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AS 1379—2007


# Specification and supply of concrete

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The following are represented on Committee BD-049:

- AUSTROADS
- Ash Development Association of Australia
- Association of Consulting Engineers Australia
- Australasian Slag Association
- Cement Concrete and Aggregates Australia—Cement
- Cement Concrete and Aggregates Australia—Concrete
- Concrete Institute of Australia
- National Precast Concrete Association Australia

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This Standard was issued in draft form for comment as DR 05253.

Standards Australia wishes to acknowledge the participation of the expert individuals that contributed to the development of this Standard through their representation on the Committee and through the public comment period.

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STANDARDS AUSTRALIA

# RECONFIRMATION
# OF
# AS 1379—2007
# Specification and supply of concrete

## RECONFIRMATION NOTICE

Technical Committee BD-049 has reviewed the content of this publication and in accordance with Standards Australia procedures for reconfirmation, it has been determined that the publication is still valid and does not require change.

Certain documents referenced in the publication may have been amended since the original date of publication. Users are advised to ensure that they are using the latest versions of such documents as appropriate, unless advised otherwise in this Reconfirmation Notice.

Approved for reconfirmation in accordance with Standards Australia procedures for reconfirmation on 04 December 2017.

The following are represented on Technical Committee BD-049:

Australasian (Iron & Steel) Slag Association
AUSTROADS
Cement Concrete & Aggregates Australia – Cement
Cement Concrete & Aggregates Australia – Concrete
National Precast Concrete Association Australia

NOTES

# Australian Standard®

# Specification and supply of concrete

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# PREFACE

This Standard was prepared by the Standards Australia Committee BD-049, Manufacture of Concrete, to supersede AS 1379—1997.

*This Standard incorporates Amendment No. 1 (June 2009) and Amendment No. 2 (March 2015). The changes required by the Amendment are indicated in the text by a marginal bar and amendment number against the clause, note, table, figure or part thereof affected.*

The objective of this Standard is to update the 1997 edition, align with modifications to the revision of AS 3600 and to improve clarity of requirements and commentary.

This edition incorporates the following major changes to the previous edition:

(a) Extension of standard concrete grades from 50 MPa to 100 MPa.

(b) Introduction of new clause covering chemical admixtures and chemical content of concrete.

(c) Introduction of new special class concrete designations, which recognize the exposure classification.

(d) Provides transparency of cement and aggregates required for durability.

(e) Introduction of reportable chemical properties of mixing water.

(f) Modification of acceptable variation between test specimens.

(g) Reformatting of Table B1 to make it more user friendly.

The term 'normative' and 'informative have been used in this Standard to define the application of the appendix to which they apply. A 'normative' appendix is an integral part of a Standard, whereas an 'informative' appendix is only for information and guidance.

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STANDARDS AUSTRALIA

# Australian Standard
# Specification and supply of concrete

## SECTION 1 SCOPE AND GENERAL

### 1.1 SCOPE

This Standard sets out the minimum requirements for—

(a) the materials, plant and equipment used in the supply of concrete;

(b) the production and, if applicable, the delivery of concrete in the plastic state;

(c) specifying, sampling, testing and compliance with specified properties of plastic and hardened concrete; and

(d) the uniformity of mixing.

This Standard applies to the supply of all concrete. It is not intended to apply to mortars or grouts.

NOTES:

1 Requirements for mortars for masonry construction are given in AS 3700 and the methods for sampling and testing mortars in AS 2701.

2 Requirements for grouts to be used for the grouting of prestressing tendons in ducts are given in AS 3600.

3 It is not intended that this Standard take precedence over existing Australian Standards for the manufacture of specific concrete products.

4 For additional requirements specified by the customer, the applicable contract documents should be consulted.

### 1.2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

| AS | | |
|---|---|---|
| 1012 | Methods of testing concrete | |
| 1012.1 | Method 1: | Sampling of fresh concrete |
| 1012.2 | Method 2: | Preparation of concrete mixes in the laboratory |
| 1012.3.1 | Method 3.1: | Determination of properties related to the consistency of concrete—Slump test |
| 1012.4.1 | Method 4.1: | Determination of air content of freshly mixed concrete—Measuring reduction in concrete volume with increased air pressure |
| 1012.5 | Method 5: | Determination of mass per unit volume of freshly mixed concrete |
| 1012.8.1 | Method 8.1: | Method of making and curing concrete—Compression and indirect tensile test specimens |
| 1012.8.2 | Method 8.2: | Method of making and curing concrete—Flexure test specimens |
| 1012.9 | Method 9: | Determination of the compressive strength of concrete specimens |
| 1012.10 | Method 10: | Determination of indirect tensile strength of concrete cylinders ('Brasil' or splitting test) |

