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GUIDE TO QA SPECIFICATION B80
CONCRETE WORK FOR BRIDGES

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IC-QA-B80

VERSION FOR:
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FOREWORD

RMS COPYRIGHT AND USE OF THIS DOCUMENT

Copyright in this document belongs to the Roads and Maritime Services.

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 6 Revision 2.
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 dependant 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 reaction 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.

RMS 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 RMS. 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 6/Rev 2 is the latest revision to RMS 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.

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

RMS Internal Technical Training:
1 GENERAL

1.1 SCOPE

This Specification sets out the requirements for bridgeworks for:

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

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

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

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

The scope of B80 is the supply, delivery, placement, 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 B0/M.

1.2 STRUCTURE OF THE SPECIFICATION

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

1.2.1 Details of Work

Project specific requirements are shown in Annexure B80/A.

1.2.2 Resolution of Nonconformities

The method of acceptance of materials and work must conform to 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 RMS Q for the definitions of HOLD POINTS and WITNESS POINTS.

The records listed in Annexure B80/C are Identified Records for the purposes of RMS Q Clause E2.

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.
If the Contract does not require you to implement a PROJECT QUALITY PLAN, the documents listed in Annexure B80/D must be submitted to the Principal for consideration at least 5 working days prior to work commencing and must be implemented.

The most important change in B80 Ed3 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 RMS Q.

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 Ed3/Rev0 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 Testing Procedures

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

The Principal may conditionally agree to your proposal to reduce the specified 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 selectively or permanently, at any time.

### 1.2.6 Referenced Documents and Abbreviations

Unless otherwise specified or is specifically supplied by the Principal, the applicable issue of a referenced document 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.

Codes, 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 RMS 3211. It comprises General Purpose cements, Blended cements and supplementary cementitious materials (SCMs).

**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.

**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 the requirements of this Specification, with a compressive strength at 28 days not less than 40 MPa at bearings and expansion joints and 32 MPa elsewhere.

**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 RMS T375.

**Exposure Classification**
Refer to Clause 4.3 of AS 5100.5:2004.

**Curing**
The control of temperature and moisture in the concrete until the concrete has developed the required properties.

**Self-Compacting Concrete**
Concrete that is able to flow and consolidate under its own weight, completely fill the formwork even in the presence of dense reinforcement, whilst maintaining homogeneity and without the need for additional compaction. Also called self-consolidating concrete or super-workable concrete.

**Standard Moist-Curing Conditions**
Standard Moist-Curing Conditions in accordance with AS 1012.8.1.

**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%.

**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.

**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.

**Cover**
The distance between the outside of the reinforcement and the nearest
permanent surface of the member excluding any surface finishing material.

**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.

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.

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 MATERIALS FOR CONCRETE, CEMENT MORTAR AND GROUT

#### 2.1 GENERAL

Materials for concrete, cement mortar and grout must conform to Section 2 of AS 1379 and Clause 2.

#### 2.2 CEMENT

Cement used in the Works must be Shrinkage Limited Type SL or General Purpose Blended cement Type GB conforming to this Specification and RMS 3211.

Supplementary cementitious materials (SCMs) and proportions must conform to Specification RMS 3211.

Blending of cement must be at either the cement manufacturer's facilities and/or at the concrete batching plant, unless otherwise specified.

Use only cement and SCMs that have been pre-registered under the Australian Technical Infrastructure Committee (ATIC) Scheme. Confirmation of pre-registration can be obtained from the RMS Materials Scientist at RMS’s Geotechnical & Scientific Laboratory at Auburn (telephone 02 8745 6038; facsimile 02 8745 6094).

*B80 requirements for cement are contained in RMS 3211 Cements, Binders and Fillers, which contains general requirements applicable to all cements supplied for concrete for RMS 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 25-40% 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 20-40% 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**

RMS 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 Ed3, the additional requirements were prescriptive such as
minimum glass content in slag and minimum SiO₂ in fly ash. Later research showed that those
prescriptive requirements did not necessarily relate to the overall quality of the SCM. From B80
Ed3/Rev3 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
RMS 3211 of limitations on loss on ignition (LOI) and fineness to control flyash quality and on
fineness for slag.

**TERNARY BLENDS**

In B80 Ed2 and Ed3/Rev0 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 Ed3/Rev0 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 1993, in Ed3/Rev6 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 RMS 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 mixing the admixtures.

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

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.

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

#### 2.3.2 Corrosion Inhibitors

Corrosion inhibitors must contain a minimum of 30% of calcium nitrite solids. Where retarders additional to those already present in the corrosion inhibitor admixture are used to further modify the acceleration characteristics of the admixture, they must be added to the concrete before or together with the admixture.

Where corrosion inhibitors are specified, the admixture application rate must be such that the concrete contains a minimum of 9 kg of calcium nitrite solids per cubic metre.

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. RMS 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 and 2.5 of this Specification.

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.

The Principal may approve the use of a particle size distribution outside the specified limits if evidence is provided that concrete made with this particle size distribution meets all other requirements of this Specification both in the fresh and hardened state. Supply additional evidence of acceptable performance for segregation, bleeding, plastic shrinkage and finishing properties.

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.

For wearing surfaces of all exposure classifications, the durability of the aggregate must conform to the requirements for exposure classification C.

Abrasion resistance is assured by specifying that aggregates meet the requirements for severe exposure in AS 2758.1.

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, 14 or 10 mm;

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

(c) Coarse aggregate must conform to the dimensional requirements of AS 2758.1 except that Tables B80.1 and B80.2 must be applied in lieu of Tables 1 and 2 of AS 2758.1, respectively.

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 dimensional requirements 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.

(d) 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.

(e) 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 RMS bridgeworks applications.

Durability of slag aggregate need only conform to exposure classification B1 requirements, except for wearing surfaces, which must conform to exposure classification C requirements.

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) Graded fine aggregate must conform to the dimensional requirements of AS 2758.1, but Table B80.3 applies instead of Table 3 of AS 2758.1.

Where more than one type of fine aggregate is proposed for use in the mix, the resulting blend must conform to dimensional requirements of the above paragraph;

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

(b) Limit water absorption to a maximum of 2.5%.

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

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

Clause 8.2.2 of AS 2758.1 does not apply to manufactured sand. The water absorption of the combined fine aggregate must not exceed 2.5%.

For manufactured sands, when tested for Methylene Blue Value (MBV) in accordance with ISSA 145, the multiple of the MBV and the passing 75 µm sieve value of any sample must not exceed 100.

For manufactured sands, the sodium sulfate loss when tested in accordance with AS 1141.24 must not exceed a weighted average loss of 6% for all exposure classifications.

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. 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.

<table>
<thead>
<tr>
<th>Sieve aperture</th>
<th>Mass of sample passing (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nominal size of aggregate (mm)</td>
</tr>
<tr>
<td>26.5 mm</td>
<td>100</td>
</tr>
<tr>
<td>19.0 mm</td>
<td>85 – 100</td>
</tr>
</tbody>
</table>
Table B80.2 - Coarse Aggregate - Limits of Deviation

<table>
<thead>
<tr>
<th>Sieve aperture</th>
<th>Limits of deviation (%)</th>
<th>Nominal size of aggregate (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>26.5 mm</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>19.0 mm</td>
<td>±5</td>
<td>–</td>
</tr>
<tr>
<td>13.2 mm</td>
<td>±10</td>
<td>±10</td>
</tr>
<tr>
<td>9.5 mm</td>
<td>±10</td>
<td>±10</td>
</tr>
<tr>
<td>6.7 mm</td>
<td>±10</td>
<td>±10</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>±5</td>
<td>±5</td>
</tr>
<tr>
<td>2.36 mm</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

The maximum deviation in the above tables refers to the deviation from the grading of the aggregate used in the nominated mix, obtained from the concrete mix submission and associated trial mix aggregate test reports.

Table B80.3 - Fine Aggregate - Particle Size Distribution Requirements and Limits of Deviation

<table>
<thead>
<tr>
<th>Sieve aperture</th>
<th>Mass of sample passing (%)</th>
<th>Maximum deviation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.5 mm</td>
<td>100</td>
<td>–</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>90 – 100</td>
<td>±3</td>
</tr>
<tr>
<td>2.36 mm</td>
<td>65 – 95</td>
<td>±10</td>
</tr>
<tr>
<td>1.18 mm</td>
<td>40 – 85</td>
<td>±10</td>
</tr>
<tr>
<td>600 μm</td>
<td>24 – 60</td>
<td>±10</td>
</tr>
<tr>
<td>300 μm</td>
<td>8 – 25</td>
<td>±5</td>
</tr>
<tr>
<td>150 μm</td>
<td>1 – 8</td>
<td>±2</td>
</tr>
</tbody>
</table>

2.5 ALKALI-AGGREGATE REACTION (AAR)

2.5.1 Testing

A representative sample of aggregate from each source to be used in the concrete incorporated into the Works must be:
(a) petrographically examined in accordance with Clause 2.5.2; and
(b) assessed and classified for AAR using the accelerated mortar bar test method RMS T363.

For blended aggregates, aggregates from different sources must be tested alone.

2.5.2 Petrographic Examination

Petrographic examination must be in accordance with ASTM C295.

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

(a) Opaline material;
(b) Unstable silica minerals such as moderate amounts of tridymite and cristobalite; or
(c) Sheared rock containing moderate amounts of strained quartz and microcrystalline quartz.

Petrographic examination must not be used alone to determine that an aggregate is non-reactive. Testing of the aggregate to Test Method RMS T363 is also required.

2.5.3 Actions Required for Control of AAR

For aggregates classified as non-reactive by Test Method RMS T363, no action for control of potential AAR is required.

Where any of the aggregates in a mix are classified as slowly reactive or reactive by Test Method RMS T363, actions required for control of potential AAR in the concrete must be in accordance with Table B80.4.

Blended cements used for control of potential AAR must be in accordance with Annexure 3211/A of Specification RMS 3211.

Aggregates classified as reactive by Test Method RMS T364 in a particular concrete mix design must not be used. Use alternative aggregates and/or alternative concrete mix designs that conform to this Specification.

<table>
<thead>
<tr>
<th>Mortar bar expansion (%) in 1M NaOH (80°C)</th>
<th>Actions Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 days</td>
<td>21 days</td>
</tr>
<tr>
<td>&lt; 0.10 *</td>
<td>≥ 0.10 *</td>
</tr>
<tr>
<td>Use blended cement</td>
<td></td>
</tr>
<tr>
<td>≥ 0.10 *</td>
<td>&gt;&gt; 0.10 *</td>
</tr>
<tr>
<td>Use an alternative aggregate; or</td>
<td></td>
</tr>
<tr>
<td>Use blended cement and assess aggregate reactivity</td>
<td></td>
</tr>
<tr>
<td>in the concrete mix using RMS T364</td>
<td></td>
</tr>
</tbody>
</table>

* Note: 0.15% for naturally occurring fine aggregates

*Alkali aggregate reactivity (AAR) is the propensity of a specific aggregate to react with the alkalies, e.g. Na₂O and K₂O, in the cement to form expansive products that adversely affect the concrete’s engineering properties and causes 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;
- a high enough alkalinity in the pore water solution;
- 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.

The main weapon employed against AAR in B80 is to reduce the alkalis available for the reaction through the use of blended cements.

In Ed3, the provisions to control AAR were simplified from Ed2. Depending on the activity range within which the aggregates fall when tested in accordance with the accelerated mortar bar test method RMS T363, which is used as a screening tool to detect and classify reactive aggregates, the appropriate cement type and mix design should be selected to comply with the specification. The Principal’s Representative has to check that the mix design is appropriate for the given T363 test results.

Because the AAR provisions in regards to the subjective petrographic examination in Ed3/Rev0 were misused on a number of projects, the accelerated mortar bar test T363 was made mandatory in later revisions.

As a result of further research, investigations and discussions with industry groups, and in line with HB79-1996 jointly published by Australian Standards and the Cement and Concrete Association, the AAR provisions in B80 were further amended in Ed3/Rev3 and have remain essentially unchanged since then.

The reactivity of aggregates is evaluated by two test RMS methods.

The first test method, T363, is mandatory. It is an accelerated mortar bar test where 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 prism age. The initial version of the test method was modified because differing interpretations of flow by different test laboratories gave large variations in test results for the same aggregates between the laboratories. Edition 2 of T363 was issued in late 2011, and is virtually identical to the VicRoads test method RC 376.03, the main difference being that blended cements can be used for the RC 376.03 test, whereas T363 permits the use of GP cements only. Expansion readings of mortar with bars made with blended cements cannot be used to assess the reactivity of an aggregate nor the effectiveness of a blended cement in controlling the reactions, because expansion limits for blended cements have not been validated in the laboratory or against field performance. T363 is strictly used to detect and classify alkali-reactive aggregates, with subsequent measures to be as prescribed in the B80 clauses above.

An aggregate’s classification using the T363 result results in subsequent actions as follows:

- Non-reactive – No action required;
- Mild/slow AAR – Use blended cements in the mix;
- Substantial AAR – Use blended cement and re-test using T364 or use an alternative aggregate.

