formwork design, materials, erection and tolerances apply to precast elements. The supply, fabrication and fixing of reinforcing steel and other embedded items for both precast and in-situ elements are covered.

B80 puts into practice the principles embodied in Part 5 – Concrete, of the Australian Bridge Design Code AS 5100 – Bridge design, which was mandated by the RTA's Chief Executive on 7th May 2004 for the design of RTA bridges. AS 5100.5 and its predecessors contain the basic strength and durability criteria on which B80 is based. AS 5100.5 is in turn based on AS 3600 - Concrete Structures. However, AS 5100.5 differs from AS 3600 in a number of areas, the main difference being design life. The former adopts a design life of 100 years for all bridge structures, whereas the latter is used for structures with a design life of 40 to 60 years. Hence the more stringent requirements of B80 for durability than specifications based on AS 3600.

Other documents to which B80 makes reference are listed in Annexure B80/M.

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.

The most important change in B80 Ed 3 from previous editions was that placing, compacting, screeding, finishing and curing of concrete were all called up as Special Processes in accordance with AS 2990. However, when RTA moved to AS/NZS ISO 9002 from AS 2990, the term "Special Process" became inappropriate. In order to give placing, compacting, screeding, finishing and curing processes the same emphasis in subsequent revisions, Annexure B80/D requires submission of "Technical Procedures" in accordance with TFNSW.

The reason why these items of work are emphasised is that in general the conformance of the finished product cannot be verified by inspection after the work has been carried out. In those few cases when the conformance can be verified, it is costly of time and money, and the cost of rectification is prohibitive. The Principal's Representative has to rely on the quality of the Contractor's work processes and of the actual work carried out in order to be assured that the finished product has the required quality.

For instance, an inspection of the surface of a concrete member after finishing and stripping will not reveal sub-surface defects. There is no way of knowing from inspection whether curing has been carried out. There is currently no reliable test for durability that can be carried out on the whole of the bridgeworks. So it was deemed necessary to call up concrete placing, compaction, screeding, finishing and curing as Special Processes in Ed 3/Rev 0 and to subsequently require the Technical Procedures in Annexure B80/D to be submitted to assure the Principal that the required finished product has been achieved.

The Principal's Representative will need to carry out the necessary assessment and surveillance of Quality Plan procedures.

This Project Quality Plan clause does not contain details of all the information required to be submitted by the Contractor, these requirements being located in the relevant clauses of the Specification.

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%.

Clause 1.3 contains a number of definitions which the specifiers felt were important to make clear. The definitions fall into two groups, the first primarily being for materials, the other being for curing.

Cement includes both General Purpose Shrinkage Limited cement "SL" and General Purpose Blended cement "GB", both as defined in AS 3972. The total quantity of cement is the sum of the SL or GB cements and Supplementary Cementitious Materials (SCMs) in the mix. Further details about cementitious material to be used in concrete for Bridge construction is listed under TfNSW QA Specification 3211.

Curing is of critical importance for long term durability, and is emphasised in B80 where the types of curing have been defined. The particular curing regime nominated in the mix design must form part of the Contractor's Quality Plan. This curing regime may have been used to cure test specimens produced during trial mixing, with the specimens tested to assess the conformance of the curing to the Specification. The Principal's Representative should check that the nominated curing for the approved concrete mix is contained in the Quality Plan and that the curing of bridge members is carried out in accordance with the method and duration nominated in the approved concrete mix design, and conforms to the definitions in Clause 1.3 and the relevant clauses of the Specification.

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.

B80 requirements for cement are contained in TFNSW 3211 Cements, Binders and Fillers*, which contains general requirements applicable to all cements supplied for concrete for TFNSW works, together with detailed requirements applicable only for specific applications e.g. bridgeworks.*

Blended cements have been specified for a number of reasons that include:

1. The need to reduce the total alkali content in the concrete in order to avoid reactions between alkalis in the cement and any reactive aggregate that may be present. Such alkali-aggregate reactivity (AAR) may be more likely now than a few years ago because modern day concretes are specified with much greater amounts of cement than previously, for both strength and for durability reasons. Where sufficient alkali is available, most NSW coarse aggregates are reactive, and nearly all the natural fine aggregate is reactive. This situation is becoming worse as good quality aggregate sources dwindle;

2. Using blended cements reduces alkali availability. Fly ash blends, as specified in B80, contain between 25-30% fly ash as a cement replacement, with the total concrete alkali content being reduced by an almost equivalent amount. The likelihood of AAR is reduced because the cement alkalies react innocuously with the silicas in the SCMs rather than with the reactive aggregates;

3. Ordinary Portland Cement (OPC) concretes have been found in a number of studies to be considerably less durable than blended cement concretes, especially in coastal areas. In recognition of this blended cements were introduced into B80 in 1994 for RTA bridgeworks;

4. Special situations may also warrant blended cements. These include large masses of concrete subject to thermal cracking from thermal gradients arising from the heating of the concrete by the exothermic chemical reactions taking place during the hydration of the cement (use fly ash and low heat cement blends), and concrete where rapid curing without strength or durability loss is required (use silica fume blends).

FLY ASH BLENDED CEMENTS

Fly ash must be supplied to AS 3582.1 at between 20-30% of the cement by mass, with increased percentages to counteract AAR and for durability reasons in aggressive environments

HIGH SLAG BLENDED CEMENTS

High slag blended cements as specified in B80 and supplied to AS 3582.2 are acknowledged as having superior durability performance in coastal and other chloride rich environments and are specified where the concrete is permanently submerged in salt water or is subject to frequent wetting or drying, typically in the tidal splash and spray zones. In the long term, excessive carbonation can occur in high-slag cement concretes, resulting in loss of alkalinity and reinforcement corrosion. For this reason a minimum quantity of OPC has been specified for Exposure Classifications A and B1.

SILICA FUME BLENDED CEMENTS

Silica fume is supplied to AS 3582.3 at between 7-10% cement by mass for use primarily for substructures in aggressive environments. Limitations are placed on the use of silica fume blended cements in B80. These conditions should be observed, as use of silica fume in concrete for larger members and for large open areas such as bridge decks can give rise to severe workability and cracking problems. Silica fume was really only specified to cover the construction of substructure elements e.g. precast piles, for Exposure Classification C and B2 environments.

QUALITY OF SUPPLEMENTARY CEMENTITIOUS MATERIALS

TFNSW 3211 and B80 require that the supplementary cementitious materials (SCMs) fly ash, slag and silica fume comply with the relevant Australian Standards. Additional requirements are also specified. In the early revisions of Ed 3, the additional requirements were prescriptive such as minimum glass content in slag and minimum SiO_2 in fly ash. Later research showed that those prescriptive requirements did not necessarily relate to the overall quality of the SCM. From B80 Ed 3/Rev 3 an attempt was made to specify SCM by performance using relative water requirements and relative strength, but this attracted criticism from suppliers and resulted in the current specification in TFNSW 3211 of limitations on loss on ignition (LOI) and fineness to control fly ash quality and on fineness for slag.

TERNARY BLENDS

In B80 Ed 2 and Ed 3/Rev 0 binary blends only were allowed i.e. OPC with only one of the SCMs: fly ash, silica fume or slag, with the blends being within set limits. Ternary and quaternary blends were not specified in Ed 3/Rev 0 because of concerns, at the time of issuing that revision, that they were relatively untested, and could give rise to unanticipated problems. However, following literature reviews and R&D projects carried out by and for RTA Bridge Engineering from 1995, in Ed 3/Rev 6 the use of ternary blends was permitted within specified limits. This has been carried through to the current version of B80.

The stability of the cement and its tendency to lose strength with age is controlled by ensuring it conforms to the tests specified in TFNSW 3211.

The propensity for the occurrence of Delayed Ettringite Formation (DEF) in concrete is governed by the chemistry of the cement and excessive curing temperatures, and is controlled by conformance with the specified limits for sulfate content and maximum heat accelerated curing temperatures.

The use of ternary blended cements enables the cement and the concrete mix to be engineered to achieve economically the specified B80 strength and durability requirements.

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.

Guidance on the different types and applications of admixtures can be found in the Appendices of AS 1478.1.

The use of calcium chloride, whilst a very effective set accelerator, is banned as it causes extensive corrosion of the reinforcement.

2.3.2 Air Entraining Agent

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

Air entraining agents will normally only be specified in environments prone to formation of ice to minimise the risk of frost damage.

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.