| | |
|---|---|
| AS | |
| 1012.11 | Method 11: Determination of the modulus of rupture |
| 1012.12.1 | Method 12.1: Determination of mass per unit volume of hardened concrete—Rapid measuring method |
| 1012.13 | Method 13: Determination of the drying shrinkage of concrete for samples prepared in the field or in the laboratory |
| 1012.18 | Method 18: Determination of setting time of fresh concrete, mortar and grout by penetration resistance |
| 1012.20 | Method 20: Determination of chloride and sulfate in hardened concrete and concrete aggregates |
| 1141 | Methods for sampling and testing aggregates |
| 1141.6.1 | Method 6.1: Particle density and water absorption of coarse aggregate—Weighing-in-water method |
| 1141.35 | Method 35: Sugar |
| 1199 | Sampling procedures for inspection by attributes |
| 1199.0 | Part 0: Introduction to the ISO 2859 attribute sampling system |
| 1199.1 | Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection |
| 1289 | Methods of testing soils for engineering purposes |
| 1289.4 | Method 4: Soil chemical tests |
| 1289.4.2 | Method 4.2: Determination of the sulfate content of a natural soil and the sulfate content of the groundwater |
| 1289.4.2.1 | Method 4.2.1: Normal method |
| 1478 | Chemical admixtures for concrete, mortar and grout |
| 1478.1 | Part 1: Admixtures for concrete |
| 2701 | Methods of sampling and testing mortar for masonry construction |
| 2758 | Aggregates and rock for engineering purposes |
| 2758.1 | Part 1: Concrete aggregates |
| 3550 | Methods for the analysis of waters |
| 3550.4 | Part 4: Determination of solids—Gravimetric method |
| 3582 | Supplementary cementitious materials for use with portland and blended cement |
| 3582.1 | Part 1: Fly ash |
| 3582.2 | Part 2: Slag—Ground granulated iron blast-furnace |
| 3582.3 | Part 3: Amorphous silica |
| 3600 | Concrete structures |
| 3700 | Masonry structures |
| 3972 | Portland and blended cements |
| AS/NZS | |
| 1580 | Paints and related materials—Methods of test |
| 1580.505.1 | pH of water-based paints |
| AS/NZS ISO | |
| 9001 | Quantity management systems—Requirements |
| 9004 | Quantity management systems—Guidelines for performance improvements |

APHA

| | |
|---|---|
| APHA | Standard Methods for the Examination of Water and Wastewater: APHA-AWWA-WEF |
| APHA 3500 | Na Sodium |
| APHA 4500 | Cl¡¥ Chloride |
| APHA 5520 | Oil and grease |
| HB 18 | Conformity assessment |
| HB 18.28 | Part 28: Guidance on a third party certification system for products |
| HB 79 | Alkali Aggregate Reaction—Guidelines on Minimising the Risk of Damage to Concrete Structures in Australia |

## 1.3 DEFINITIONS

For the purpose of this Standard, the definitions below apply.

### 1.3.1 Agitator

An item of plant or equipment that maintains the plastic concrete in a mixed state.

### 1.3.2 Aggregate-cement ratio

The ratio of saturated surface dry (SSD) mass of aggregate to the mass of cement (as defined in Clause 1.3.6) in the batch.

### 1.3.3 Batch

A quantity of concrete containing a fixed amount of ingredients and produced in a discrete operation.

### 1.3.4 Batching

The process of combining the concrete ingredients in fixed proportions by weight or by volume.

### 1.3.5 Blended cement

A hydraulic cement as defined in AS 3972.

### 1.3.6 Cement

A hydraulic binder composed of portland or blended cement used alone or combined with one or more supplementary cementitious materials.

### 1.3.7 Characteristic strength

That value of the concrete strength, as assessed by standard test, which is exceeded by 95% of the concrete.

### 1.3.8 Concrete

A mixture of cement, aggregates, and water with or without the addition of chemical admixtures or other materials and defined as follows:

(a) *Plastic concrete* Concrete in the state between completion of mixing and initial set as defined in AS 1012.18.

(b) *Hardened concrete* Concrete after initial set, as represented by test specimens that have been subjected to a specified process and duration of curing.

(c) *Normal-class concrete* Concrete that is specified primarily by a standard compressive strength grade up to 50 MPa and otherwise in accordance with Clause 1.5.3.

(d) *Special-class concrete* Concrete that is specified to have certain properties or characteristics different from, or additional to, those of normal-class concrete and otherwise in accordance with Clause 1.5.4.