Aggregates with a Substantial AAR classification to T363 may still be evaluated by T364 and used only if they pass the requirements of the latter method.

The second test method, T364, involves the testing of concrete prisms made using the concrete mix containing blended cement and 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.

The use of an aggregate which fails the T364 test is subject to changes to the mix design and re-testing using the same test method, or the rejection of the aggregate for use in RMS concrete for bridgeworks.

2.6 SOLUBLE SALTS

2.6.1 Chlorides

Determine the chloride ion content by testing ground samples of hardened concrete in accordance with AS 1012.20.

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 110°C ± 5°C for a minimum of one hour before taking the samples for analysis.

Analyse five (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 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.

The average mass of acid-soluble chloride ion per unit volume of concrete as placed must not exceed the values given in Table B80.5.

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>
<thead>
<tr>
<th>Exposure Classification</th>
<th>Unreinforced concrete</th>
<th>Reinforced concrete</th>
<th>Prestressed concrete</th>
<th>Grout</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.8</td>
<td>0.8</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>B1</td>
<td>0.8</td>
<td>0.4</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>B2</td>
<td>0.8</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>C</td>
<td>0.8</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>U</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>In accordance with Annexure B80/A1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Chloride ion content may be expressed in percentage weight of oven dried concrete. (0.1 kg/m³ ion content is approximately equivalent to 0.0042% by weight of oven dried concrete)
2.6.2 Sulphates

Determine the sulfate content of concrete by calculation, expressed as the percentage by mass of acid-soluble SO₃ to cement, by summing the sulfate content of the individual concrete constituents. The sulfate content must not exceed 3.0% for heat accelerated cured concrete or 5.0% otherwise.

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. Base the mix design on the anticipated conditions which will prevail on site so that under these conditions and after supply, placement, 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:


A mix is designed by selecting the aggregates, cement and water contents, blending the coarse aggregates to obtain a reasonable grading 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/m³ 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. Excessive water leads to increased shrinkage and bleeding. Excessively dry concrete will be subject to self-desiccation and cracking.

Minimum OPC cement quantities for various strengths, assuming normally graded 20 mm max aggregate:

32 MPa – 300 kg/m³
40 MPa – 350 kg/m³
50 MPa – 390 kg/m³

The minimum cement contents are lower if maximum density grading or larger sized aggregates are used.

Water/cement ratio for strength (assuming wet/moist cured for 28 days and OPC cement)

0.32 – 60 MPa
0.36 – 50 MPa
0.40 – 40 MPa
0.45 – 32 MPa
0.50 – 25 MPa

Water/cement ratio for durability (assuming wet/moist curing for 28 days and OPC cement):

Below 0.4 – Exposure Classification C
0.4 to 0.45 – Exposure Classification B2
0.45 to 0.5 – Exposure Classification B1
0.5 to 0.56 – Exposure Classification A

Slump requirements for placement are:

- Chute, sufficient for placement: 50 to 200 mm
- Kibble, but not to be dropped too high, to avoid impact loading on forms: 50 to 120 mm
- Pump, to prevent blockages: 70 to 120 mm
- Tremie, for self compaction: 180 to 220 mm
- Injection, high slump: 200 mm
- Machine, e.g. horizontal slip form: Nil
- Hand (shovel, bucket, barrow): 80 mm to 120 mm

### 3.2 DESIGN FOR DURABILITY

The concrete mix must be designed to achieve a structure service life of at least 100 years in the specified environment without significant maintenance.

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 inhibitor 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 RMS 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.

For concrete durability, conform to Table B80.6 and the following:

(a) For exposure classifications A and B1, concrete made with blended cement must contain a minimum of 240 kg/m³ of General Purpose or Shrinkage Limited cement conforming to Specification RMS 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 limit cracking.

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 C must contain a corrosion inhibitor in accordance with Clause 2.3.2, 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 2.3.2.
(d) For precast concrete members requiring durability suitable for exposure classification C 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, $f_{c,\text{min}}$, must not exceed 32 MPa, except for exposure classification B2 where it must not exceed 40 MPa, to limit cracking.

To prevent the recurrence of extensive bridge deck cracking experienced on a number of RMS 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) Provide curing equivalent to a minimum of 3 days wet curing or better, 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) Self-compacting concrete may only be used for precast concrete members, except where permitted by the Principal and Clauses 3.6 and 7.8, 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 Ed6, this restriction has been eased to permit its use on bridge sites subject to the imposed limitations based on RMS’ 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.

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 3.3. Demonstrate in the Concrete Durability Plan a durability performance equivalent to or better than that achieved by conforming to Table B80.6 and the preceding items of this Clause.

The Concrete Durability Plan must:

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

(ii) Propose the measures to be taken during the Works to achieve the specified structure service life; and

(iii) Propose suitable concrete mixes for each structure and/or individual members on 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 RMS 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.
Table B80.6 - Durability Requirements for Concrete

<table>
<thead>
<tr>
<th>Exposure classification</th>
<th>Minimum cement content (kg/m³)</th>
<th>Maximum cement content (kg/m³)</th>
<th>Maximum water/cement ratio (by mass)</th>
<th>Minimum water/cement ratio (by mass)</th>
<th>Maximum chloride test coefficients at 20°C ( \times 10^{-12} \text{ m}^2/\text{sec} )</th>
<th>Minimum strength for durability ( f_{c,min}(d) ) (MPa)</th>
<th>Actions required</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cast-in-place Concrete</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>320</td>
<td>400</td>
<td>0.56</td>
<td>0.4</td>
<td>N/A</td>
<td>N/A</td>
<td>25</td>
</tr>
<tr>
<td>B1</td>
<td>320</td>
<td>450</td>
<td>0.50</td>
<td>0.4</td>
<td>N/A</td>
<td>N/A</td>
<td>32</td>
</tr>
<tr>
<td>B2</td>
<td>370</td>
<td>500</td>
<td>0.46</td>
<td>0.32</td>
<td>3.5</td>
<td>8.0</td>
<td>40</td>
</tr>
<tr>
<td>C</td>
<td>420</td>
<td>550</td>
<td>0.40</td>
<td>0.32</td>
<td>2.0</td>
<td>4.0</td>
<td>50</td>
</tr>
<tr>
<td>U</td>
<td></td>
<td></td>
<td>In accordance with Annexure B80/A1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Precast Concrete</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A, B1</td>
<td>320</td>
<td>600</td>
<td>0.5</td>
<td>0.28</td>
<td>N/A</td>
<td>N/A</td>
<td>40</td>
</tr>
<tr>
<td>B2</td>
<td>370</td>
<td>600</td>
<td>0.46</td>
<td>0.28</td>
<td>3.5</td>
<td>8.0</td>
<td>60</td>
</tr>
<tr>
<td>C</td>
<td>420</td>
<td>600</td>
<td>0.40</td>
<td>0.28</td>
<td>2.0</td>
<td>4.0</td>
<td>60</td>
</tr>
</tbody>
</table>

Notes:
1. N/A denotes not applicable for this exposure classification. FA denotes flyash and BFS denotes ground granulated iron blast furnace slag conforming to Specification RMS 3211.
2. \( D_e \) denotes effective diffusion coefficient from Nordtest NT Build 443.
3. \( D_{RMC} \) denotes rapid migration coefficient from Nordtest NT Build 492.
4. Continuously standard moist-cure after demoulding specimens for the Nordtest NT Build 443 and NT Build 492 tests and test at an age of 56 and 28 days respectively.
5. The specified coefficients are based on the minimum concrete covers specified in AS 5100.5:2004 Table 4.10.3 (A). If the specified corrosion inhibitor is included, the minimum cover may be reduced by 10 mm.
6. The Principal may modify the specified coefficients if the concrete cover is increased.
7. The specified coefficients are for a test temperature of 20°C. Modify the required coefficients for a given temperature as follows:
\[
(D_e)_{\text{req}} = 4.15 \times 10^{-5} e^{-0.0703 T}, \text{ where } T \text{ is the specified temperature.}
\]
Table 80.6 tabulates the durability requirements for concrete for RMS 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 Ed2 carried out when drafting B80 Ed3, 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 Ed6 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 Ed2 carried out when drafting B80 Ed3, 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 Ed5, 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-dessication.

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, in that 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 Ed2 carried out when drafting B80 Ed3, 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 C for aggressive environments to ensure adequate durability performance.
3.3 **PREVENTION OF ADVERSE EFFECTS**

Design the concrete mix for prevention of adverse effects arising from excessive drying shrinkage, alkali-aggregate reactions, soluble salts, inadequate compaction and cracking, and from exposure to acid sulfate soils, chloride ingress and carbonation.

### 3.3.1 Drying Shrinkage

Maximum drying shrinkage must be in accordance with Clause 3.7.

### 3.3.2 Alkali-Aggregate Reactions (AAR)

Control alkali-aggregate reactions in accordance with Clause 2.5.

### 3.3.3 Soluble Salts

Maximum soluble salts must be in accordance with Clause 2.6.

### 3.3.4 Compaction

Concrete compaction must be in accordance with Clauses 7.4.3 and 8.3.

### 3.3.5 Cracking

Maximum crack widths must be in accordance with Clause 7.2.

#### 3.3.5.1 Plastic Shrinkage Cracking

Control plastic shrinkage cracking in accordance with Clause 7.6.

#### 3.3.5.2 Thermal Cracking

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. Thermal cracking is usually aggravated with large volume concrete members.

Model the effects in larger members of temperature increases as a result of cement hydration during production and curing of the concrete member and use measures to prevent thermal cracking.

Limit the temperature of all concrete members following concrete placement to a maximum of 70°C.

*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.*

### 3.3.6 Acid Sulfate Soils (ASS)

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.
3.3.7 Chloride Ingress

For the exposure classifications specified on the Drawings, design the concrete mix against chloride ingress in accordance with Table B80.6. The values of diffusion or migration coefficients for the concrete mix must be verified on a trial mix with samples taken for testing for chloride resistance.

Carry out chloride resistance 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 Principal will specify which test method to use, depending on the time available to obtain the test results.

3.3.8 Carbonation of Concrete

Refer to Item (a) of Clause 3.2.

New Clause 3.3 has been added to B80 Ed6 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.

3.4 CURING

The curing of the concrete must conform to either Provision A – (Performance) or Provision B – (Method), as specified in Clauses 3.4.1 and 3.4.2.

3.4.1 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 B80.7.

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

The maximum sorptivity penetration depth must be verified 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.

Table B80.7 - Curing Requirements for Concrete (Provision A)

<table>
<thead>
<tr>
<th>Exposure classification</th>
<th>Maximum sorptivity penetration depth (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>General Purpose cement</td>
</tr>
<tr>
<td>A</td>
<td>35</td>
</tr>
<tr>
<td>B1</td>
<td>25</td>
</tr>
</tbody>
</table>
3.4.2 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 7.12.

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 RMS 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 RMS 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 Ed2, 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 Ed3.

The RTA T362 test method was originally specified in B80 Ed3 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 Ed6 Table B80.7 sorptivity limits were first set in Ed3 using experiences in bridgeworks contracts in the early 1990’s with Ed2 and expert opinion and consensus, with minor changes to the limits in subsequent revisions following industry experience with Ed3.

The specified RMS 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.

3.5 **TARGET STRENGTH FOR MIX DESIGN**

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

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

and

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

where:

(a) $f_{c\text{.min}}$ is the greater of $f_{c\text{.min(s)}}$ and $f_{c\text{.min(d)}}$;

The applicable minimum concrete strength $f_{c\text{.min}}$ 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.

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

(c) $f_{c\text{.min(d)}}$ is the minimum 28 day compressive strength required for durability obtained from Table B80.6;

(d) $M_{\text{control}}$ is the margin nominated for variations in strength as defined in Clause 4.1; and

(e) $f_{c\text{.max}}$ is the maximum 28 day compressive strength test result 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.

Unless otherwise specified on the Drawings or approved by the Principal:

(i) the target strength $f_{c\text{.md}}$ for cast-in-place deck concrete must not exceed 42 MPa except for exposure classification B2 where it must not exceed 50 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.

(ii) the target strength $f_{c\text{.md}}$ for all other concrete must not exceed 75 MPa; and

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.

(iii) $M_{\text{control}}$ must not exceed 10 MPa.

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

3.6 **LIMITATIONS ON SLUMP**

Unless otherwise specified 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 5.3.2, that the concrete may be placed, compacted and finished without deleterious effects.
Unless otherwise approved by the Principal, the above limitations on slump may be waived only for the bridge members specified in Annexure B80/A2 for which self-compacting concrete may be used in accordance with Annexure B80/G.

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.

### 3.7 LIMITATIONS ON SHRINKAGE

Prepare concrete specimens from the nominated mix in accordance with AS 1012.13 for the purpose of shrinkage testing. Measure the shrinkage of the specimens in accordance with AS 1012.13.

Shrinkage of the concrete specimen after either of the 3 or 8 weeks’ drying periods must conform to Table B80.8.