Following intensive and prolonged interchange of information with admixture suppliers, RTA acknowledged that calcium nitrite as an admixture in concrete in chloride rich environments acts as an effective corrosion inhibitor that delays the onset of corrosion by forming a durable passivating film over the steel reinforcement. Minimum dosages are required for the admixture to be effective. B80's specified amount will result in long-term protection in most coastal-type environments, given the low permeability of the concrete mixes specified for such environments. TFNSW experience since its adoption is that cost is a deterrent to calcium nitrite's use, as well as there being issues on site with handling and concrete workability. Calcium nitrite is a set accelerator, which is controlled by incorporation of a retarder into the admixture or the concrete mix. Experience is required before a calcium nitrite admixture's effects become predictable. Use of calcium nitrite is most successful in precast operations e.g. precast piles, where there is good control of concrete production and concrete batch quantities are smaller.

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.

A good aggregate is stable in an alkaline environment, sound, strong, not overly affected by moisture changes, free of organic impurities and excessive silt or clay particles, without an elongated or flaky shape and is well graded.

Use of out-of-grading aggregates is permitted, provided the Contractor can provide evidence, especially in the form of relevant test reports, that the deviation from the specified grading is not detrimental to the plastic or hardened concrete properties.

2.4.2 Additional Requirements for Coarse Aggregate

(a) Do not use lightweight coarse aggregate;

For control of shrinkage and creep and for durability.

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

The maximum nominal size refers to the largest stone size in a graded aggregate.

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

To give a well-shaped aggregate for good workability and hardened concrete properties e.g. shrinkage.

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.

To permit mixing of aggregates from different sources to obtain a desirable overall grading with the required maximum nominal stone size.

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

Sieve aperture	Mass of sample passing (%)			Limits of deviation (%)		
	Nominal aggregate size (mm)			Nominal aggregate size (mm)		
	20	**14**	**10**	**20**	**14**	**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) where 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%;

To obtain a good quality aggregate, and provides a concession to permit the use of slag aggregate, subject to the condition in Item (e) below.

(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;

Only one of the three test methods for aggregate durability in AS 2758.1 is specified, being the most appropriate for TFNSW bridgeworks applications.

(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.

To permit the conditional use of slag aggregate, which is not as durable or hard wearing as the specified naturally occurring aggregates.

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 to 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;

To give a well-shaped aggregate for good workability and hardened concrete properties e.g. shrinkage.

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		–

Sieve aperture	Mass of sample passing (%)			Limits of deviation (%)
	Envelope "A" (1)	Envelope "B" (2)	Envelope "C" (3)	
4.75 mm	90 – 100	90 – 100	Not specified	±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.

Envelope "C" presents a more relaxed fine aggregate grading targets, to ensure aggregate are durable and fit for purpose, additional requirements are mentioned under (b). The relaxed grading allows for a wider range of quarries to be used in TfNSW projects which has sustainability benefits.

(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;

The use of manufactured sands is permitted, in recognition that sources of good natural fine aggregate are decreasing and to reduce environmental effects from spoiling of crusher dust from quarrying operations. The source rock for manufactured sands must be of equivalent quality to that used for the coarse aggregates. Washing of manufactured sands will usually be required to minimise effects on concrete plastic properties from variations in fine aggregate water content.

(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%;

To reduce effects of variability of water content of the fine aggregate on concrete workability, including slump loss, and on drying shrinkage.

(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.

The limit on the combination of the MBV value and passing 75 µm sieve value controls the amount of fines and clays in the mix, excessive amounts of which increase the water demand of the mixed concrete batch resulting in loss of slump during discharge, which can cause loss of workability and lack of compaction, resulting in nonconforming concrete.

(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. The quantity passing 2 µm sieve must not exceed 1% of the total fine aggregate (by mass) where 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 to 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.

Alkali aggregate reactivity (AAR) is the propensity of a specific aggregate to react with the alkalis, e.g. Na_2O and K_2O, in the cement to form expansive products that adversely affect the concrete's engineering properties and cause cracking that exposes the reinforcement to corrosion.

The intention is that each aggregate from each supply source within a mix must be tested for AAR. Testing of blended aggregates supplied from different sources does not conform to the intent of the test method or B80.

For AAR to occur, all three of the following factors are required:

- *sufficient moisture in the concrete pores;*
- *sufficiently high level of alkalis; and*
- *Reactive material in the aggregate.*

With any one of these factors not being present, the reaction will not proceed, which provides direction on how AAR can be controlled.

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.

Aggregates cannot be accepted as Non-Reactive solely based on the petrographic examination, as some fine reactive components cannot be identified petrographically. Identifying potential ACR aggregates through petrographic examination may not be conclusive and may need further testing.

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.

The reactivity of aggregates is evaluated in B80 by two test methods.

- *The first test method is accelerated mortar bar test (AMBT). The AAR reaction is accelerated by immersing the test specimen in a NaOH solution at elevated temperatures, with expansion readings associated with the reaction taken up to and including 21 days.*

- *The second test method is the concrete prism test (CPT). The test involves concrete prisms made using concrete mix containing the aggregates in question to which additional NaOH is added followed by moist curing the test specimen at 38°C , with accelerated expansion measurements taken up to and including one year prism age.*

It has been reported in the literature (refer to Austroads Project No. TT1905, 2017) that the cement alkali level in AS 1141.60.2 of 1.25% Na2O equivalent by mass of cement may cause lower expansion for some aggregates and may lead to failure in detecting AAR in some Australian aggregates. Therefore, it is recommended that cement alkali level in Test Method T364 of 1.38% be used in the CPT.

Carrying out the CPT at high temperature enables detecting some slowly reactive Australian aggregate and has the advantage of shorter test duration than that required for AS 1141.60.2. The accelerated concrete prism test included in Ed 7 Rev 3 of B80 is carried out at 60°C in accordance with RILEM AAR-4.

It must be noted that the AMBT is a screening test which determines whether a rock contains sufficient amounts of reactive components to cause deleterious expansion in the test. The behaviour of aggregate in the AMBT may not represent behaviour in concrete.

Some aggregates may show AMBT expansion of less than 0.50%, but result in a very large expansion in the CPT, whereas an aggregate with AMBT of 0.60% may show a smaller CPT expansion.

Some moderately deformed gneissic granites may cause AMBT expansion values slightly below or on the border of 0.10% at 21 days, but they are capable of causing deleterious expansion and damage when used in concrete of sufficient alkali content.

Although the inclusion of fly ash as mineral addition to GP cement is permitted in AS 3972, the use of such cement may highly supress the AMBT and CPT results. It is essential that the GP cement is free from any mineral addition that may supress aggregate reactivity.

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.

Aggregates classified as non-reactive in Table B80.3 can be used in concrete without AAR control, provided that the aggregate does not exhibit the so-called "Pessimum Effect".

The "Deemed-to-Comply" is basically the long standing prescribed approach in B80 to control AAR. However, the approach was modified in Ed 7 to incorporate finding from latest research. The approach prescribes proportions of SCMs to be blended in the cement, without the need for further investigation.

The "Performance Based" approach was introduced in Ed 7 Rev 3 of B80 to allow the use of SCMs at different dosages to those specified in the Deemed-to-Comply approach using a performance approach based on testing. In this approach, further AMBT and CPT testing are required to be carried out on a generic mix with different dosages of SCMs. The amount of SCMs that achieves the specified expansion limits will be accepted for AAR control.

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
$0.30 \le E < 0.50$	$e < 0.03$	Use blended cement with a minimum of 25% FA or 50% BFS [(2)] in production concrete
	$e \ge 0.03$	Use blended cement with a minimum of 30% FA or 60% BFS [(3)] in production concrete
$0.50 \le E < 0.80$ [(4)]	$e < 0.06$	
	$e \ge 0.06$	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.