#### Table B80.8 - Maximum Shrinkage Strain of Concrete Specimens

<table>
<thead>
<tr>
<th>Exposure classification</th>
<th>Maximum shrinkage strain (microstrain)</th>
<th>Drying period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3 Weeks</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td>570</td>
</tr>
<tr>
<td>B1, B2</td>
<td></td>
<td>500 (600#) (650§)</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>430 (530§) (550§) (650*)</td>
</tr>
<tr>
<td>U</td>
<td></td>
<td>In accordance with Annexure B80/A1</td>
</tr>
</tbody>
</table>

Note: # For self-compacting concrete.
§ For concretes with slag-blended cement.
* For precast members where the specified corrosion inhibitor has been included in the mix.

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/m3) is likely to result in excessive shrinkage, bleed and settlement cracking. Insufficient water (below 160 kg/m3) 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.

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

### 3.8 NOMINATING MIXES

#### 3.8.1 Submission of Nominated Mixes

Submit to the Principal the details of each concrete mix and the 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 mix which conforms to this Specification, is currently approved and is listed on the Register of RMS Approved Concrete Mixes [http://www.rms.nsw.gov.au/doingbusinesswithus/downloads/apprv_conc_mix.pdf](http://www.rms.nsw.gov.au/doingbusinesswithus/downloads/apprv_conc_mix.pdf).

Approval of RMS concrete mixes is covered by Infrastructure Contracts Note ICN-125, which states that approval to the use of a concrete mix for RMS 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 RMS’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.

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:
(a) (i) all details in Clause 3.8.2; or
(ii) nomination of a mix from the Register of RMS Approved Concrete Mixes; and
(b) a statement stating that the mix conforms to this Specification and is suitable for its intended use,

at least 5 working days before the concrete mix is proposed to be used.

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.

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.

Report the test results for the hardened concrete prepared from the trial mixes.

From the trial mix results, nominate the water/cement ratio and slump for production. Include the nominated values on the delivery dockets. AS 1379 Clause 4.2 provides for tolerances on production batch ingredients.

A trial mix conforming to AS 1012.2 produced under strictly controlled laboratory conditions is required for each mix prior to use on RMS 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 RMS 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.
3.8.2 New Concrete Mix Design

The submission for a mix not currently approved must include the following details:

(a) Material Constituents

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

(i) Source; and

(ii) Current test results not more than 12 months old for the characteristics and properties specified in Clause 2.

(b) Mix Design

(i) Constituent quantities;

(ii) Method of controlling alkali-aggregate reactions as specified in Clause 2.5.

(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) $f_{c,md}$, $f_{c,min}$, $f_{c,min(s)}$, $f_{c,max}$ and $f_{c,min(d)}$ determined in accordance with Clause 3.5;

(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; and

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

(c) Batching, Mixing and Transport

(i) Methods;

(ii) Level of control and accuracy of batching;

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

(iv) $M_{control}$ and method of determination of $M_{control}$; and

(v) Minimum mixing time.

(d) Curing regime

(i) Method and duration of curing;

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

(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.
### Other Test Results for Hardened Concrete Characteristics

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(i)</td>
<td>28 day compressive strength in accordance with AS 1012.9 (cylinders must be moulded in accordance with AS 1012.8.1 using rodding only);</td>
</tr>
<tr>
<td>(ii)</td>
<td>Shrinkage in accordance with AS 1012.13;</td>
</tr>
<tr>
<td>(iii)</td>
<td>Sulfate and chloride ion contents in accordance with Clause 2.6;</td>
</tr>
<tr>
<td>(iv)</td>
<td>Chloride resistance in accordance with Clause 3.3.7; and</td>
</tr>
<tr>
<td>(v)</td>
<td>Trial mix report in accordance with AS 1012.2.</td>
</tr>
</tbody>
</table>

### 3.9 Variations to Nomination Mixes

The quantities of the constituents in a nominated mix may be varied to improve the quality of the concrete. Variations to the quantities of constituents in the nominated mix must not exceed the following:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>Cement: 3% by mass of each constituent.</td>
</tr>
<tr>
<td>(b)</td>
<td>Aggregates: 5% by mass of each constituent.</td>
</tr>
<tr>
<td>(c)</td>
<td>Water: 3% by volume and/or mass.</td>
</tr>
<tr>
<td>(d)</td>
<td>Admixture: 20% by volume and/or mass of each admixture and within the manufacturer’s recommendations.</td>
</tr>
</tbody>
</table>

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) | not have a water/cement ratio exceeding that nominated for the concrete mix (refer to Clause 3.8); |
| (ii) | conform to Clause 3.2 for minimum cement content and maximum water/cement ratio; and |
| (iii) | conform to Specification RMS 3211 for the range of SCMs in blended cement. |

If you wish to vary the quantities of the constituents 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 3.8, unless otherwise approved 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 and Delivery of Concrete

#### 4.1 General

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

Produce and deliver concrete to the site of the Works or to the precasting yard 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 RMS. Consequently, specification of conformance to AS 1379 for concrete supply should result in the delivery of conforming concrete to RMS 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 Ed6.

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 Clause 1.5.4 of 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.

Nominate a margin for strength which is consistent with the nominated method of production assessment under which the plant operates. This margin for strength, M_{\text{control}}, is the measure of the level of control for the nominated plant producing the nominated mix.

The level of control achieved by the plant is reflected in the size of M_{\text{control}}, which is typically the standard deviation of the 28 day concrete compressive strengths from a series of production batches multiplied by 1.65.

Ensure that water, contaminants, debris, excess concrete and other materials from concrete supply operations are disposed of in accordance with Specification RMS G35 or 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 equivalent 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, subject to the time limits specified for incorporation of the concrete into the work 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.*

#### 4.3.4 Delivery

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 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.  

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

- (a) Delivery docket number;
- (b) Truck number;
- (c) Batch number;
- (d) Date and time batched;
- (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; and
(r) Concrete supplier and plant details.

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

### 4.3.5 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 addition of the cement to the aggregates.

*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 a hydration control admixture is added 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 Clause 2.6;
(c) Carry out trials with the mix containing the admixture prior to and 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 including shrinkage tests in accordance with Clause 3.7 and additional compression strength cylinders in accordance with Clause 8.2 taken after the addition of the second part 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 S LUMP AND WATER/CEMENT RATIO TOLERANCES

Check and record the slump of the concrete within 45 minutes of adding cement to the aggregate or at discharge. Also check and record the slump immediately prior to discharge when the actual haul time exceeds 45 minutes and/or when water is added to a mixed batch in accordance with Clause 4.5.

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 or water/cement ratio 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.

For batches produced with a high level of process control, the Principal may accept proposals, in accordance with Specification RMS Q, for a reduced frequency of slump checking compared to Annexure B80/L.

When variations in slump from load to load are minimal, frequency of slumping may be reduced, as long as supply remains in control as assessed from slump test records.

The water/cement ratio of each batch must conform to Item (b) of Clause 4.2.1.2 of AS 1379.

See guide notes on Clauses 3.8.1 and 4.2.

4.5 A DDITION OF WATER TO A MIXED BATCH

Provided 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, operate the mixing mechanism at 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/m³, and the nominated water/cement ratio plus 10% tolerance and maximum water/cement ratio in Table B80.6 are not exceeded;
(d) The quantity of water added is measured and recorded;
(e) The slump of the concrete is checked after the water has been added, in accordance with Clause 4.4.

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 any time 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.

4.6 TEMPERATURE AT POINT OF DELIVERY

Do not use 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.

4.7 PRESENCE OF CORROSION INHIBITOR IN FRESH CONCRETE

Where the corrosion inhibitor is specified in the nominated mix, determine the presence and quantity of the calcium nitrite within the fresh concrete in accordance with Test Method RMS 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 and this Specification.

With the exception of Clauses 5.1, 5.3, 5.8, 5.9 and 5.10, Clause 5 does not apply to formwork for precast concrete members cast in off-site precasting yards.

Design formwork to account for all load cases in accordance with AS 3610. 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 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.

5.2  FORMWORK DESIGN, DOCUMENTATION AND CERTIFICATION

5.2.1  Quality Management System Requirements

Attention is drawn to Specification RMS Q for the design control of temporary structures. These requirements apply to the design of formwork.

5.2.2  Project Documentation

Project documentation must conform to Section 2 of AS 3610.

5.2.3  Formwork Design and Documentation

Note 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 are carried out without reference to any other documentation.

Design any steel girders used for support and all associated bolted or welded splices in accordance with AS 5100. All welded splices must be full penetration butt welds conforming to Specification RMS B204. All bolts and other fasteners must conform to Specification RMS B240.

5.2.4  Submission of Formwork Documentation and Certification

For the purposes of this clause, the formwork for the various members of the bridge structure is divided into three Risk Categories as detailed in Table B80.9.
Table B80.9 - Risk Categories for Formwork

<table>
<thead>
<tr>
<th>Category</th>
<th>Bridge Members</th>
</tr>
</thead>
</table>
| **A Low Risk** | (a) Abutments, pilecaps, footings, piers, columns and walls, with heights less than 3 metres  
(b) Members not included in either Category B or Category C                  |
| **B Moderate Risk** | (a) Abutments, pilecaps, footings, piers, columns and walls, with heights greater than 3 metres and less than 6 metres  
(b) Headstocks more than 3 metres off the ground  
(c) Decks and off-ground slabs with maximum thickness less than 600 mm |
| **C High Risk** | (a) Abutments, pilecaps, footings, piers, columns and walls, with heights greater than 6 metres  
(b) Parapets  
(c) Decks and off-ground slabs with maximum thickness greater than 600 mm  
(d) Concrete box girders  
(e) Any member for which self-compacting concrete is proposed  
(f) Job specific bridge members listed in Annexure B80/A3 |

The submission of formwork documentation and certification for each Category must be in accordance with Table B80.10.

For bridges over or adjacent to railways and/or roads conveying more than 5000 vehicles/day in any lane, formwork for the members listed under Category B must conform to the submission requirements of Category C of Table B80.10.

The submission for the use of a formwork assembly more than once for members listed under Category C need only conform to the requirements of Category A of Table B80.10 after its initial use, if approved by the Principal.

Table B80.10 - Submission Requirements for Formwork

<table>
<thead>
<tr>
<th>Category</th>
<th>Formwork documentation</th>
<th>Design certification</th>
<th>Erected formwork certification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time of submission</td>
<td>by</td>
<td>Time of submission by</td>
</tr>
<tr>
<td><strong>A Low Risk</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>B Moderate Risk</strong></td>
<td>Prior to placing reinforcement</td>
<td>Engineer</td>
<td>Prior to placing reinforcement (HP)</td>
</tr>
<tr>
<td><strong>C High Risk</strong></td>
<td>Prior to erecting formwork</td>
<td>Engineer</td>
<td>Prior to erecting formwork (HP)</td>
</tr>
</tbody>
</table>

Notes: (HP): Hold Point  N/A: Not Applicable
When certification by an Engineer is required by Table B80.10, nominate an Engineer who is a member of Engineers Australia (or equivalent) and who is experienced in the design and erection of formwork of at least a similar complexity.

When design certification of formwork is required in Table B80.10, the certification must state that the design of the formwork and the formwork documentation conform to AS 3610 and this Specification. Where multiple systems are combined to create the formwork, ensure that the design certification covers 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 Category A, or the certified design for Categories B and C, as applicable.

Any changes proposed to the certified design or erected formwork must be accompanied by documentation and certification conforming to this Clause.

HOLD POINT  
(Does not apply to Category A formwork)

Process Held: For Category B formwork – Placement of reinforcement.  
For Category C formwork – Erection of formwork.

Submission Details: For Categories B and C, 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.

Risk categories of formwork were introduced for the first time in B80 Ed3.

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 SURFACE FINISH

5.3.1 Class of Finish

For the purpose of this Specification, the classes of surface finish are as defined in AS 3610.

Design and construct the formwork to produce concrete with the following Class of finish unless otherwise stated in Annexure B80/A4 or the Drawings:

(a) Structures beyond 1 km from coast:

(i) precast girders and piles - Class 2 in accordance with Clause 3.4.5 of AS 3610. The dimensional tolerances of Specifications RMS B110 and RMS B115 take precedence over this Specification;
(ii) deck soffit between precast girders - Class 2X;
(iii) all piers, abutment and retaining wall surfaces exposed to view - Class 2X;
(iv) all other external surfaces including soffits of precast planks - Class 2; and
(v) all internal and permanently hidden surfaces - Class 3.

(b) Structures within 1 km from coast:

(i) as for (a) except that Class 2X becomes Class 2.

The surface finish for Class 2X is the surface finish which conforms to Class 2 except that the blowholes requirement is relaxed to Class 3 (refer Figure B3 of AS 3610).

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 good 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.

5.3.2 Test Members

Test members are not required unless specified in Clause 3.6 or Annexure B80/A4 or the Drawings.

When test members are required they must be designed and constructed in accordance with AS 3610. The method of constructing the test members must effectively simulate the formwork, reinforcement layout and concreting operations to be applied in the Works.