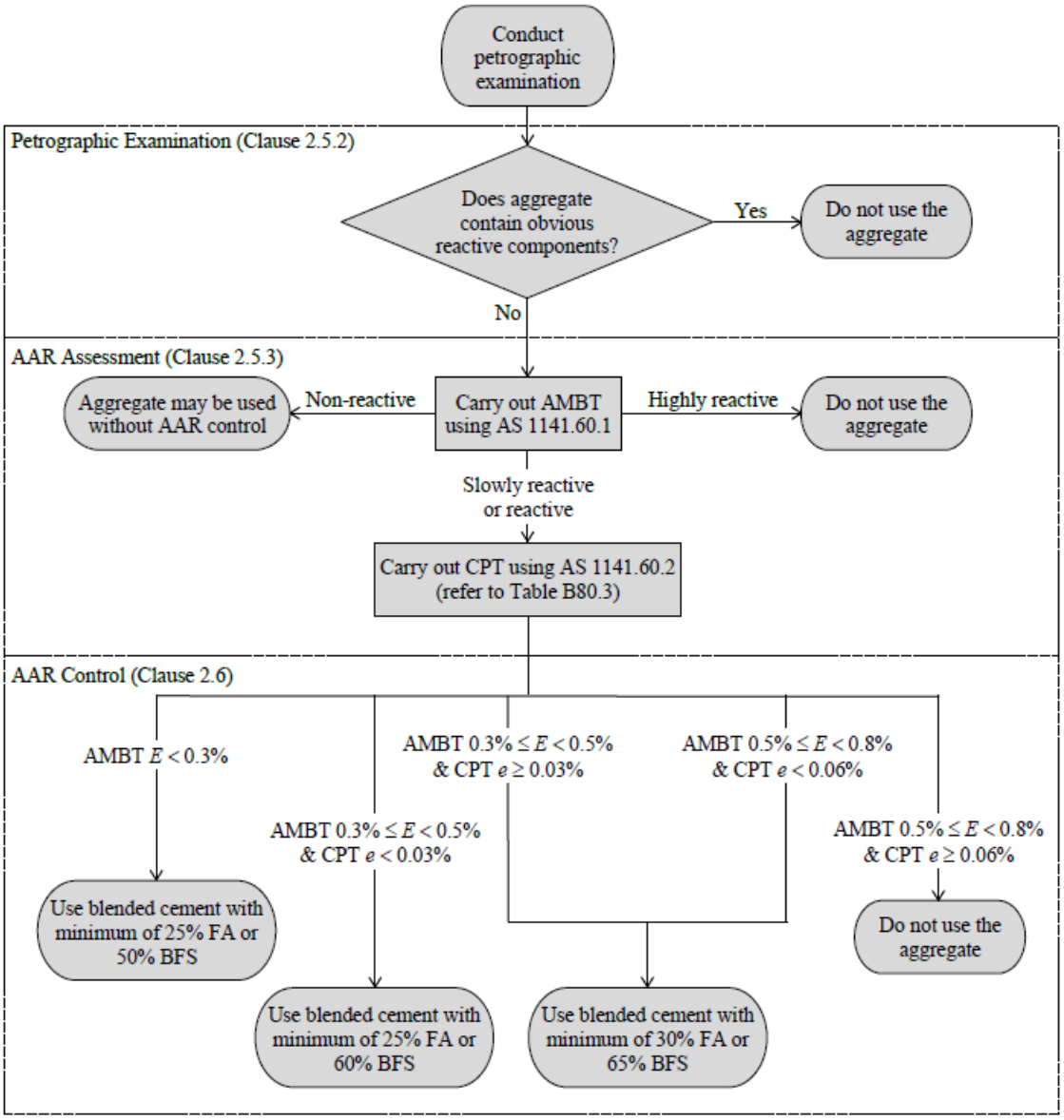


Figure B80.1 – "Deemed-to-Comply" Approach to Control AAR

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.

The alkali content of concrete is significantly reduced when 25% of cement is replaced by fly ash and this reduces even further when 65% of cement is replaced by slag in the tests. The concrete with FA blended binder will have approximately 4.20 kg Na_2O/m^3, instead of 5.25 kg Na_2O/m^3 in the concrete with GP cement. Therefore, the reduction of the alkali content in the concrete with the SCM may suppress the expansion and show up as more effective than it actually is. For this reason, the alkali content in the CPT in the "performance based approach" must be maintained as 1.38% by mass of total binder and not only of the GP cement component as in Clause 2.5.3.

This edition of B80 does not permit the use of the performance based approach to "critical" applications (i.e. applications prone to AAR damage). However, it is intended that such restriction to be eased or waived in future editions of the specification once satisfactory performance records and laboratory test results validating field performance become available.

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.

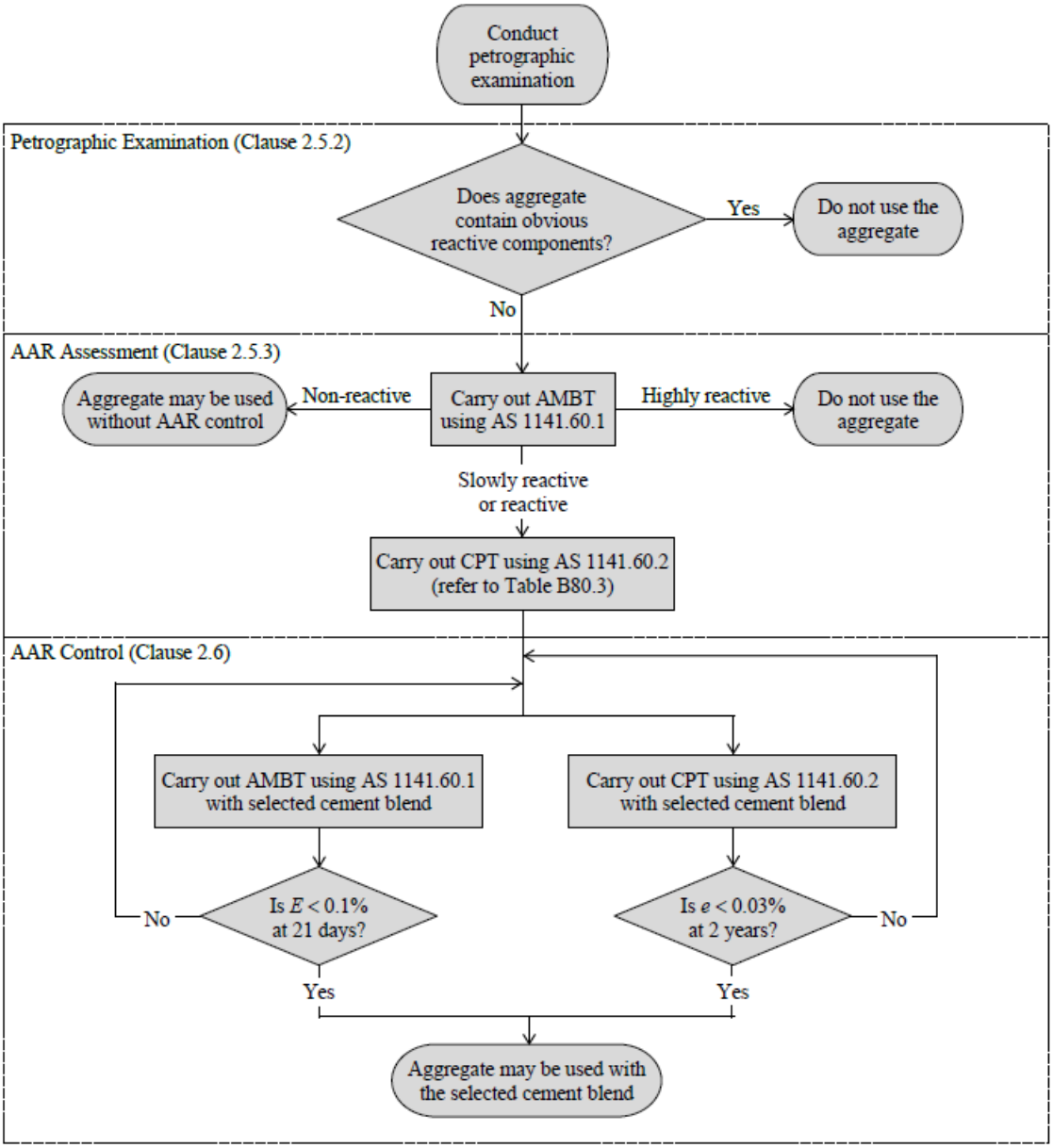


Figure B80.2 – "Performance-Based Approach" to Control AAR

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
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.

Chloride content is limited to increase time to initiation of reinforcement corrosion. Lower limits are specified for prestressed concrete because stressed high strength steel tendons are susceptible to stress corrosion cracking.

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.

To minimise the risk of Delayed Ettringite Formation (DEF), which can cause delayed large-scale cracking of heat accelerated cured precast concrete members.

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.

The Volhard test method option enables a more precise determination of the chloride content because the titrating solution turns bright red at a specific calibrated 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.

To minimise the risk of Delayed Ettringite Formation (DEF), which can cause delayed large-scale cracking of heat accelerated cured precast concrete members.

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.

Concrete mix design is the selection and proportioning of the ingredients of cements, aggregates, water and additives so that the resulting concrete will be fit for purpose, in regards to:

1. *Strength;*
2. *Stability;*
3. *Resistance to abrasion;*
4. *Shrinkage:*
   a. *Plastic;*
   b. *Drying;*
   c. *Creep.*
5. *Resistance to environmental attack;*
6. *Delivery:*
   a. *How;*
   b. *How far;*
   c. *Weather;*
   d. *Traffic.*
7. *Site handling and placing:*
   a. *Pumps;*
   b. *Crane and kibble;*
   c. *Chute;*
   d. *Tremie;*
   e. *Injection;*
   f. *Machine;*
   g. *Hand.*
8. *Placing conditions:*
   a. *Open forms;*
   b. *Restricted or complex forms;*

9. *Detail:*
    a. *Reinforcement and inclusions;*
    b. *Confined spaces;*
    c. *Cover;*
    d. *Dry, underwater or flowing water;*
    e. *Weather conditions – season.*
10. *Compacting and finishing:*
    a. *Hand or machine methods;*
    b. *Internal, external or surface vibration;*
    c. *Super-workable.*
11. *Finish standard required:*
    a. *Class 1,2,3,4 on formed surfaces;*
    b. *Tolerances and texture on unformed surfaces.*
12. *Curing:*
    a. *Water;*
    b. *Sealed;*
    c. *Heat accelerated;*
    d. *Self curing.*
13. *Temperatures during curing;*
14. *Temperature gradients in the concrete during curing.*

A mix is designed by selecting the aggregates, cement and water contents, blending the coarse aggregates to obtain a reasonable grading in accordance with Table B80.1 & Table B80.2 and, by using void space principles, proportioning the fine aggregates and cement paste to get the required strength, durability and finishing properties, using admixtures to provide other concrete properties.