<table>
<thead>
<tr>
<th>HOLD POINT</th>
<th>(If test members are required)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Held:</td>
<td>Erection or prefabrication of formwork for members specified in Annexure B80/A4 or on the Drawings.</td>
</tr>
<tr>
<td>Submission Details:</td>
<td>Give the Principal two working days notice in writing of the proposed placement of concrete in the test member to permit observation of the process. Thereafter, give the Principal the opportunity to inspect the completed member.</td>
</tr>
<tr>
<td>Release of Hold Point:</td>
<td>The Principal will consider the method of construction and the finished test member, prior to authorising the release of the Hold Point.</td>
</tr>
</tbody>
</table>

5.4 SITE-RELATED REQUIREMENTS

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.

5.5 CONSTRUCTION JOINTS

Construct the Works with construction joints at the locations shown on the Drawings. If additional construction joints or the relocation of those shown on the Drawings is required, submit details of the
proposals with the formwork documentation. Make any additional construction joints 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.

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

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

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

5.6 MATERIALS FOR FORMWORK SURFACES

The formwork for exposed concrete surfaces must be steel plate conforming to AS/NZS 1594 or plywood conforming to AS/NZS 2271. Make plywood 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. Place plywood panels with the grain of the outer plies perpendicular to the studding or joists.

Place all form panels in a neat, symmetrical pattern.

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

Where left in place, do not use expanded metal mesh as formwork, including for the forming of construction joints.

Sealed penetrations through the formwork may be permitted for dowel bars, tie rods and the like.

Forms for surfaces which will be completely enclosed or permanently hidden below the ground may be constructed from dressed or rough sawn timber, steel, or plywood.

Where indicated on the Drawings, narrow spaces between concrete faces may be formed by the use of suitable rigid foamed plastic material (polystyrene or similar). Unless otherwise noted on the Drawings, this material may be left in the finished concrete. 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.

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 care to prevent the foamed plastic being damaged by fire, petroleum products, or any other solvents, before the concrete has hardened.
5.7 ERECTION OF FORMWORK

5.7.1 General

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

Treat the interior surface of the formwork and any removable items so that adhesion of the concrete does not occur. Commercial quality form release agents, oil or grease are acceptable, 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.

Reinforcement, tendons, and embedments must not be soiled by the treatment used. 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 compatible with any applied curing compound so that its adhesion to the concrete is not affected.

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

Make joints in formwork mortar-tight to prevent slurry loss and subsequent honeycombing.

5.7.2 Surveying Control

Control all survey activities in accordance with Specification RMS G71.

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

Carry out all necessary investigations and calculations to ensure that the estimated deflections 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:

As planned
(a) the designed characteristic (level, dimension etc) at that point on the structure as shown on the Drawings;
(b) the calculated or estimated deflection/settlement of the formwork prior to and during concreting;
(c) the target characteristic for the formwork (allowing for deflection/settlement); and
(d) the specified tolerance on final location of the structure at that point.

As measured
(e) the characteristic as set out;
(f) the characteristic as verified;
(g) the difference between the verified value and the target value; and
the magnitude of any out of tolerance measurement (i.e. the amount by which the measured difference exceeds the specified tolerances).

5.8 TOLERANCES

Design, document and erect the formwork so that, after it is removed, the formed and unformed surfaces have the dimensions shown on the Drawings within the tolerances given in Table B80.11 and conform to the surface finish requirements of Clause 5.3.

Achieve the tolerances in Table B80.11 at the completion of the Works for cast-in-place and precast concrete members.

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

Table B80.11 - Dimensional Tolerances for Formed and Unformed Surfaces

<table>
<thead>
<tr>
<th>Item</th>
<th>Tolerance (mm) unless shown otherwise</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i)  Footings:</td>
<td></td>
</tr>
<tr>
<td>Plan dimensions for formed footings and pilecaps</td>
<td>-10 to +50</td>
</tr>
<tr>
<td>Plan dimensions for unformed footings</td>
<td>0 to +150</td>
</tr>
<tr>
<td>Thickness &lt; 300 mm</td>
<td>-5 to +25</td>
</tr>
<tr>
<td>Thickness ≥ 300 mm</td>
<td>-10 to +50</td>
</tr>
<tr>
<td>Top of footing or pilecap reduced level</td>
<td>-25 to +25</td>
</tr>
<tr>
<td>Departure from the plan position in any direction</td>
<td>50</td>
</tr>
<tr>
<td>(ii) Variation in cross section of columns, piers, headstocks, slabs, walls, beams and similar parts (excluding deck slabs and barrier end posts):</td>
<td></td>
</tr>
<tr>
<td>&lt; 3 m</td>
<td>-5 to +15</td>
</tr>
<tr>
<td>≥ 3 m</td>
<td>-10 to +25</td>
</tr>
<tr>
<td>(iii) Variation of cross section of barrier end posts</td>
<td>-5 to +5</td>
</tr>
<tr>
<td>(iv) Decks:</td>
<td></td>
</tr>
<tr>
<td>Variation in thickness of deck slabs (after allowing for corrections for camber or hog and variations in design loads, forces and load effects).</td>
<td>-5 to +15</td>
</tr>
<tr>
<td>Deviation of top of deck slab reduced level/s from design after allowing for corrections for camber or hog and variations in design loads, forces and load effects.</td>
<td>-10 to +5</td>
</tr>
<tr>
<td>Flatness of top surface of bridge deck in any direction (after allowing for superelevation and vertical curvature or grade)</td>
<td>3 mm in 3 m &lt;sup&gt;1/1000&lt;/sup&gt;</td>
</tr>
<tr>
<td>(v) Deck joints:</td>
<td></td>
</tr>
<tr>
<td>Width of slot</td>
<td>-3 to +3</td>
</tr>
<tr>
<td>(vi) Variation from vertical of specified batter of columns, piers, walls, kerbs and barriers:</td>
<td></td>
</tr>
<tr>
<td>Unexposed concrete</td>
<td>12 mm in 3 m &lt;sup&gt;1/250&lt;/sup&gt;</td>
</tr>
<tr>
<td>Exposed concrete</td>
<td>6 mm in 3 m &lt;sup&gt;1/500&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
Guide to B80 Concrete Work for Bridges

<table>
<thead>
<tr>
<th>Item</th>
<th>Tolerance (mm) unless shown otherwise</th>
</tr>
</thead>
<tbody>
<tr>
<td>(vii) Kerbs and barriers:</td>
<td></td>
</tr>
<tr>
<td>Variation from grades shown on the Drawings</td>
<td>3 mm in 3 m (1/1000)</td>
</tr>
<tr>
<td>Kerb and barrier height above deck slab</td>
<td>-5 to +10</td>
</tr>
<tr>
<td>Variation in plan from straight or curved horizontal alignment</td>
<td>5 mm in 3 m (1/600)</td>
</tr>
<tr>
<td>Steps in plan and elevation</td>
<td>5</td>
</tr>
<tr>
<td>Flatness of front face of kerbs and barriers</td>
<td>3 mm in 3 m (1/1000)</td>
</tr>
<tr>
<td>(viii) Reduced level of tops of headstocks and piers:</td>
<td></td>
</tr>
<tr>
<td>With pedestals</td>
<td>-10 to +10</td>
</tr>
<tr>
<td>Without pedestals</td>
<td>-5 to +5</td>
</tr>
<tr>
<td>Difference in level across width of headstocks</td>
<td>5</td>
</tr>
<tr>
<td>(ix) Bearing pads and pedestals:</td>
<td></td>
</tr>
<tr>
<td>Reduced level</td>
<td>-2.5 to +2.5</td>
</tr>
<tr>
<td>Variation from grade across the width of individual pads and pedestals must not exceed</td>
<td>1 in 200</td>
</tr>
<tr>
<td>Deviation from flat surface</td>
<td>+1.0 to -1.0</td>
</tr>
<tr>
<td>(x) Departure from plan position at any level:</td>
<td></td>
</tr>
<tr>
<td>Columns, piers, walls, headstocks, beams, slabs, kerbs and barriers and other similar members</td>
<td>25</td>
</tr>
<tr>
<td>Relative displacement of adjoining members must not exceed</td>
<td>10</td>
</tr>
<tr>
<td>Centreline of bearings</td>
<td>5</td>
</tr>
<tr>
<td>(xi) Departure from alignment:</td>
<td></td>
</tr>
<tr>
<td>Rows of columns, faces of piers or walls</td>
<td>10</td>
</tr>
<tr>
<td>Handrails, faces of hand rail posts, kerbs and barriers</td>
<td>5</td>
</tr>
<tr>
<td>(xii) Maximum allowance for irregularities in exposed concrete surfaces:</td>
<td></td>
</tr>
<tr>
<td>Sections less than 1 m in dimension when measured with a straight edge across the dimension of the section</td>
<td>2.5</td>
</tr>
<tr>
<td>Sections greater than 1 m in dimension when measured with a straight edge across the dimension of the section, except that when sections are greater than 3 m in dimension, a 3 m straight edge must be used</td>
<td>5</td>
</tr>
<tr>
<td>Deviation from design kerb and barrier dimensions</td>
<td>-2.5 to +2.5</td>
</tr>
</tbody>
</table>

5.9 REMOVAL OF FORMWORK

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 otherwise specified, 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 otherwise specified, the minimum stripping time is the longest of the times governed by curing in accordance with Clause 3.4 and the time required to achieve the concrete compressive strength in Table B80.12.

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

<table>
<thead>
<tr>
<th>Member and Surface</th>
<th>Minimum Concrete Compressive Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast-in-place members</td>
<td></td>
</tr>
<tr>
<td>Vertical surfaces</td>
<td>7 MPa</td>
</tr>
<tr>
<td>Underside of horizontal surfaces</td>
<td>80% of ( f_{c,\text{min}}(s) )</td>
</tr>
<tr>
<td>Other surfaces</td>
<td>A compressive strength as approved by the Principal</td>
</tr>
<tr>
<td>Precast Concrete Members</td>
<td></td>
</tr>
<tr>
<td>All surfaces</td>
<td>A compressive strength as approved by the Principal</td>
</tr>
</tbody>
</table>

Determine the concrete compressive strength by testing representative test cylinders cured under the same conditions as the concrete in question or by other approved means. Provide 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 Repairs to Formed Surfaces

The method and materials for repairing minor surface imperfections including porous spots, shallow honeycombing, rough areas, and blowholes not conforming to the specified Class must be approved by the Principal and must be detailed in the PROJECT QUALITY PLAN.

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

6 Supply and Fixing of Steel Reinforcement and Embedments

This Clause applies to all steel reinforcement and embedments, except where specified otherwise for stainless steel in Annexure B80/F.

6.1 Quality Management System Requirements

The reinforcement material supplier must be certified by the Australian Certification Authority for Reinforcing Steels for the supply of reinforcement material.

The reinforcement fabricator must be certified by the Australian Certification Authority for Reinforcing Steels for fabricating reinforcement and implement and maintain a quality management system in accordance with AS/NZS ISO 9001 as a means of ensuring that the product conforms to this Specification.

RMS 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.

6.2 MATERIALS

6.2.1 Reinforcement

Reinforcement must be deformed bars or welded wire fabric except that plain bars or wire may be used for fitments (a fitment is a unit of reinforcement commonly known as a tie, stirrup, ligature or helix). All reinforcement must conform to AS/NZS 4671.

6.2.2 Protective Coatings

Unless otherwise specified, reinforcement with protective coatings, including epoxy coating, must not be used.

6.3 FABRICATION, BENDING AND WELDING

6.3.1 Fabrication

Fabricate reinforcement to the shape and dimensions shown on the Drawings and within the tolerances given in Clause 6.9.

6.3.2 Bending

Bend reinforcement without impact or damage to the bar either by cold bending around pins or by 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 again reinforcement already bent and straightened, or bend in reverse again, within 20 bar diameters of the previous bend.

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

Reinforcement 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.
The nominal internal diameter of a reinforcement 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 Bend and Hooks**

<table>
<thead>
<tr>
<th>Type of Bar</th>
<th>Minimum Internal Diameter of Bend</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Normal bends</td>
<td></td>
</tr>
<tr>
<td>Fitments: bar Grade 250 and wire Grade 450</td>
<td>$3d_b$</td>
</tr>
<tr>
<td>Fitments: bar Grade 500</td>
<td>$4d_b$</td>
</tr>
<tr>
<td>Bars other than in (b) and (c) below</td>
<td>$5d_b$</td>
</tr>
<tr>
<td>(b) Bends designed to be straightened or subsequently re-bent</td>
<td></td>
</tr>
<tr>
<td>$d_b \leq 16$ mm</td>
<td>$4d_b$</td>
</tr>
<tr>
<td>$d_b = 20$, $24$ mm</td>
<td>$5d_b$</td>
</tr>
<tr>
<td>$d_b \geq 28$ mm</td>
<td>$6d_b$</td>
</tr>
<tr>
<td>(c) Bends in reinforcement epoxy coated or galvanised either before or after bending</td>
<td></td>
</tr>
<tr>
<td>$d_b \leq 16$ mm</td>
<td>$5d_b$</td>
</tr>
<tr>
<td>$d_b \geq 20$ mm</td>
<td>$8d_b$</td>
</tr>
</tbody>
</table>

Note: “$d_b$” is the nominal diameter of the bar or wire

### 6.3.3 Welding

Tying of reinforcement is preferred over welding.

All welding must conform to Specification RMS B204 and the bar manufacturer's recommendations.

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.

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.

Welding of reinforcement for prestressed members must not take place after the prestressing tendons have been placed in the reinforcement assemblies or cages being assembled.

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

Welding includes any welding used to assemble reinforcing cages (refer to Clause 6.7.3) 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 static and dynamic loadings and any stress reversals that may occur during lifting, moving and transport.

*RMS 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.*
6.4  **SPICING**

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 requiring the approval of the Principal.

6.4.2  **Lapped Splices**

Lapped bar splices not shown on the Drawings must have lengths not less than the following:

(a) Deformed and plain bars:

(i) If the bars to be lapped are not top bars and the lapped bars are in contact with each other, the splice length must be in accordance with Table B80.14.

(ii) For top bars (defined as horizontal bars with 300 mm or more of concrete cast below the bar), increase the length of lap splices by 30% of the lengths given in the preceding item (i) of this Clause.

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

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

(v) The length of the lap splice is governed by the smaller size bar at the splice.

(vi) The preceding items of this Clause also apply to lapped bars not in contact. For bars not in contact where the clear distance between the two bars, \( s_b \), is larger than 3 times the bar diameter, increase the lap length by a further 1.5 times \( s_b \).

(vii) Do not lap splice bars unless the concrete cover to the nearest fitment in beams or bar in slabs exceeds the sizes of the bars to be lapped.

(b) Reinforcing fabric:

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

### Table B80.14 - Splice Lengths

<table>
<thead>
<tr>
<th>Bar Type</th>
<th>Bar Diameter (mm)</th>
<th>Splice Length (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deformed</td>
<td>12</td>
<td>430</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>660</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>910</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>1180</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>1470</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>1770</td>
</tr>
<tr>
<td></td>
<td>36</td>
<td>2070</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>2400</td>
</tr>
</tbody>
</table>

Notes:
1. The above lapped bar splice lengths assume concrete cover of 35 ± 5 mm, and clear bar spacing ≥ 70 mm. Longer splice lengths are required for smaller concrete covers or bar spacings.
2. For concrete strengths less than 32 MPa multiply the above figures by $\sqrt{32 / f'_{c}}$.

3. The splice lengths for plain bars must be 1.5 times the splice lengths of deformed bars.

**6.4.3 Mechanical Splices**


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

**6.5 STORAGE**

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

**6.6 SURFACE CONDITION**

At the time the concrete is placed, the surface condition of the reinforcement must not impair its bond to the concrete or its performance in the member.

**6.7 PLACING AND FIXING OF REINFORCEMENT AND EMBEDMENTS**

**6.7.1 General**

The provisions of Clause 6.3 with regard to bending and welding apply to reinforcement being placed or worked on site as well as to bending and fabrication off site.

**6.7.2 Support of Reinforcement**

Support the reinforcement and hold it clear of the formwork or blinding concrete by using individual concrete spacers ("aspros"), or by suspension using mild steel fitments that do not encroach into the cover.

The smallest aspro dimension must not be less than the cover. The largest aspro dimension must not exceed 1.8 times the cover. Aspros circular in plan with sharp edges are preferred.

Manufacture concrete aspros from machine mixed concrete conforming to this Specification, with the 28 day compressive strength of the concrete in the aspros being at least the same as the concrete in the member. Make concrete aspros so that the sorptivity of the concrete conforms to this Specification. Do not use aspros made from porous concrete or mortar.

Space aspros sufficiently close together so that the specified cover is maintained during concreting and so that crushing of the aspros or penetration into the formwork does not occur.

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.

Cementitious and fibre reinforced cementitious spacers must have sharp corners and a minimum footprint flush on the formed surface and may only be used for precast and cast-in-place concrete members located in exposure classifications A, B1 or B2 where a Class 1, 2 or 2X surface finish is specified, and for enclosed internal surfaces not exposed to view.
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 where the concrete is self-compacting 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 size aggregate in the concrete mix.

Any excessive staining of the concrete surface caused by the use of continuous bar chairs must be cleaned at your cost.

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

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

6.7.3 Assembly of Reinforcement

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 6.3.3.

Tie bars at all intersections except where the spacing is less than 300 mm in any direction, in which case the alternate intersections must be tied.

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.

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

Stiffen the reinforcement to ensure that the specified surface finish tolerances of Clause 5.8 and the clear cover for the reinforcement are achieved.

Note the design location of lifting and transport support points for prefabricated reinforcement cages on shop drawings, and mark these locations indelibly on the cage during fabrication, and show the lifting requirements on a durable drawing attached to the cage, all prior to lifting. Conform to Clause 6.3.3 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 sign 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.
6.7.4 Support of Screeding Guide Rails and Height Pins

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.

6.7.5 Provision of Embedments

Plan in detail the placement of embedments such as stressing anchorages, bearings or 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 RMS B113 and B170 respectively.

6.7.6 Inspection of Placed Reinforcement and Embedments

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.

6.8 COVER

Fabricate, bend and place the reinforcement to provide the cover shown on the Drawings, within the tolerances given in Clause 6.9.

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 reinforcemnt 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.

6.9 TOLERANCES

Fabrication tolerances are as shown in Table B80.15.
Table B80.15 - Fabrication Tolerances

<table>
<thead>
<tr>
<th>Type of Reinforcement</th>
<th>Tolerances (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bars and Fabrics used for reinforcement</td>
<td></td>
</tr>
<tr>
<td>Overall dimension for lengths up to 600 mm</td>
<td>-25 +0</td>
</tr>
<tr>
<td>Overall dimension for lengths over 600 mm</td>
<td>-40 +0</td>
</tr>
<tr>
<td>Overall offset dimension of a cranked column bar</td>
<td>-0 +10</td>
</tr>
<tr>
<td>Bars and Fabrics used for fitments</td>
<td></td>
</tr>
<tr>
<td>Overall dimension for deformed bars and fabrics</td>
<td>-15 +0</td>
</tr>
<tr>
<td>Overall dimension for plain round bars and wire</td>
<td>-10 +0</td>
</tr>
</tbody>
</table>

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.

Cover tolerances are as shown in Table B80.16.

Table B80.16 - Cover Tolerances

<table>
<thead>
<tr>
<th>Reinforcement location</th>
<th>Tolerances (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formed surfaces</td>
<td>-5 +10</td>
</tr>
<tr>
<td>Unformed finished surfaces</td>
<td>-5 +10</td>
</tr>
<tr>
<td>Slabs cast on ground</td>
<td>-10 +20</td>
</tr>
<tr>
<td>Footings cast against ground</td>
<td>-20 +40</td>
</tr>
<tr>
<td>Cast-in-place piles without permanent steel casing</td>
<td>-20 +40</td>
</tr>
</tbody>
</table>

Notes for Table B80.16:
1. A positive value indicates the amount by which the cover may exceed the specified thickness and a negative value indicates the amount by which the cover may be reduced below the 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.

Achieve the tolerances for cover irrespective of all other dimensional tolerances in the fabrication and casting of concrete members.

Tolerances for location of reinforcement not controlled by cover are as shown in Table B80.17.
Table B80.17 - Placing Tolerances (Locations Not Controlled by Cover)

<table>
<thead>
<tr>
<th>Reinforcement location</th>
<th>Tolerances (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ends of reinforcement</td>
<td>50</td>
</tr>
<tr>
<td>Spacing (S) of bars in walls/slabs, and of fitments in beams and columns</td>
<td>15, or 0.1S whichever is the greater</td>
</tr>
</tbody>
</table>

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.

7 PLACING, COMPACTING, FINISHING AND CURING OF CONCRETE

7.1 GENERAL

Concrete must be placed, compacted, finished and cured so as to:

(a) prevent segregation or loss of materials;
(b) prevent premature stiffening;
(c) prevent nonconforming displacement of reinforcement, fitments 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.

Ensure that water, contaminants, debris, excess concrete and other materials from concrete placing, compaction, finishing and curing operations are disposed of in accordance with Specification RMS G35 or G36, as applicable.

At least half of the crew involved in a concreting operation, excluding the Concrete Supervisor, must hold a RMS Bridgeworks Concreting Grey Card.
HOLD POINT

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 RMS 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 RMS 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 RMS Bridgeworks Concreting Grey Card prior to 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 Ed5/Rev3 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 RMS site staff take the appropriate action for compliance.

7.2 CONCRETE CRACKING

At the completion of the curing period the concrete must have no cracks of width greater than 0.05 mm, measured at the concrete surface. Where such cracks exist, they must be identified as a nonconformity.

At 28 days after placement or later the concrete must have no cracks of width greater than 0.1 mm, measured at the concrete surface. Where such cracks exist, they must be identified as a nonconformity.

All cracks identified as nonconforming must be measured and mapped. The crack maps must form part of the documentation submitted to the Principal, together with the proposed corrective actions to rectify the nonconformities.

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.
### 7.3 Certification by Contractor

#### 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’ notice of intention to commence production of precast members for the Works.
- Prior to the proposed commencement of production of precast members, 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.

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. The Concrete Supervisor must hold a RMS 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.

#### 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 intention to place concrete in the Works, submit to the Principal a pour specific method statement detailing:
  1. delivery rate;
  2. placement method and rate; and
  3. equipment on standby.
- At least 4 working hours prior to the proposed 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 is to 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.

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.*
7.4 **CONCRETE PLACEMENT AND COMPACTION - BASIC REQUIREMENTS**

7.4.1 **General**

Where necessary, place and compact concrete in discrete layers.

Carry out continuous monitoring of the placement and compaction of the concrete at each head of pour during concreting. Provide access and lighting as necessary to permit adequate monitoring.

7.4.2 **Placement**

Do not place concrete in water except as provided for in Clause 7.8.

Carry out concreting in one continuous operation between the ends of members and/or construction 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 adequate 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.*

7.4.3 **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 all 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.

Vibrators must be of the rotary out-of-balance type and be checked prior to use to ensure they are in proper working order.

Internal vibrators must have a minimum diameter of 50 mm with an 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.

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. Do not count vibrators used for spreading concrete in the number of vibrators used for compaction.

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, ensure that full compaction of the concrete is 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.

### 7.5 Temperature and Rain

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 4.6.

Unless the Principal approves special precautions, all concrete other than for cast-in-place piles must not be placed 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.

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

(a) watering the aggregate stockpiles;
(b) the 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.
For cast-in-place concrete piles, do not place concrete if ice exists on pile casings, embeddings, steel reinforcement or in pile holes.

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 curing is deemed to be nonconforming.

Cement hydration is a chemical reaction whose 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.

7.6 **CONTROL OF MOISTURE LOSS**

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 Technical Procedures for the restriction of the evaporation rates to less than 1 kg/m²/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.*

If an evaporation retarder is used to restrict the evaporation of water, its application must be by a fine uniform spray.

*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.*

Figure B80.1 may be used 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.*

7.7 **PLACING 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.

7.8 **PLACING IN WATER**

Unless otherwise specified, do not place concrete for the permanent structure, except for footings, pilecaps and cast-in-place piles, in water.

Where concrete is placed for footings, pilecaps and cast-in-place piles, remove all free water from the area where concrete is to be placed and provide suitable cofferdams or other means to stop any inflow of water so that the concrete is placed in the dry.
Where concrete cannot be placed in the dry, place in water using tremie concrete in accordance with Specifications RMS B58 or RMS B59 or suitable self-compacting concrete conforming to Annexure B80/G.

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

*Figure B80.1 – 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/m²/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.

7.9 Preparation of Surface of Construction Joints

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. Prior to placing the adjoining concrete, clean the surface of the construction joint and the projecting reinforcement and saturate the concrete surface with water conforming to the requirements of AS 1379. Remove all excess water and loose material prior to placing the adjoining concrete.

In marine or aggressive environments, remove salt or other contamination from the joint surface and reinforcement by using water under high pressure. Provide temporary openings in formwork to allow contaminated water to be removed.

7.10 Additional Requirements for Voided Slab Construction

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

7.11 Screeding and Finishing of Unformed Surfaces

7.11.1 Surfaces other than Deck and Approach Slabs

Unformed surfaces must be compacted and tamped to bring a layer of fines to the surface. Screed the surface to the specified levels and finish with a wooden or “magnesium” float to an even uniform surface. Leave construction joints rough in accordance with Clause 7.9.

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.

Do not delay at any location the completion of the finishing operation and the commencement of curing at that location.

7.11.2 Deck and Approach Slab Surfaces

7.11.2.1 Profile

For all types of deck and approach slab surfaces, whether concrete, asphalt or bitumen-sealed, screed the decks using vibrating screeds set on screeding guide rails.
Alternatively, and only when required by the deck and barrier or kerb layout and when permitted by the Principal or Annexure B80/A5, deck slabs may be screeded by experienced operators using power vibrating screeds and height pins. Use the wet screeding technique provided the concrete strips between height pins that are used to guide the screed 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 correct finished deck surface levels shown on the Drawings and concrete cover will be produced on completion of the superstructure.