A water content of about 180 kg/m^3 usually provides good workability. The water/cement ratio should reflect the needs of strength and durability, with a water/cement ratio of about 0.32 required for full hydration. The following conditions are detrimental and should be avoided as far as reasonably practicable. Excessive water leads to increased shrinkage and bleeding. Excessively dry concrete will be subject to self-desiccation and cracking.

3.2 DESIGN FOR DURABILITY

Concrete environmental attack is typically from chlorides, sulfates and carbonation. Groundwater and fresh water may also transport deleterious substances. The exposure classification assigned by the designer accounts for these issues as prescribed in AS 5100.5, and should always be found on the concrete bridge member drawings.

Influences on susceptibility to attack are the permeability and thickness of the cover concrete, and the type of cement and aggregates. Cement blends are selected based on the specified exposure classification. Calcium nitrite corrosion inhibiter must be used for Exposure Classification C for protection against chloride attack. Alternatives to corrosion inhibitors are available, for which advice should be sought from experienced specialists in the field.

B80 specifies minimum cement contents and maximum water/cement ratios for the different exposure classifications, with blended cements specified for severe exposure (Exposure Classification C or beyond) in TFNSW 3211.

The type of curing selected changes the applicable cement content and maximum water/cement ratio. Moist curing is usually required for cast-in-place concretes in severe exposures.

3.2.1 General

For concrete durability, 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;

To prevent carbonation in drier conditions by increasing the proportion of General Purpose Cement to compensate for that which carbonates.

(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;

To prevent cracking of susceptible cast-in-place bridge members such as bridge decks and larger members such as pilecaps, columns and headstocks, particularly in drier environments.

(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;

See guide notes on Clause 2.3.3.

(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;

A bridge member may be in an environment which is aggressive, but for reasons other than chlorides. In such environments the specified calcium nitrite corrosion inhibitor will offer no additional protection to the concrete, as its chemistry and application is specifically for chloride attack only.

(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;

To prevent shrinkage and cracking from self-desiccation, i.e. internal drying caused by consumption of pore water by the hydrating cement.

(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;

To prevent the recurrence of extensive bridge deck cracking experienced on a number of TFNSW bridge projects due to the use of excessive amounts of cement in the concrete for early strength gain. This resulted in higher concrete strengths and greater shrinkage, as well as delayed cracking caused by the excessive amounts of cement extracting water internally from the concrete as the cement hydrated resulting in a concrete volume reduction with subsequent, sometimes full depth, cracking of the decks.

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

To ensure that freshly place concrete deck slabs do not dry out to minimise the risk of early age cracking, following cracking of a number of RTA bridge deck pours. Equivalent curing can be proven using the sorptivity test T362.

(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.

Self-compacting or super-workable concrete was permitted in B80 Edition 5, but was restricted to use in precasting yards only due to concerns about ensuring consistent supply, which is more achievable in such applications. In Ed 6, this restriction has been eased to permit its use on bridge sites subject to the imposed limitations based on TFNSW' confidence in achieving consistent supply at a specific site. Consistent supply as well as good mix design is fundamental to achieving a stable flowing concrete that does not segregate during supply, transport and placement.

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.

Table 80.8 tabulates the durability requirements for concrete for TFNSW bridgeworks to address a number of issues of concern for concrete durability.

The first column of the table lists the range of concrete exposure classifications from AS 5100.5, which must be obtained from the concrete bridge member drawings. The concrete exposure classification drives the concrete mix design, in that the values of the parameters specified in the other columns of the table are dictated by the exposure classification in the initial column.

The second column contains the minimum cement content of the mix. The specified minimum cement quantities were originally derived from a review of trial mix data for mixes prepared to B80 Ed 2 carried out when drafting B80 Ed 3, with minimum cement quantities selected taking into account strength and sorptivity test results.

The third column contains the maximum cement content of the mix. It has been included for the first time in B80 Ed 6 to address the issue of excessive quantities of cement being used in mixes to achieve high early strength at the expense of concrete quality, in particular delayed cracking, refer to the guide notes on Clause 3.2 (f).

The fourth column contains the maximum water/cement ratio of the mix, originally derived from a review of trial mix data for mixes prepared to B80 Ed 2 carried out when drafting B80 Ed 3, with w/c ratios selected taking into account strength and sorptivity test results.

The fifth column contains the minimum water/cement ratio of the mix, originally included in the durability clauses of B80 Ed 5, but now included in Table B80.6 for clarity. It attempts to address the use on RTA projects of very low water/cement ratios to increase concrete strength and laboratory measured concrete durability properties, but which resulted in dry mixes for field placed concretes that were very sensitive to weather conditions and which resulted in widespread cracking of bridge decks in particular because the concretes were subject to self-desiccation.

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.

The sixth and seventh columns contain the limits for chloride ion ingress into concrete test specimens. The two Nordtest tests specified, Build 443 and B492, both attempt to measure the rate of ingress of chloride ions into test specimens soaked in brine for the specified period. Build 443 measures chloride ion levels with depth using samples extracted from the specimen, whereas Build 492 measures the charge passed across the specimen. Both tests have been specified to provide an alternative based on the time available to do either of the tests as nominated by the Principal. Where time is short, Build 492 is acceptable (test age is 28 days). When more time is available, Build 443 may be used (test age is 56 days). The results should be comparable. Note that the tests are purely laboratory tests; the test specimens are made under controlled conditions to tight production tolerances and are moist cured for an appreciable length of time. The test results cannot be used directly to assess the durability of a concrete pour at a particular bridge site, as field placed concrete will generally be of much lesser quality than that in the test specimens, due to the greater variability of field batched concrete, the less thorough placing and compaction due to the larger volumes involved, and the lesser quality of the curing in terms of type and duration. The Nordtest tests are used solely to assess the relative durability of different concretes mixes against chloride attack, to eliminate from use those mixes which are unsuitable. The specified limits in the table are based on analysis of limited test data from a number of RTA and NSW projects and from the Boral Materials Services Laboratory.

The eighth column contains the minimum concrete strength required for durability, originally derived from a review of trial mix data for mixes prepared to B80 Ed 2 carried out when drafting B80 Ed 3, with strengths selected taking into account the sorptivity test results. Where the structural strength is less than the durability strength, the higher durability strength must be used for the concrete mix design for the concrete of the bridge member.

The ninth column contains the additional prescribed actions for the concrete mix design for the specific concrete exposure classification, namely the use of specific blended cements in Classifications B2 and C1 & C2 for aggressive environments to ensure adequate durability performance.

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.

Based on the fact that Contractors have engaged specialist consultants to provide advice in the form of project-specific durability plans and concrete mix designs for a large number of TFNSW projects in a range of environments, proposing project specific variations of B80 for the project, the above provisions formalise this arrangement. The underpinning intent is that project-specific durability plans and concrete mix designs must result in a durability performance for the project equivalent or better than specified in Clauses 3.2 and 3.3 of B80, as proven by laboratory test results on trial mix specimens made and tested to replicate project mixes and conditions compared to the provisions specified in B80.

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.

Controlling heat of hydration is required to prevent/reduce restraint cracking, which causes problems where only one face of the concrete is insulated or sections have least dimensions exceeding 1 metre. Solutions include cooling using chilled water or ice in the mix, reducing content of and using coarse grind versions of OPC, using high proportion SCM blends, and using larger aggregates.

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.

New Clause 3.3 has been added to B80 Ed 6 to clarify for specification users the actions required to prevent the adverse effects listed from occurring during the production of concrete bridge members. References are either given to the relevant B80 clauses, or details of the required actions are given in the relevant sub-clause, compliance with which should prevent occurrence of the listed effects. The listed adverse effects are the main problems that have been encountered during RTA bridge works, but a number of other adverse effects may occur if good concrete production, transport and placement practices are not followed. The references listed before Clause N.3 of these guide notes give useful information about good concreting practices.

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.

Curing is of vital importance to the quality of a concrete bridge member. Proper curing ensures that water is available during the curing period for the ongoing hydration of the cement in the concrete, essential for the development of a dense and impermeable microstructure. A lack of water during the curing period means that the available water is consumed but voids remain where the cement remains unhydrated, leaving pathways by which vapour and moisture can penetrate deep into the member.

Two options for concrete curing open to the Contractor are:

- *Curing Provision A – (Performance); and*
- *Curing Provision B – (Method).*

The performance option "Provision A" is different to the method option in that it specifies for a particular exposure classification the required minimum TFNSW T362 sorptivity test result that must be achieved by the nominated concrete mix and the nominated curing regime.

"Provision A" is usually only used on larger contracts, where the Contractor can obtain large cost savings in concrete supply costs over the duration of the Works by reducing cement quantities or curing times.

The deemed to comply method option "Provision B", instead of carrying out sorptivity tests, permits a curing regime to be used on site which complies with one of the three tables in Annexure B80/E. These tables give three curing types of wet, sealed and heat accelerated curing, with the permissible curing and duration of curing varying according to the cement type and the concrete exposure classification. This option can result in a shortening of overall contract time especially where prior concrete trial mix test results exist.

The TFNSW T362 sorptivity test measures concrete characteristics similar to permeability, and was originally developed by Dr David Ho of the CSIRO as a measure of the effectiveness of a concrete curing regime.

In RTA contracts carried out using Ed 2, the Contractor had to carry out sorptivity tests on a Durability Reference Mix (DRM) in order to define the limits applicable to the Works, the results from which the specifiers set the sorptivity limits in Ed 3.

The RTA T362 test method was originally specified in B80 Ed 3 as an indirect measure of concrete durability, and was effective in that regard because low sorptivity results can only be achieved if the concrete is dense and well cured. Such concrete should also be durable as most durability problems arise due to the ingress of harmful substances from the environment into the concrete by way of vapour or moisture transmission.

B80 Ed 6 Table B80.7 sorptivity limits were first set in Ed 3 using experiences in bridgeworks contracts in the early 1990's with Ed 2 and expert opinion and consensus, with minor changes to the limits in subsequent revisions following industry experience with Ed 3.

The specified TFNSW T362 sorptivity limits are now intended for assessment of the effectiveness of a curing regime, as originally designed, by applying the curing regime to a laboratory trial mix test specimen, with measurements taken of both the curing temperature and relative humidity over the duration of the curing period. The clause clarifies that the curing of the bridge member must be proven to be the same as that of the laboratory test specimen, by taking curing temperature and relative humidity measurements of the bridge member over the duration of the curing period, and comparing with the laboratory test specimen measurements. Such measurements can now be easily obtained using current technologies non-existent a decade ago.

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:

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

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

The applicable minimum concrete strength $f_{c.min}$ is the maximum of the structural strength f'_c specified on the Drawings or elsewhere, that required for durability specified in Table B80.6 using the exposure classification specified on the Drawings, and that required for stripping and prestress transfer.

$M_{control}$ 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.

To reduce the susceptibility of the concrete bridge member to cracking arising from the use of excessive quantities of cement for early strength gain.

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;

To reduce the susceptibility of exposed concrete bridge decks to cracking arising from the use of excessive quantities of cement for early strength gain. The limit of 42 MPa applies to Exposure Classifications A and B1.

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

To keep the structural behaviour of the concrete within the strength ranges for which AS 5100.5 is applicable i.e. for f'_c up to 65 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.

To limit the concrete strength and cement contents for good durability performance, in particular cracking.

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.

Self- compacting concrete may be used on projects within the specified constraints. Refer to Concrete Institute of Australia's Z40 publication Recommended Practice – Super-Workable Concrete *regarding self-compacting concrete and controls required for consistent supply.*

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 ()	
	Drying period microstrain	
	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.

Concrete shrinkage relates to paste volume and aggregate type, with paste volume governing if the aggregate conforms to Clause 2.4.1. Table B80.8 gives limits for drying shrinkage, which is the only type of shrinkage AS 1012.13 captures. Excessive water (over 210 kg/m^3) is likely to result in excessive shrinkage, bleed and settlement cracking. Insufficient water (below 160 kg/m^3)is likely to result in plastic shrinkage cracking and longer term cracking from self-desiccation.

Table B80.8 limits have been modified to reflect the influence on test results of cement and concrete type.

TFNSW uses the shrinkage limits of this clause as an indirect way of specifying for good concrete.

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

Approval of TFNSW concrete mixes is covered by Infrastructure Contracts Note ICN-125, which states that approval to the use of a concrete mix for TFNSW projects can only be given following an assessment of a mix submission received from the concrete supplier by nominated Regional assessors under the direction of the Region's Geotechnical Scientist or by nominated Engineering Technology Services assessors.

The mix submissions are stored in the TFNSW's Concrete Mix Register and Database (CMR), and can be retrieved for use in a specific project upon request to the Geotechnical Scientist. A quick check of a mix's approval status can be carried out by reviewing the Register.

Each mix in the CMR has a unique identifier that enables traceability to the original trial mix submission and test reports, enabling verification that the proposed project mix is the same as that submitted for approval. The approved concrete mix design cannot be simply filed away. The concrete

mix design includes the nominated gradings for the aggregates against which the weekly aggregate test reports should be compared and the nominated curing regime which must be referenced when performing surveillance and audits of the work.

The Principal's Representative should check a concrete mix submission received from the Contractor as follows:

1. *Does the Contractor propose a registered mix?;*
2. *Is the mix on the register? (ICN-125 refers);*
3. *If yes, check mix design details and properties from the register;*
4. *Check with the Regional Administrator for validity of materials certificates, i.e. that recent materials test reports less than 12 months old are provided for comparison with the trialled mix;*
5. *Ensure that the properties of the mix are appropriate:*
    a. *Slump;*
    b. *Strength;*
    c. *Maximum aggregate size;*
    d. *Setting time;*
    e. *Cement blend, i.e. quantities and % of OPC and SCMs.*
6. *Is the curing regime proposed for the nominated mix appropriate?;*
7. *Is the concrete exposure classification proposed for the nominated mix appropriate?;*
8. *Is the placement method consistent with the mix design?;*
9. *If not on the register, then:*
    a. *Obtain the mix design, trial mix report and materials test reports;*
    b. *Ensure all the required information is provided;*
    c. *Ensure all the information is up to date (not more than 12 months old);*
    d. *Ensure that the properties are appropriate:*
        i. *Slump;*
        ii. *Strength;*
        iii. *Maximum aggregate size;*
        iv. *Setting time;*
        v. *Cement blend, i.e. quantities and % of OPC and SCMs.*
    e. *Is the proposed curing regime appropriate?;*
    f. *Is the proposed concrete exposure classification appropriate?;*
    g. *Is the placement method consistent with the mix?;*
    h. *Submit to Regional Administrator for detailed assessment.*

The nominated mix and its associated site curing regime must be in accordance with the requirements of the Specification and Drawings. If no curing regime is nominated, then the nominated mix is not conforming.

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.

A trial mix conforming to AS 1012.2 produced under strictly controlled laboratory conditions is required for each mix prior to use on TFNSW projects. Use of concrete samples taken from a production run is not acceptable, as concrete batch plant production tolerances are not suitable for obtaining baseline concretes for the required strength and durability tests.

Trial mix test results for an approved mix need not be less than 12 months old, provided that NATA endorsed test results in accordance with TFNSW Q less than 12 months old are supplied proving that the constituents of the mix do not differ from those used in the trialled mix. Where the constituents are not identical, a new trial mix must be carried out or use a conforming approved mix.

It is intended that the trial mix represents concrete that is batched with the worst combination of tolerances that could occur in the field, to represent the worst batch of conforming site concrete. The properties of such concretes must conform to the specification, to give the Principal assurance that if all the site concrete conforms to the specification, then all the concrete in the bridge will have the required strength and durability properties.

The water/cement ratio of the trial mix will be different to that of the nominated water/cement ratio, and will be governed by the greater of the tolerances on slump and water/cement ratio, or by the maximum permissible water/cement ratio. For concretes with w/c ratios equal to or above 0.4, trial mixes at the limit of the wetter side tolerances only are required, as dryer concretes at these w/c ratios will usually have better strength and durability properties. However, concrete mix designs with w/c ratios less than 0.4 must have 2 trial mixes, one at the limit of the wetter side tolerances, and the other at the limit of the drier side tolerances. This is because these dryer mixes may have worse strength and durability properties if the mix becomes dryer, as insufficient water will be present for complete hydration of the cement.

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.

Minor changes are permitted to an approved mix that do not affect its durability or strength, with the allowable variations specified. Variations do not apply to already varied mixes. Variations outside the specified limits require the new mix to be submitted for approval. A new mix submission is required if any of the constituents of the mix, these being the source, ingredients or supplier, are changed from those used in the approved mix.