Supports for screeding guide rails and height pins must conform to Clause 6.7.4.

Screeding guide rails or height pin markings must be at levels to allow 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 the length of the vibrating screed or three (3) metres, whichever is the lesser.

### 7.11.2.2 Technical Procedures

The Technical Procedures for finishing referred to in Annexure B80/D must include:

(a) evidence including survey results that the finishing method produces decks conforming to this Specification, and certification that nonconforming results have been included;

(b) type and rate of proposed evaporation retarders;

(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; and

(h) type and size of allowances to be made for screeding guide rails or height pin marks for profile adjustments such as those mentioned in Clause 7.11.2.1.

### 7.11.2.3 Screeding

Place and compact the concrete in accordance with Clause 7.4. If a vibrating or power screed is used, bring the surface to the required level with a vibrating screed operating at a frequency of at least 100 Hz.

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

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;
• Girders/plank heights usually being constant;
• Girders/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.

Supplementary floating to bring fines to the surface is permissible.

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 6.9.

7.11.2.4 Protection of Surfaces

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 7.6.

See Clause 7.6 guide notes.

7.11.2.5 Finishing

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 7.11.2.4 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, approved proprietary finishing aids may be used in adverse conditions when the concrete sheen is about to disappear, in which case apply the finishing aid without working it into the surface to restore the sheen.

Finishing must consist of either:

(a) wood or "magnesium" floating the surface; or

(b) steel trowelling followed 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.

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 float.

There must be no delay between the completion of the finishing operation at any location and the commencement of curing at that location.
The texture depth of the surface must not be less than 0.90 mm when measured in accordance with Test Method RMS T240.

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 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 daggs out, barrowing with water and shaking the mortar out.

7.12 CURING

7.12.1 General

Apply curing in accordance with the approved curing regime nominated in Item (d) of Clause 3.8.2. 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.

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

Wet cure all cast-in-place bridge decks and approach slabs for a minimum of 72 hours after finishing operations are completed. Further curing conforming to Annexure B80/E or to the approved curing regime of Item (d) of Clause 3.8.2 may be by either wet or sealed curing methods.

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 Ed5/Rev3 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).

7.12.2 Wet Curing

Concrete surfaces must be wetted and completely covered with canvas, hessian, geofabric with plastic sheeting, or other suitable materials and be kept continuously wet. When used for vertical surfaces, keep these materials effectively wrapped and in place for the whole curing period. Water used for curing must conform to AS 1379 and be not more than 10°C cooler than the concrete surface.

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.

Apply wet curing:
(a) to unformed surfaces immediately after the completion of all finishing operations;
(b) in such a manner that staining of the formed surfaces does not produce a nonconforming finish;
(c) to formed surfaces immediately after the removal of the forms.

7.12.3 Sealed Curing

7.12.3.1 Retention of Formwork

Keep all parts of the formwork used under the sealed curing provision in place for the minimum periods nominated in Item (d) of Clause 3.8.2. Where it is proposed to strip part of or all the
formwork before the required curing is completed, apply a curing compound or wet curing to the stripped members for the remainder of the curing period.

7.12.3.2 Curing Compounds

Curing compounds must conform to AS 3799 for the Classes and Types specified in Table B80.18.

Ensure that no evidence of the curing compound remains on any concrete surface exposed to view within a period of six (6) months from the date of application of the compound.

<table>
<thead>
<tr>
<th>Description of curing compound</th>
<th>Class to AS 3799</th>
<th>Minimum non-volatile content to AS 1580 Method 301.1</th>
<th>Type to AS 3799</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wax-based (Wax emulsion)</td>
<td>A</td>
<td>30%</td>
<td></td>
</tr>
<tr>
<td>Resin-based (Hydrocarbon resin)</td>
<td>B</td>
<td>30%</td>
<td>1-D</td>
</tr>
<tr>
<td>Waterborne emulsions</td>
<td>Z</td>
<td>30%</td>
<td></td>
</tr>
</tbody>
</table>

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

For each curing compound proposed for use in the Works, provide the Principal 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 T1005.

For each batch delivered, provide the Principal a Certificate of Uniformity from the supplier, supported by uniformity testing on both non-volatile content and density in accordance with AS 3799 Clause 3.2, and on viscosity in accordance with AS 3799 Clause 3.1.5. Additionally, provide an infrared spectrum which matches the reference infrared spectrum. 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.

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/m² 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 m² 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 period nominated in Item (d) of Clause 3.8.2. Make good any damage to the curing membrane by respraying the affected areas.

The two main RMS 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.

### 7.12.3.3 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.

### 7.12.4 Heat Accelerated Curing

#### 7.12.4.1 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 or time elapsed must be the greater of 50°C.hrs or two hours respectively, and time elapsed must not be longer than five hours, unless wet curing is applied in the interim period prior to its application;

(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; and
(g) For Durability Provision B only, keep the concrete at a temperature, $T$ ($^\circ$C) of not less than 50°C, for a period, $P$ (hours), so that the result of the multiplication $P$ times $T$ is not less than 350°C.hours.

### 7.12.4.2 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._

### 7.13 Slipformed Barriers

Concrete barriers must not be slipformed.

_Provisions for slipformed barriers were removed from B80 Ed6 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._

### 7.14 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 a flowable mortar with 28 day compressive strength not less than 60 MPa and shrinkage of not more than 500 microstrain at 3 weeks or 700 microstrain at 8 weeks. The mortar must contain aggregate conforming to Clauses 2.4.1 and 2.4.3.

Prepare the blockout for concreting strictly in conformity with Clause 7.9.

_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, Ed5/Rev3, 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 Ed6/Rev1 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.

### 7.15 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/m² pressure over the track area, providing the concrete is protected from surface damage.

Carry out in-place strength assessment in accordance with Clause 8.2 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.

### HOLD POINT

<table>
<thead>
<tr>
<th>Process Held:</th>
<th>Early trafficking of concrete bridge deck.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Submission Details:</td>
<td>Strength versus age relationship of concrete and evidence of completion of curing, with supporting test results.</td>
</tr>
<tr>
<td>Release of Hold Point:</td>
<td>The Principal will consider the submitted documents, prior to authorising the release of the Hold Point within 2 working days of receipt of the documents.</td>
</tr>
</tbody>
</table>

Make good any damage arising from early trafficking of the bridge deck must at no cost to the Principal.

### 8 Properties of Hardened Concrete

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

Scabble and clean core holes and restore using a 10 mm maximum nominal aggregate size concrete mix 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.

### 8.2 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, in accordance with Annexure B80/L Clauses L3 and L4.

Concrete must be considered nonconforming where the RCS is less than $f_{c,\min}$ determined in accordance with Clause 3.5. Refer to Annexure B80/B for resolution of nonconformities.

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

### 8.3 COMPACTION

The relative compaction, determined 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, must be at least 98%. Any concrete failing to meet this requirement must be identified as nonconforming.

### 8.4 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 or as directed by the Principal.

Any concrete members failing to conform to Clause L6.2.3 of Annexure B80/L must be identified as nonconforming and marked and mapped to identify the nonconforming locations.

All individual cover survey results which indicate a cover less than 75% of the specified cover must be identified and reported to the Principal together with the cover map and the proposed corrective action to rectify each nonconformity.
ANNEXURE B80/A – PROJECT SPECIFIC REQUIREMENTS

(Refer to Clause 1.2.1)

A1 MEMBERS IN EXPOSURE CLASSIFICATION U

A1.1 General

Concrete members in exposure classification U must conform to Specification RMS 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 contained in Table B80/A.1 or as specified 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

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Project Specific</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Exposure Classification:</td>
<td></td>
</tr>
<tr>
<td>1 B1</td>
<td></td>
</tr>
<tr>
<td>2 B2</td>
<td></td>
</tr>
<tr>
<td>3 C</td>
<td></td>
</tr>
<tr>
<td>Nature of Exposure:</td>
<td></td>
</tr>
<tr>
<td>1 Acid sulfate soil</td>
<td></td>
</tr>
<tr>
<td>2 Soft or running water</td>
<td></td>
</tr>
<tr>
<td>3 Others</td>
<td></td>
</tr>
<tr>
<td>Full isolation of concrete surface from the aggressive environment:</td>
<td></td>
</tr>
<tr>
<td>1 Not required</td>
<td></td>
</tr>
<tr>
<td>2 Optional</td>
<td></td>
</tr>
<tr>
<td>3 Mandatory</td>
<td></td>
</tr>
</tbody>
</table>

A1.3 Additional Requirements

Cement: .............................................................................................................................

Aggregate: ............................................................................................................................

Admixtures: ............................................................................................................................

Mandatory Durability Provision (A, B, either): .................................................................

Others: .................................................................................................................................

Note: For concretes requiring durability suitable for exposure classification C, e.g. for acid sulfate soils, but which are not in a chloride aggressive environment, the corrosion inhibitor is not required.
A2  **BRIDGE MEMBERS FOR WHICH SELF-COMPACTING CONCRETE IS PERMITTED (JOB SPECIFIC)**

(Refer to Clauses 3.6 and 7.8 and Annexure B80/G1)

Precast concrete members manufactured under controlled conditions in off-site precasting yards.

---

A3  **FORMWORK CATEGORY C (JOB SPECIFIC)**

(Refer to Clause 5.2.4)

---

A4  **SURFACE FINISH REQUIREMENTS (JOB SPECIFIC)**

(Refer to Clause 5.3)

---

A5  **BRIDGE DECKS FOR WHICH SCREEDING USING VIBRATING POWER SCREEDS AND HEIGHT PINS IS PERMITTED (JOB SPECIFIC)**

(Refer to Clause 7.11.2.1)
ANNEXURE B80/B – RESOLUTION OF NONCONFORMITIES

(Refer to Clause 1.2.2)

Work and materials must be rejected unless they conform to the requirements of this Specification or, where permitted in this Annexure, are accepted with the specified deductions.

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 an Engineer who is a member of Engineers Australia (or equivalent) and 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 $f_{c,\text{min}}$ (refer to Clause 3.5) or greater than 100 MPa is nonconforming.

Where the RCS is less than $f_{c,\text{min}}$ but greater than or equal to 90% of $f_{c,\text{min}}$, the concrete represented may be accepted by the Principal at his discretion. In such cases, and when the concrete is accepted by the Principal, the schedule rate for the nonconforming concrete must 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 the priced unit rate for the members.

<table>
<thead>
<tr>
<th>Deficiency in strength below $f_{c,\text{min}}$</th>
<th>Deduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 5%</td>
<td>2% of the schedule price for each 1% (or fraction thereof) deficiency in strength.</td>
</tr>
<tr>
<td>Over 5% and up to 10%</td>
<td>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%.</td>
</tr>
</tbody>
</table>
ANNEXURE B80/C – SCHEDULES OF HOLD AND WITNESS POINTS AND IDENTIFIED RECORDS

(Refer to Clause 1.2.3)

C1 SCHEDULE OF HOLD AND WITNESS POINTS

<table>
<thead>
<tr>
<th>Clause</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.8</td>
<td>Hold</td>
<td>Nomination of concrete mix, including submission of all details for new concrete mixes.</td>
</tr>
<tr>
<td>5.2.4</td>
<td>Hold</td>
<td>Submission of formwork documentation and design certification.</td>
</tr>
<tr>
<td>5.3.2</td>
<td>Hold</td>
<td>Construction of test members.</td>
</tr>
<tr>
<td>6.7.3</td>
<td>Witness</td>
<td>Assembly, lifting and transport of prefabricated reinforcement cages.</td>
</tr>
<tr>
<td>7.1</td>
<td>Hold</td>
<td>Submission of names of personnel involved in concreting operations and evidence that they hold a RMS Bridgeworks Concreting Grey Card.</td>
</tr>
<tr>
<td>7.3</td>
<td>Hold</td>
<td>Submission of checklists for verifying conformity of the nominated concrete mix, formwork, reinforcement and embedments for precast concrete members cast off the site.</td>
</tr>
<tr>
<td>7.3</td>
<td>Hold</td>
<td>Submission of Certificate of Conformity of formwork, reinforcement and embedments for concrete other than precast concrete members cast off the site.</td>
</tr>
<tr>
<td>7.15</td>
<td>Hold</td>
<td>Early trafficking of concrete bridge deck.</td>
</tr>
</tbody>
</table>

C2 SCHEDULE OF IDENTIFIED RECORDS

The records listed below are Identified Records for the purposes of Specification RMS Q Clause E2.

<table>
<thead>
<tr>
<th>Clause</th>
<th>Description of the Identified Record</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.8</td>
<td>Submission of nominated mixes</td>
</tr>
<tr>
<td>3.9</td>
<td>Variations from nominated mixes</td>
</tr>
<tr>
<td>5.2.4</td>
<td>Category B &amp; C formwork: Documentation and Engineer’s design certification</td>
</tr>
<tr>
<td>7.3</td>
<td>Certificate of Conformity in respect of formwork, reinforcement, embedments and other relevant details or precast concrete members cast off the site</td>
</tr>
<tr>
<td>7.12.3.2</td>
<td>Certificate of Conformity of Curing Compound</td>
</tr>
</tbody>
</table>
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, and must be submitted to a timeline indicated by the project critical path, with due allowances for review by the Principal. The requirements of this Specification and others included in the Contract must be reviewed to determine additional documentation requirements.

The information to be submitted as part of the PROJECT QUALITY PLAN includes, but is not limited to, the following:

(a) Procedures for addition of corrosion inhibitors (refer to Clause 2.3.2)
(b) All concrete mix designs and trial mix reports (refer to Clause 3.8)
(c) Procedures for trialling and details of set retarding admixture to delay hydration (refer to Clause 4.3.5)
(d) Details of the design and construction of test members (refer to Clause 5.3.2)
(e) Details of the methods to be used in determining the stripping time of formwork other than by direct testing of representative cylinders (refer to Clause 5.9.2)
(f) Approved procedure for repair to minor surface imperfections (refer to Clause 5.10)
(g) Welding procedures and design of load bearing welds in reinforcement cages (refer to Clause 6.3.3)
(h) Details of the method of placing embedments (refer to Clause 6.7.5)
(i) Technical Procedures in accordance with Specification RMS Q for the placing, compacting, screeding, finishing and curing operations in Clause 7. The personnel required to carry out the operations together with proof of any relevant training and experience must be included. As well as the methods for placing, the procedures must include the delivery method and placing rates for varying pour sizes.

The compaction procedures must include detailed plans for the use of vibrators in the concrete and the method for ensuring full compaction of the whole of the concrete member.

(j) Details of the methods to be used to prevent thermal cracking (refer to Clause 7.1)
(k) Name, qualifications and experience of the Concrete Supervisor for concrete pours other than precast members cast off the site (refer to Clause 7.3)
(l) Technical Procedures for the restriction of the evaporation rates (refer to Clause 7.6)
(m) Details of the method of fixing and removing screed guide rails or height pins (refer to Clause 7.11.2)
(n) Technical Procedures for deck finishing (refer to Clause 7.11.2)
(o) Verification of the conformity of a proposed heat accelerated curing method with the Specification requirements (refer to Clause 7.12.4)
(p) Procedures for supply and placement of self-compacting concrete (refer to Annexure B80/G)
(q) Identification of work lots and name, qualifications and experience of technicians for cover surveys (refer to Annexure B80/L6).
ANNEXURE B80/E – CURING PROVISION B

(Refer to Clause 3.4.2)

For formed surfaces, the wet curing provision is applicable only when the formwork is removed within 48 hours of completion of concrete placement, and the surface 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).

Table B80/E.1 - Wet Curing

<table>
<thead>
<tr>
<th>Exposure classification</th>
<th>SL cement</th>
<th>Blended cement containing BFS and/or FA</th>
<th>Blended cement containing AS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7</td>
<td>7</td>
<td>N/A</td>
</tr>
<tr>
<td>B1</td>
<td>7</td>
<td>7</td>
<td>N/A</td>
</tr>
<tr>
<td>B2</td>
<td>N/A</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>C</td>
<td>N/A</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>U</td>
<td></td>
<td>In accordance with Annexure B80/A1</td>
<td></td>
</tr>
</tbody>
</table>

Table B80/E.2 - Sealed Curing

<table>
<thead>
<tr>
<th>Exposure classification</th>
<th>Curing period (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SL cement</td>
</tr>
<tr>
<td>A</td>
<td>7</td>
</tr>
<tr>
<td>B1</td>
<td>7</td>
</tr>
<tr>
<td>B2</td>
<td>N/A</td>
</tr>
<tr>
<td>C</td>
<td>N/A</td>
</tr>
<tr>
<td>U</td>
<td>In accordance with Annexure B80/A1</td>
</tr>
</tbody>
</table>
### Table B80/E.3 - Heat Accelerated Curing

<table>
<thead>
<tr>
<th>Exposure classification</th>
<th>Permissibility of curing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SL cement</td>
</tr>
<tr>
<td>A</td>
<td>√</td>
</tr>
<tr>
<td>B1</td>
<td>√</td>
</tr>
<tr>
<td>B2</td>
<td>N/A</td>
</tr>
<tr>
<td>C</td>
<td>N/A</td>
</tr>
<tr>
<td>U</td>
<td>In accordance with Annexure B80/A1</td>
</tr>
</tbody>
</table>

**Notes:**
- For the definition of cement, refer to Clause 1.3 Definitions
- 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
- N/A Not applicable. Durability Provision B does not apply for this case
- √ Applicable. Durability Provision B may be applied for this case
ANNEXURE B80/F – STAINLESS STEEL REINFORCEMENT

(Refer to Clause 6)

F1 GENERAL

All the 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 C, a corrosion inhibitor 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 fabric.

Stainless steel reinforcement must be strength grade 500 in accordance with Table 7, BS 2001 and conform to designation 1.4362, 1.4429, 1.4436 or 1.4462 to BS 10088 (as identified by Table 5, BS 6744:2001). Uniform elongation must conform to AS/NZS 4671 for Grade 500N.

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.

F4.2 Bending

Tools for bending stainless steel reinforcement must not have been used and must not be used for other materials. Pins used for bending stainless steel must be made from stainless steel.

Do not heat stainless steel reinforcement for bending.

Do not field bend bars with diameters greater than 20 mm.
**F4.3 Welding**

Carry out welding only when permitted by the Principal in writing.

All welding for stainless steel reinforcement must comply with Specification RMS B204 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 allows 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 must conform to Category 1B to AS 1554:6 Table 6.1.1. Assess defects in accordance with AS 1554:3 Sections 9 and 10. Examine welds using dye penetrant or magnetic particle examination methods. Treat any arc strikes as welds.

(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.

(g) Test welds and the welded bars in the vicinity of the welds for corrosion resistance against pitting and intergranular corrosion in accordance with AS 1554:6 Appendix E using a laboratory with appropriate NATA registration. Corrosion resistance testing must include qualification tests and be carried out on not less than 10% of all welds performed in the Works.

(h) Where any of the tested bars fails the corrosion resistance test, test all welds and bars in the vicinity of the welds for corrosion resistance.

**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

G1 GENERAL

All the requirements of this Specification apply to the design, supply, delivery, placement and curing of self-compacting concrete except where modified by this Annexure.

Only supply self-compacting concrete for the specific bridge members listed in Annexure B80/A2.

For self-compacting concrete, where ‘slump’ is specified in this Specification, use ‘slump flow spread’ instead.

Prepare concrete test samples without mechanical or manual compaction.

G2 PERFORMANCE REQUIREMENTS

The fresh properties of self-compacting concrete must conform to Table B80/G1.

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Criteria</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filling ability</td>
<td>ASTM C1611</td>
<td>Spread: 550 – 800 mm</td>
<td>Target Value ± 50mm may be used</td>
</tr>
<tr>
<td>Stability</td>
<td>ASTM C1611</td>
<td>VSI rating: &lt; 2</td>
<td>VSI rating of 2 may be acceptable depending on the type of concrete pour</td>
</tr>
<tr>
<td></td>
<td>EN 12350-11</td>
<td>Sieved portion: ≤ 15 %</td>
<td>Required during trial mixing</td>
</tr>
<tr>
<td></td>
<td>ASTM C1712</td>
<td>Penetration: ≤ 10mm</td>
<td>Penetration depth ≤ 15mm may be acceptable depending on the type of concrete pour</td>
</tr>
<tr>
<td>Passing ability</td>
<td>ASTM C1621</td>
<td>Δ Spread: 25 – 50 mm</td>
<td>Complete test within 6 minutes of ASTM C1611 to harmonise results</td>
</tr>
<tr>
<td></td>
<td>EN 12350-12</td>
<td>Δ Height: ≤ 15 mm</td>
<td>Difference between height at centre and mean height just outside J-ring. Required during trial mixing.</td>
</tr>
<tr>
<td>Viscosity</td>
<td>ASTM C1611</td>
<td>T500: 2 – 5 seconds</td>
<td>Gives indication on consistency between batches</td>
</tr>
</tbody>
</table>

G3 TRIAL MIXES

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

Where self-compacting concrete is trialled, submit:

(a) Spread and corresponding nominated slump flow spread instead of slump;
(b) Time to 500 mm slump flow spread, $T_{500}$, and corresponding nominated $T_{500}$ range;
(c) Visual stability index (VSI) rating and nominated VSI requirement;
(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;

G4 TEST MEMBERS

Where a test member is required under Clause 5.3.2, conform to the following:
(a) For columns, the test member must consist of a column not less than the height of the column in question or 6 m, whichever is less, with similar corner detailing and steel reinforcement layout.
(b) For other members, replicate the most complex part of the member.
(c) Cut the concreted test member as directed by the Principal to demonstrate that segregation has not occurred.

G5 FORMWORK DESIGN

Where self-compacting concrete is supplied and when 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

Where self-compacting concrete is supplied, include the following additional details on the concrete batch delivery dockets:
- Target value and accepted range for slump flow, instead of nominated slump;
- Instructions for adding admixtures at the site to adjust workability.

Where self-compacting concrete is supplied, do not add water to the mixed batch in-transit or at the site. High-range water reducers may be added to adjust deformability or flowability at the site at a dosage determined and agreed prior to full production.

For all operations where self-compacting concrete is approved, implement rigorous production control especially of water and admixtures during concrete batching and delivery in accordance with CIA Z40 or SCC 028.

Where self-compacting concrete is supplied by pump for columns and shafts, to prevent segregation, keep the end of the pump hose initially as close as possible to the bottom of the pour to limit the free fall height, and keep it submerged at least 300mm as the pour progresses upwards.

Keep the distance of horizontal flow less than 10 metres. Do not exceed the rate of placement specified in the formwork design for the placement conditions.

Although compaction is not normally required for self-compacting concrete, apply supplementary compaction as required to ensure full compaction of the member.

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.
Submit with the Quality Plan procedures for achieving the required level of control for supply, delivery, placement, supplementary compaction and curing of self-compacting concrete, including the action required when a delivered batch of concrete does not have the required rheological properties.

The minimum frequency of testing during supply and delivery of self-compacting concrete must conform to Table B80/G2.

### Table B80/G2 - Minimum Frequency of Testing for Self Compacting Concrete

<table>
<thead>
<tr>
<th>Characteristic Analysed</th>
<th>ASTM Test Method</th>
<th>Minimum Frequency of Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply and delivery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passing ability, J-ring slump flow</td>
<td>C1621</td>
<td>Initial batch</td>
</tr>
<tr>
<td>differential</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stability, penetration depth</td>
<td>C1712</td>
<td>Initial batch and every fourth batch thereafter</td>
</tr>
<tr>
<td>Filling ability, slump flow spread</td>
<td>C1611</td>
<td>One per batch of concrete</td>
</tr>
<tr>
<td>Viscosity, $T_{500}$</td>
<td>C1611</td>
<td>One per batch of concrete</td>
</tr>
<tr>
<td>Stability, VSI rating</td>
<td>C1611</td>
<td>One per batch of concrete</td>
</tr>
</tbody>
</table>

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 Ed6 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.

**ANNEXURE B80/H TO B80/K – (NOT USED)**
## ANNEXURE B80/L – TESTING PROCEDURES
(Refer to Clause 1.2.5)

### L1 MINIMUM FREQUENCY OF TESTING

<table>
<thead>
<tr>
<th>Clause</th>
<th>Characteristic Analysed</th>
<th>Test Method</th>
<th>Minimum Frequency of Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply and Delivery of Concrete</td>
<td>All test reports specified in Clause 2</td>
<td>As specified in Clause 2</td>
<td>At start of project and yearly thereafter</td>
</tr>
<tr>
<td>2.3</td>
<td>Each chemical admixture - sample and store for 6 months at batch plant</td>
<td>AS 1478 – Appendix A</td>
<td>At start and every two months during production</td>
</tr>
<tr>
<td>2.3.2</td>
<td>Quantity of calcium nitrite in fresh concrete only where corrosion inhibitor is specified</td>
<td>RMS T371</td>
<td>One pair per 25 m³ or part thereof</td>
</tr>
<tr>
<td>2.4.2 (c)</td>
<td>Particle size distribution of coarse aggregate - deviation from nominated particle size distribution</td>
<td>AS 1141.11</td>
<td>One per week or one per 400 tonnes</td>
</tr>
<tr>
<td>2.4.3 (a)</td>
<td>Particle size distribution of fine aggregate - deviation from nominated particle size distribution</td>
<td>AS 1141.11</td>
<td>One per week or one per 400 tonnes</td>
</tr>
<tr>
<td>2.4.3 (c)</td>
<td>Fine aggregate:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Material &lt; 75 micrometre:</td>
<td>AS 1141.12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufactured and unwashed natural sand</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Washed natural sand</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Soundness</td>
<td>AS 1141.24</td>
<td>One per 4,000 tonnes</td>
</tr>
<tr>
<td></td>
<td>Methylene Blue Value</td>
<td>ISSA 145</td>
<td>One per 10,000 tonnes</td>
</tr>
<tr>
<td>4.4</td>
<td>Slump*</td>
<td>AS 1012.3.1</td>
<td>One per batch of concrete</td>
</tr>
<tr>
<td>Hardened Concrete</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.2</td>
<td>Compressive strength 28 days:</td>
<td>AS 1012.8 AS 1012.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Mass concrete</td>
<td></td>
<td>One per 50 m³ or part thereof</td>
</tr>
<tr>
<td></td>
<td>- Reinforced concrete</td>
<td></td>
<td>One per 25 m³ or part thereof</td>
</tr>
<tr>
<td></td>
<td>- Prestressed concrete</td>
<td></td>
<td>One per 15 m³ or part thereof</td>
</tr>
<tr>
<td>8.2</td>
<td>Compressive strength for other purposes</td>
<td>AS 1012.8 AS 1012.9</td>
<td>One per pour or more as required by the Contractor</td>
</tr>
<tr>
<td>8.3</td>
<td>Relative compaction of concrete</td>
<td>AS 1012.12.2 Annexure B80/L5</td>
<td>As directed by the Principal</td>
</tr>
<tr>
<td>8.4</td>
<td>Concrete cover to reinforcement</td>
<td>Annexure B80/L6</td>
<td>If directed by the Principal, as per Table B80/L6.1</td>
</tr>
</tbody>
</table>

* 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  MOULDING OF SAMPLES
Moulded concrete specimens must be standard cylinders moulded in accordance with the requirements and procedure of AS 1012.8.1 using rodding only.