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.

AS 1379 underpins the specification and supply of concrete conforming to B80. Australian Standard AS 1379 is drafted by the Standards Australia BD-049 committee which comprises representatives from major Australian concrete industry stakeholders, including Austroads, which represents the interests of Australian state road authorities, including the TFNSW. Consequently, specification of conformance to AS 1379 for concrete supply should result in the delivery of conforming concrete to TFNSW projects by the local concrete batching plant. The additional requirements of B80 over and above those of AS 1379 are achievable given B80's long history of use and the contributions from the concrete industry to the drafting of each edition, including B80 Ed 6.

Testing must be carried out at the frequencies specified in Annexure B80/L to verify conformance of the delivered concrete to the approved mix.

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.

Statistical control of concrete production from a batch plant is called production assessment in AS 1379, and is nominated as part of the submission for approval of the mix.

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.

Storage of aggregates in the saturated surface dry condition or wetter has been specified in an attempt to reduce the variability in aggregate moisture content and its effects on the consistency of concrete supply, to reduce water demand and subsequent slump loss during discharge from the take-up of mix water by dry lesser quality aggregates in the concrete mix.

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.

One of the main variables affecting the workability and variability of the concrete is the water in the mix. The implication of concrete being supplied in accordance with AS 1379, as required by Clause 4.1, is that for typical concrete the total water in the concrete can only be controlled to an accuracy of ± 10% to 12% of the total water (i.e. to about ± 20 litres/cubic metre).

The major variable in water content is the moisture in the aggregates, especially the fine aggregates. In order to reduce the variability of water in the mix, the moisture content of the aggregates should be

controlled as tightly as possible. Hence the requirement of Clause 3.8.2 (c) (iii) for the Contractor to state the level of control and accuracy of determination of aggregate moisture content. The current requirement of AS 1379-1997 is for a tolerance of ±10% of the water/cement ratio. Anything greater than 10% is nonconforming.

If aggregate water content can be controlled, the concrete supply should be consistent.

4.3 ADDITIONAL REQUIREMENTS FOR MIXING

4.3.1 Equipment

Do not use continuous mixers.

Split drum or agitator trucks, not continuous mixers, are specified to control concrete variability by accurately measuring/weighing ingredients for each batch.

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

Adequate agitation for at least minimum specified number of revolutions of the mixer is critical to ensure complete mixing

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.

Excess agitation promotes hydration of the mixed batch, which is undesirable when discharge and placement are delayed, because of the risk of slump loss and resulting inadequate compaction.

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.

Additional mix details have been specified to enable tighter control over concrete supply, in particular w/c ratio.

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.

To reduce the risk of slump loss becoming excessive from so much water being consumed during cement hydration that slump becomes out of tolerance and the concrete is no longer workable. In uncontrolled hot conditions early set may occur.

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, nominate the extended setting time and 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.

Hydration control admixtures are two-part admixtures used delay hydration and extend the setting time of the concrete mix to gain longer haul times than permitted by B80.

The first part of the admixture is added during mixing to effectively coat the cement grains, temporarily stopping the normal hydration process. The extension of the setting time is determined by the dose level of the admixture and, hence, the 'thickness' of the coating. On arrival at the site the concrete can be re-activated by adding the second part of the admixture, a set accelerator, or the concrete can be left to set slowly.

Usually a loss of strength compared to the trial mix occurs, the extent of which needs to be determined by testing.

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.

To keep concrete temperatures within limits so that cement hydration does not occur too slowly or too fast, to minimise the risks associated with these events. The rate of cement hydration varies exponentially with temperature.

Cold concrete hydrates too slowly to finish the concreting during the time allocated for the pour, with work probably needing to continue into the cold night, with people becoming too tired to think, causing mistakes. In cold weather, heating of the aggregates may be required. Do not use hot water as this may cause flash setting of the cement. Below 5°C hydration will never occur and concrete mix water may freeze causing cracking.

Hot weather concreting can result in early stiffening, problems in compaction and finishing, and rapid set, all of which can cause nonconforming concrete. In hot weather, cooling of the aggregates or the mix water may be needed. At temperatures above 30°C the risk of flash set exists. Concrete placed hot risks loss of strength and durability.

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.

The slump of the concrete is a measure of its consistency and hence its workability. The nominated slump is specified to ensure that the delivered concrete can be placed and compacted to achieve a concrete in the bridge member that is dense and homogeneous. Slump losses resulting from delays to delivery or placement mean that workability will be less, the concrete will be more difficult to place and compaction may be less than specified. See also the guide notes on Clause 4.3.5.

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.

Slump measurements are also used to measure concrete supply variability/uniformity. Variable slumps mean that there has been less than optimal control of supply, especially of water content, and hence lack of uniformity in concrete deliveries. Variations in concrete delivery means concreting

operations become more difficult, with the concreting crews needing to make appropriate allowances for the variable concrete in their work practices.

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.

Slump tolerances are specified to ensure that water content and mixing of the concrete is being controlled. Concrete batches with out of tolerance slumps must be rejected.

Batches that are too wet may segregate or have strengths that are too low. Batches that are too dry may not achieve the required compaction or result in cracking of the bridge member.

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

See guide notes on Clauses 3.8.1 and 4.2.

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.

Water addition and concrete supply should be under control. Water could be added at anytime and anywhere from batching until placement by the truck driver, pump operator, deck finisher etc. with or without knowledge and acquiescence of people supervising the pour. Excess water than the quantity nominated in the approved mix will impact adversely on strength and durability. Compressive strength specimens could be collected before the water is added, and the illegal water addition may not be detected.

Water can be added to a mixed batch provided its addition is measured and controlled to ensure that the applicable tolerances on water content and slump are not exceeded, and adequate mixing of the batch occurs following the addition.

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.

Test strips can be obtained from the admixture supplier.

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.

Formwork must be strong enough to resist the specified design loads, in particular settlement and fluid concrete hydrostatic pressures without excessive deflections, and its quality should be such that the specified concrete finish is achieved.

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

Conform to AS 3610.1 for project documentation.

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.

Risk categories of formwork were introduced for the first time in B80 Ed 3.

Each item of formwork to be provided for a bridgeworks project shall be assessed as falling into one of the three risk categories. The allocation of formwork types to each category depends on both the degree of difficulty of the formwork design and the consequences of failure.

Early on in the project, the Principal's Representative and Contractor should get together and agree on the risk category to be assigned to each item of formwork. The Contractor can then arrange for the necessary design, documentation and certification to be carried out in time to fulfil its obligations under the Contract.

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 pilecaps.

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.

Provisions for slipformed barriers were removed from B80 Ed 6 following unsatisfactory results on RTA projects. Concrete for slipforming essentially has 0 mm slump, but needs to be intensely compacted to expel all entrapped air. Whilst suitable for road pavements, slipformed concrete has proven to be unsuitable for bridge barriers. Slipformed bridge barriers were found to lack compaction, be nonconforming with Table B80.11 tolerances, and construction joints at deck level leaked, raising concerns about the long-term durability of the tensile traffic barrier reinforcement.

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.

TFNSW expects that the reinforcement suppliers' and fabricators' quality systems can be relied on to supply steel reinforcing bars conforming to the relevant Australian standards, fabricated to the required degree of accuracy, with oversight of this provided by the Australian industry initiated ACRS third party accreditation scheme, in response to the supply to the Australian market of deficient reinforcement from overseas suppliers.

The Principal's Representative should carry out surveillance to verify that reinforcement supplied conforms to the specified requirements and initiate corrective action if required.

Surveillance must verify:

- *Conformance to the Drawings in regards to:*
  - *Correct locations;*
  - *Correct steel grade, as evidenced by the markings on the bar;*
  - *Correct length, size and shape, by comparing the measurements to the supplier's steel list.*
- *Conformance to B80 in regards to:*
  - *Tying;*
  - *Welding;*
  - *Bar chairs;*
  - *Form cleanliness.*

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.

To prevent adverse changes to the steel microstructure caused by overheating or rapid cooling.

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.

To prevent damage to the steel microstructure from cold working the bar.

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

A + tolerance refers to an increase in a design dimension or value, and a - tolerance refers to a decrease in a design dimension or value.

In Table B80.15, the +0 tolerance for fitments means the overall dimension of the fitment cannot be more than the design dimension, e.g. for a 200 mm wide stirrup, the overall actual width must be between 185 mm and 200 mm.

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 to 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.

TFNSW reinforcement welding requirements specified in B204 are intended to ensure that the reinforcement is not damaged by poor welding and that preassembled cages will withstand handling effects safely.

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.

To prevent damage to the prestressing tendons from arc strikes or welding spatter.

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. Conform to Clause 6.5 for welding of load bearing welds.

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.