L3  SPECIMENS CUT FROM THE WORKS (CORES)
When directed by the Principal, core specimens must be cut by means of a core drill, wet pre-treated and tested in accordance with AS 1012.14. The corrected (for length to diameter ratio) strength so determined must be adjusted for age by dividing the result by the factors shown in Table B80/L.1.

Do not cut reinforcement during extracting core specimens. Prior to coring, do cover meter survey at representative locations to identify the rebar positions. Do not test cores containing reinforcement and replacement cores must be cut at new locations.

L4  COMpressive STRENGTH

L4.1 Testing
The compressive strength of the concrete represented by a pair of specimens moulded from one sample, cured and tested in accordance with AS 1012, 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 Adjustment for Age of Specimen
Should any specimen be tested more than 28 days after moulding, 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 General Purpose and Blended cement. For intermediate ages the factor must be determined on a pro-rata basis.

<table>
<thead>
<tr>
<th>Age of specimen at time of test (days)</th>
<th>Age factor</th>
<th>Age factor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>General Purpose cement</td>
<td>Blended cement</td>
</tr>
<tr>
<td>28</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>56</td>
<td>1.08</td>
<td>1.19</td>
</tr>
<tr>
<td>112</td>
<td>1.14</td>
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<tr>
<td>224</td>
<td>1.22</td>
<td>1.42</td>
</tr>
<tr>
<td>365 or greater</td>
<td>1.25</td>
<td>1.45</td>
</tr>
</tbody>
</table>

Table B80/L.1 - Factors for Age of Specimens
L5  **COMPACTION**

*Refer to guide notes on Clause 7.4.3.*

### L5.1  Cores

Take cores in the deck and elsewhere only as and when 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, the cores must be placed in either a tank of lime saturated water or individual plastic bags, sealed to prevent water loss and stored in the shade.

Cores must not be subjected to temperatures:

(i) in excess of the ambient temperature or 28°C, whichever is higher; or
(ii) less than 10°C.

### L5.2  Testing

Determine the unit mass of representative cylinders for concrete compaction 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 RMS 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/m³, in which case the higher result must represent the unit mass of the pair.

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 Test Method RMS T368 for excessive voids and, if warranted, dress voids prior to testing;

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

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

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

   (i) non-concrete materials such as bitumen must be removed, and
   (ii) up to 20 mm of concrete may be removed from each end of the core;

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

(f) round individual results for unit mass to the nearest 10 kg/m³ in accordance with AS 1012.12.2.

_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._


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**

When directed by the Principal, test concrete cover in discrete lots at the minimum frequency specified in Table B80/L6.1 or as directed by the Principal.

**L6.1.1 Identification of Work Lots**

A lot must be representative of concrete bridge members or products produced under essentially constant conditions. Discrete portions of a lot that are visually non-homogeneous and/or non-representative must be excluded and either treated as separate lots or repaired/replaced to achieve conformity to this Specification.

The size of a lot must not exceed the extent of the day’s concrete pour except where directed by the Principal.

Describe in the PROJECT QUALITY PLAN how the lot is to be identified in the field or the pre-casting yard.

Determine the bounds of each lot before testing. Set the bounds of each lot and use statistical methods to determine test locations and compliance. Demonstrate the relationship of the boundaries of all adjacent/following lots to confirm that the lots will represent the bridge members or products being examined.

Give each lot a unique lot number. Use this lot number as an identifier on all quality records. The lot numbering system must be compatible with any activity numbering system used for the bridge construction operations. Record the lot number on a register that indicates the three-dimensional location of the lot. Include in the PROJECT QUALITY PLAN details of the lot numbering system and the place where the lot register is kept. Record the start, finish, lateral and height locations. When the lot number does not indicate the location of the lot, agree the method for identification of the lot with the Principal.

**L6.1.2 Exclusion from Work Lots**

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

**L6.1.3 Technicians**

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.

**L6.1.4 Reports**

Concrete cover survey reports must be provided to the Principal within 5 working days of the Principal’s direction. Reports must be prepared in a format acceptable to the Principal and must contain lot numbers, test locations, measurement results, standard deviations on progressive accumulated results, progressive maximum and minimum value of attribute (Q) and comments on compliance with this Specification and the technician’s name and signature.
The report must also list all individual cover survey result which indicates a cover less than 75% of the specified cover, a map of the nonconforming areas and the proposed corrective action to rectify each deficiency.

L6.1.5 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.

L6.1.6 Resolution Limits

Since bar spacing, \( s \) mm, and cover depth, \( \delta \) mm, influence cover meter resolution, limit readings to:

\[
\delta \text{ cover, where } (s - 20) \geq \delta \text{; and } \\
\delta \leq 90
\]

L6.2 Statistical Techniques

Use statistical techniques in accordance with the following sub-Clauses.

L6.2.1 Number and Location of Tests

The number of cover meter tests (n) per lot must be not less than shown in Table B80/6.1.

<table>
<thead>
<tr>
<th>Concrete Member</th>
<th>Minimum Testing Frequency for Lot Area of:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt; 50 m²</td>
</tr>
<tr>
<td>First member *</td>
<td>1 per 3 m²</td>
</tr>
<tr>
<td>Subsequent similar members ∆</td>
<td>1 per 7 m²</td>
</tr>
<tr>
<td>First precast member #</td>
<td>1 per 5 m²</td>
</tr>
<tr>
<td>Subsequent similar precast members ∆</td>
<td>1 per 10 m²</td>
</tr>
</tbody>
</table>

* Where standard formwork and compaction are used.

# Where rigid formwork and intense compaction are used.

∆ Concrete bridge members may be considered similar if produced on a regular time cycle and proportions and concrete volumes and surface areas do not vary by more than 5%.

Testing locations must be determined by the testing personnel in a random or unbiased manner (refer Specification RMS Q Clause 8.2.4.1) as follows:

(a) Representing the lot as a developed rectangle, subdivide the lot lengthwise into equal-area sub-lots in accordance with the number of tests selected (n);
(b) Establish six equally spaced grid lines within the lot, as illustrated in Figure B80/L6.1;
(c) Where the width of lot is between 0.5 m and 1.7 m, the number of grid lines may be reduced such that the distance between adjacent grid lines (equally spaced) does not exceed 300 mm;
(d) Where the lot is less than 500 mm wide, the offset locations must be randomly selected;
(e) Determine the order of testing of the six lines by selecting a six digit number from Table B80/L6.2. A starting point on the table (e.g. 1st number, block 6D (= 415236)) will be advised by the Principal prior to the commencement of testing. The numbers are to be used sequentially down the Table until further notice from the Principal, starting at the point advised by the Principal, and selecting a new number for each lot tested;

(f) Where there are less than 6 grid lines in the Lot, delete from the random number selected from Table B80/L6.2, the numerals that exceed the number of gridlines in the Lot (e.g. in the above example, where there are only 4 grid lines, the sequence is 4123);

(g) If for any reason the starting point has not been advised then it must be the first number in the block determined, by the following method, from the date on which testing is first undertaken:

<table>
<thead>
<tr>
<th>Select column:</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>For: January</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For: February</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>For: March</td>
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<tr>
<td>For: April</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>For: May</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For: June</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>For: July</td>
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<tr>
<td>For: August</td>
<td></td>
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</tr>
<tr>
<td>For: September</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>For: November</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For: December</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day: select a row on the basis of:</td>
<td>1st, 11th, 21st, 31st = Row 1; 2nd, 12th, 22nd = Row 2; etc.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(h) For each block in Table B80/L6.2, use the Fraction R at the right of the relevant random number. Length coordinate for testing location in sub-lot 1 = RL/n;

(i) Record the lot number on Table B80/L6.2 to the right of the applicable random number and indicate the date of the testing on the Table;

(j) For the testing location in the next sublot:

Add L/n to the previous length coordinate.

Go to the next line as indicated by the six-digit number

(e.g. if the number is 415236 the first line tested is 4, followed by 1, 5, 3, 2 and 6 and the sample locations are as shown in Figure B80/L6.1);

(k) If the lot requires more than six testing locations, repeat the sequence using the same Grid Line Sequence and Fraction R to provide as many additional locations as are required.

(l) Outer bar steel reinforcement may not exist directly under each derived testing location and testing personnel may then offset the location marginally to obtain a reading.

(m) All test locations must be marked with weatherproof chalk or crayon to facilitate audit testing.
Figure B80/L6.1 Testing Locations for the Developed Lot
<table>
<thead>
<tr>
<th></th>
<th>Sequence</th>
<th>R</th>
<th>Lot No.</th>
<th></th>
<th>Sequence</th>
<th>R</th>
<th>Lot No.</th>
<th></th>
<th>Sequence</th>
<th>R</th>
<th>Lot No.</th>
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<td>.17</td>
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<td>.74</td>
<td>163542</td>
<td>.61</td>
<td>352614</td>
</tr>
</tbody>
</table>
L6.2.2 Method for Statistical Calculation for Conformity of Lots

When acceptance criteria specify a maximum and/or minimum characteristic value of attribute \( Q \), \( Q_U \) and/or \( Q_L \) must be used to determine \( Q \).

The calculation of the characteristic value of attribute \( Q \) for the lot/s must be as follows:

\[
Q_U = \bar{x} + ks \\
Q_L = \bar{x} - ks
\]

where \( \bar{x} \) = arithmetic mean of attribute test results for all lots and sub-lots (mm)
\( s \) = standard deviation of lots and sub-lot attribute test results

\[
s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}
\]

\( k \) = acceptance constant from Table B80/L6.3 (based on 10% producer's risk)

<table>
<thead>
<tr>
<th>No of tests</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10 - 14</th>
<th>15 - 19</th>
<th>20 +</th>
</tr>
</thead>
<tbody>
<tr>
<td>( k )</td>
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<td>0.67</td>
<td>0.72</td>
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<td>0.83</td>
<td>0.90</td>
<td>0.95</td>
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L6.2.3 Conformity

For the first lot and subsequent accumulated lots, conformity is achieved if:

\[
Q_U \leq 1.15 \text{ times the specified upper limit for characteristic value of the attribute; and} \\
Q_L \geq 0.87 \text{ times the specified lower limit for characteristic value of the attribute.}
\]

The concrete bridge member(s) or product(s) is/(are) nonconforming if:

\[
Q_U \text{ is more than 1.15 times the specified upper limit for the characteristic value; or} \\
Q_L \text{ is less than 0.87 times the specified lower limit for the characteristic value.}
\]
### ANNEXURE B80/M – REFERENCE DOCUMENTS AND ABBREVIATIONS

(Refer to Clause 1.2.6)

#### M1 REFERENCES

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**Concrete Institute of Australia Publication**

- CIA Z40 Super-Workable Concrete

**ASTM Standards**

- 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

**British Standards**

- BS 10088 Stainless steels. List of stainless steels
- BS 6744:2001 Stainless steel bars for the reinforcement of and use in concrete. Requirements and test methods
- 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

**Self-compacting concrete European Project Group Publication**

- SCC 028 The European Guidelines for Self-Compacting Concrete

**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
| ISSA 145 | Technical Bulletin No 145 - Test method for determination of methylene blue adsorption value (MBV) of mineral aggregate fillers and fines |

### ABBREVIATIONS

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<th>Acronym</th>
<th>Description</th>
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<tr>
<td>NATA</td>
<td>National Association of Testing Authorities, Australia</td>
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<td>RMS</td>
<td>Roads and Maritime Services</td>
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