The concrete clear cover over the steel reinforcement is critical for its protection against corrosion by maintaining an alkaline environment around the steel. The specified cover is intended to achieve the 100 year design life required for bridges by resisting, in addition to the other means employed within AS 5100.5 and B80, attack from chlorides, carbonation and acid sulfate conditions.

Reinforcement will not corrode provided the hydroxides in the cement maintain the concrete at a pH of 13.5, under which alkaline conditions a protective iron oxide film forms around the reinforcement. This film stops corrosion and is stable at pH >10.5 that passivates the reinforcement against corrosion.

Carbonation which is:

$$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$$

reduces the pH to about 8.5, at which level the passive film dissolves and corrosion initiates.

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

Tolerances on dimensions are only specified to control inaccuracies in fabrication and construction, not to accommodate a change required as the result of a design or construction issue.

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.

In Table B80.15, a -5 tolerance on cover means the cover cannot be less than (design cover -5 mm) e.g. for a 40 mm cover to a girder web, in accordance with Table B80.15 the actual cover can lie between 35 mm and 50 mm. Covers less than 35 mm or more than 50 mm are nonconforming.

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 to 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.

Clause 7.3 requires the Contractor's Concrete Supervisor to verify that the concrete operations have been carried out as specified for the whole of each pour, to ensure that the required degree of control is achieved.

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.

Based on the RTA Pavements Grey Card course, the Bridgeworks Concreting Grey Card training course was first presented in May 2007 and was introduced into B80 in Ed 5/Rev 3 in June 2008 to address the perception that all personnel involved in bridgeworks concreting operations needed to

appreciate the importance of their work to the RTA insofar as the quality of concrete bridge members depends on how well they do their job. The course discusses more the reasons why concreting operations need to be carried out correctly rather than how to perform the operations, with the expectation that once the reasons were explained, concreting crew personnel would improve the way operations are carried out. Mandating that personnel involved in concreting operations must hold a Grey Card ensures that Contractors and TFNSW site staff take the appropriate action for compliance.

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.

Cement hydration is a chemical reaction which rate is determined by temperature. The colder the concrete temperature the slower the rate of hydration, and the hotter the temperature the faster the rate. The rate of hydration dictates the speed of the concreting operations.

In warm and hot weather, use retardant admixtures to retard hydration and delay set. In cold weather, warm the aggregates or use accelerant admixtures to accelerate hydration and achieve set, but do not use additives containing calcium chloride.

Sample the concrete at the end of the day to verify conformance. Use other measures such as insulated forms to protect the fresh concrete from damage in extreme conditions.

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.

Any rubbish and dirt left in forms will show up in the concrete surfaces when the forms are stripped. All tie wire off-cuts must be removed, otherwise they will cause rust stains on soffits.

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.

The aim of concrete placement is to get the concrete into its final position with minimum handling so that segregation does not occur. Placement should be carried out as close as possible to the final position.

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.

Concrete is compacted for two main reasons:

- *To remove any voids in the concrete to obtain the maximum strength and density of the concrete in place;*
- *To obtain complete contact between the concrete with the formwork and the surface of the reinforcing steel.*

Compaction removes entrapped air produced during mixing, transporting, placing and spreading.

If compaction is not complete and entrapped air remains in the concrete, a 5% reduction in concrete density results in a 20% reduction in strength and a halving of durability. Poor compaction compromises durability by allowing water and air to penetrate and corrode the reinforcement, e.g. allow chloride attack. Many if not most early-life maintenance 'patches' are the result of poor compaction.

The keys to good compaction are that compaction methods must be systematic to a defined repeated pattern and uniform, always done the same way. For internal vibration, compaction at depth by the vibrator to liquefy the concrete is essential.

Liquefaction of the plastic concrete using vibrators makes the concrete around the vibrator become liquid, as a result of which all the entrapped air can rise to the surface and be expelled from the concrete.

Compaction occurs in two stages:

1. *Liquefaction of the concrete allows it to slump and completely fill the form, and takes from 3 to 5 seconds to occur;*
2. *Expulsion of entrapped air, which takes from 7 to 15 seconds.*

The total time for both stages of compaction for each dip of the vibrator is therefore between 10 to 20 seconds. However, if during vibration air bubbles cease breaking at the surface compaction is complete and the vibrator can be withdrawn slowly for the next adjacent insertion.

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.

High-strength flowable mortar is specified for concreting deck joint blockouts because at these locations the blockout is usually congested with the deck and blockout reinforcement as well as the deck joint anchorages and the deck joint itself.

The main objective of specifying flowable mortar for a joint blockout is to produce a void-free blockout with acceptable interface at construction joints, i.e. to protect steel and metal components against corrosion and to maintain structural capacity across the construction joints.

When this requirement was first introduced in B80, Ed 5/Rev 3, it applied to all blockouts that are to be cast after placing bridge deck regardless of the space available to place and compact concrete.

Revision Ed 6/Rev 1 of B80, mandated flowable mortar only where:

(a) The block out is cast after concreting the deck (construction joint); and

(b) Space in the blockout is not sufficient to place and compact concrete.

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.

Fine mist water sprays, but not streams of water, may be used to minimise water loss from the concrete surface without damaging the plastic and fresh concrete.

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.

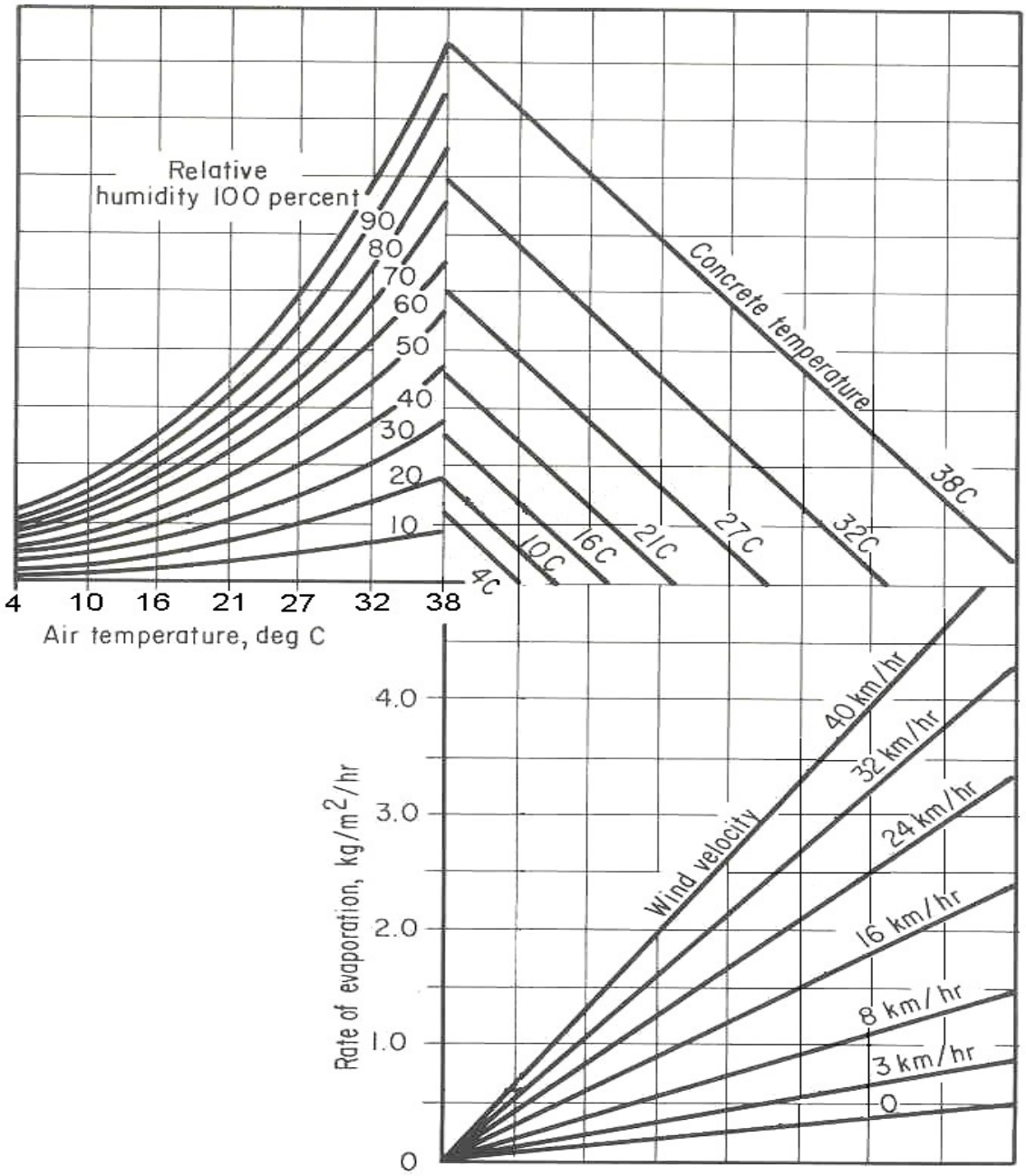
Aliphatic alcohol can be used as an evaporation retarder provided it is applied as a mist spray, and is not worked into the surface of the concrete, as this will damage the concrete.

7.10.3 Rate of Evaporation

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

Use of the nomograph is essential, especially on windy, dry days and will require the use of a cheap anemometer to measure wind velocity and wet/dry bulb thermometer to measure temperature and humidity.

***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.

Screeding is working off screeding guide rails or screeding pin markings to get the concrete trimmed to shape and flatness with a tight dense surface.

Surveying for deck slabs and thickness needs to account for:

- *Bearing levels usually being co-planar;*
- *Girder/plank heights usually being constant;*
- *Girder/plank hogs not being equal;*
- *Deflections from dead load of deck concrete;*
- *Differential shrinkage between deck and girders/planks;*
- *Deflections due to superimposed dead load (asphalt, barriers, medians and services).*

Screeding is not compaction. Vibrating screeds are screeding tools, and should not be regarded as giving additional compaction as they can only compact the upper surface of the concrete to a depth of about 75 mm. Travel speed, vibration frequency and vibration amplitude must match the mix being placed.

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. Conform to Clause 7.10 for control of moisture loss.

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.

Finishing is the process where surface marks or small localised high spots are corrected, taking place while the concrete is stiff but still plastic and bleed water is just disappearing. Edging tools are not normally used at joints or edges for bridge decks, to not add any bumps. Use helicopters with caution as they can bring fines to the surface, and can cause scaling.

The broom finish should be applied using a light broom, not a heavy 'bass' broom, using only the self-weight of broom without leaning on it or gouging the surface. Use straight slightly overlapping runs

at right angles to the deck pavement and clean the broom after each pass by knocking the handle barrowing with water and shaking the mortar out.

7.12 SCREEDING AND FINISHING OF ALL OTHER UNFORMED SURFACES DAGS

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.

For curing, concrete temperature (not air temperature):

- *23 ℃ – Ideal temperature;*
- *Below 5 ℃ – Undesirable for first couple of days;*
- *At 4 ℃ – Water volume is maximum before freezing and concrete microstructure is adversely affected;*
- *Below zero – Concrete freezes and hydration stops.*

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

Curing is a process of retaining moisture at a reasonable temperature to keep the reaction between the cement and the mix water going. Hydration is the development of the desirable properties of concrete due to chemical reactions between the cement and the mix water, but takes time and needs water to be available for the reaction to proceed.

The types of curing have been defined explicitly at the beginning of B80, with the requirements for each type contained in Clause 7.12.

Curing develops the strength and durability of the concrete and most affects:

- *Chemical resistance;*
- *Ductility;*
- *Tensile strength;*
- *Impact resistance;*
- *Abrasion resistance;*

and least affects:

- *Density;*
- *Compressive strength;*
- *Modulus of elasticity;*
- *Resistance to AAR.*

Curing must be applied as soon as possible after finishing to avoid moisture loss, which commences as the bleed water disappears.

The type of curing used affects the microstructure of the concrete, the strength that can be achieved from the mix, and strongly influences long-term durability. The curing methods in order from best to worst are:

- *Wet/Moist;*
- *Sealed in form;*
- *Heat in form;*
- *Sprayed on curing membrane;*
- *Covered only;*
- *Air dried.*

The curing regime actually used on site must conform to the B80 definitions and that for the approved nominated concrete mix designs. Surveillance must ensure that curing is performed to the nominated curing regime for the approved nominated concrete mix.

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.

A minimum of 3 days wet curing is specified for cast-in-place concrete bridge decks because conformance to earlier versions of B80 without this provision resulted in a number of RTA bridge deck pours cracking during or after the pour. Bridge decks are wide, long, flat and relatively thin reinforced concrete members potentially exposed to sun, wind and rain during and after the deck pour. The risk of the concrete drying out as water evaporates rapidly from the surface as the result of windy weather was addressed in B80 Ed 5/Rev 3 by mandating that the concrete surface must never be allowed to dry out, and that wet curing be applied immediately after finishing to keep the deck surface moist until the concrete gains sufficient strength to prevent cracking. See also the guide notes on Clause 3.2(f).

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.

Water of at least a quality suitable for use as concrete mix water is considered acceptable for curing. This will eliminate from use for curing most unsuitable water sources e.g. heavily polluted, sea water. The water temperature must be similar to the concrete temperature to prevent thermal shock and subsequent cracking.

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.

To prevent adverse effects on adherence of asphalt and bitumen spray seal binders.

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.

The two main TFNSW requirements for curing membranes are that a continuous unbroken film with no gaps or holes is applied, and is maintained intact for curing period, with any damage made good. Apply using two coats so application rate can be monitored to ensure film is thick enough and continuous. A white or red fugitive dye is specified to give a temporary colour to see that the specified coverage is achieved.

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.

The requirements for heat accelerated curing take into account precasting industry practices without sacrificing long term concrete performance. This should potentially save the Contractor time and money. The temperature of the concrete in a curing chamber should be measured at the surface of the concrete, not by using internal probes. Where steel forms are used, a good proxy is the temperature of the form.

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.

A performance requirement has been specified for concrete cracking to make it easier for the Principal's Representative administering the contract to obtain conforming concrete bridge members. Concrete containing cracks anywhere greater than 0.05 mm at the end of curing or 0.1 mm after 28 days is nonconforming, and the Contractor and Principal's Representative will have to agree on an appropriate course of action. The action to be taken will depend on the bridge environment, the severity, size and location of the crack, as well as its structural significance.

The cracking requirement is an indirect way of controlling the quality of the total concrete production, placing, finishing and curing operations. Cracking should not be ignored, as it is a signal that something is not right. Any cracking should be investigated for causes, and the Contractor's operations rectified so that it is eliminated on future pours.

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 to Figure B3 of AS 3610.1).

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

Refer to the photographs of example surface finishes in AS 3610 for guidance.

For the specified B80 unformed finish the concrete will require sufficient fines, and for well-formed finishes, unless colour matching is required, will mostly require adequate compaction. Finer details may need flowable concrete using smaller aggregates with maximum stone sizes of up to 14 mm to achieve the required finishes.

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 – Requirements for base exposure classification, concrete isolation and parameters

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.

Refer to Clause N.2 at the front of this document and the guide notes on Clause 3.4.2.

The permissible curing regimes are dictated by the type of cement, whether Type SL or Blended, which is determined from the durability requirements for each Exposure Classification in Table B80.6, while the curing itself must conform to Clause 7.12.

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

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 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 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 are 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 welds that are welded by each welder and for each WPS used in the fabrication are to be examined by liquid penetrant testing. Examine 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.

Provisions for stainless steel reinforcement have been included to provide more options for durability of substructures in tidal splash and spray zones in marine environments. The selection of the correct grade is critical as are the precautions required during handling and fixing of the steel.

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	Δ Spread: ≤ 50 mm	Complete test within 6 minutes of ASTM C1611 to harmonise results
	EN 12350-12	Δ 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, 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.

Self-compacting concrete eliminates the need for compaction during concreting, which can reduce construction time, increase worker safety by reducing manual handling, and improve the construction of bridge members such as piles and tall congested columns.

Previous B80 versions restricted its use to precast elements, but Ed 6 gives scope to more widespread use of self-compacting concrete, recognising that there are controls needed for formwork, production and placement to reduce the risks related to its use. Lower costs of construction are also possible.

The clauses in Annexure B80/G and the tests and associated limits in Table B80/G1 were included in B80 following a literature review of overseas practices, local laboratory trials using local constituents and trial concrete pours at country locations using local batch plants.

Concrete Institute of Australia's Z40 publication Recommended Practice - Super-Workable Concrete is a useful Australian reference regarding self-compacting concrete and the controls required for its consistent supply

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

Refer to guide notes on Clause 7.4.3.

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;

Dressing of voids is required to ensure that the correct volume of water is displaced to enable correct assessment of the density of the concrete cylinder being measured.

(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 Steel Reinforcement
TfNSW B240	Steel Fasteners
TfNSW 3211	Cements, Binders and Fillers

TfNSW Test Methods

TfNSW T240	Texture Depth of Coarse Textured Road Surfaces
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 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	Method 3.2.1: Soil classification tests – Determination of the plastic limit of a soil – Standard method
AS 1289.4.2.1	Method 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	Chemical admixtures for concrete, mortar and grout
AS 1478.1	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	Method 301.1: Non-volatile content by mass
AS/NZS 1580.505.1	Method 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	Aggregates and rock for engineering purposes
AS 2758.1	Part 1: Concrete aggregates
AS 3610	Formwork for concrete
AS 3610.1	Part 1: Documentation and surface finish
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