### 1.3.9 Customer

The person, persons or corporate body to whom the supplier supplies, or supplies and delivers a quantity of plastic concrete.

### 1.3.10 Mean grade strength

The arithmetical mean of all relevant 28 day sample strengths taken in a production interval for the particular strength grade.

### 1.3.11 Mixing

The mechanical process of combining the constituent ingredients of concrete.

### 1.3.12 Point of acceptance

The point of discharge from the supplier's equipment or an otherwise agreed point at which the customer accepts the plastic concrete from the supplier.

### 1.3.13 Portland cement

A hydraulic cement as defined in AS 3972.

### 1.3.14 Production assessment

An assessment procedure for concrete defined by strength grade, carried out by the supplier and based on the statistical assessment of standard compressive strength tests on concrete, specified by compressive strength and produced by a specific supplying plant.

### 1.3.15 Project assessment

An assessment procedure for concrete defined by strength grade, specified at the customer's option, which provides additional test data for the statistical assessment of concrete supplied to a specific project.

### 1.3.16 Standard strength grade

One of the strength grades given in Table 1 (see Clause 1.5.2).

### 1.3.17 Strength grade

The specified value of the characteristic compressive strength of the concrete at 28 days $(f'_c)$.

### 1.3.18 Supplementary cementitious material (SCM)

Material as defined in the relevant Part of the AS 3582 series.

### 1.3.19 Supplier

The person, persons or corporate body responsible for the supply of the concrete.

### 1.3.20 Supply

The process whereby the concrete ingredients are stored, batched, mixed, delivered if applicable, and discharged and sampled in the plastic state.

### 1.3.21 Total free water

The mass or volume of water contained in liquid admixtures and batch aggregates, in excess of their SSD condition, plus the mass or volume of all water added to the batch before commencement of discharge.

### 1.3.22 Water-cement ratio (*w/c*)

The ratio of the mass of total free water in a batch to the mass of cement (as defined in Clause 1.3.6) in the batch.

## 1.4 NOTATION

Unless a contrary intention appears, the following applies:

(a) Where non-dimensional ratios are involved, both the numerator and denominator are expressed in consistent units.

(b) Dimensional units used in expressions or equations shall be consistent, unless otherwise specified.

(c) The notations used in this Standard shall have the following meanings with respect to the structure or member or element or condition to which a clause is applied:

$f'_c$ = characteristic compressive strength of concrete at 28 days

$f_{cm}$ = mean value of the compressive strength of concrete at the relevant age

$k_c$ = an assessment factor corresponding to the number of samples used to determine $f_{cm}$ (see Clause 6.3.1.4)

$m_c$ = mass per unit volume of the plastic concrete in the sample (see Paragraph A3.4 of Appendix A)

$m_{ac}$ = oven dry mass of the retained coarse aggregate (see Paragraph A3.5 of Appendix A)

$m_{ma}$ = mass per unit volume of the air free mortar (see Paragraph A3.6 of Appendix A)

$n$ = number of samples used in the calculation of standard deviation (see Clauses 6.3.5.1)

$n_c$ = number of samples used in the production interval for the controlled grade (see Clause 6.3.1.2)

$p$ = percentage air content in the concrete of the sample (see Paragraph A3.3 of Appendix A)

$P$ = mass per unit volume of the other hardened cylinders in kg/m$^3$ (see Clause 5.5.2)

$s_a$ = standard deviation of the sample strengths of an associated grade (see Clause 6.3.5.3)

$s_c$ = standard deviation of the sample strengths of a controlled grade (see Clause 6.3.5.1)

$s$ = standard deviation for the grade being assessed ($s_c$ or $s_a$) (see Clause 6.3.1.5)

$Q$ = volume of plastic concrete produced from the batched ingredients (see Clause 4.2.1.1)

$V$ = volume of concrete used in calculating $m_c$ (see Paragraph A3.5 of Appendix A)

$w/c$ = water-cement ratio; as defined in Clause 1.3.22

$\bar{x}$ = mean strength (see Clause 6.3.5.1)

$x$ = sample strength (see Clause 6.3.5.1)

$\beta_{sc}$ = mass of coarse aggregate per unit volume of the sample (see Paragraph A3.5 of Appendix A)

$\rho$ = density of the coarse aggregate particles (see Paragraph A3.5 of Appendix A)

## 1.5 SPECIFICATION OF CONCRETE

### 1.5.1 General

Concrete shall be specified—

(a) as either—

(i) normal-class, in accordance with Clause 1.5.3; or

(ii) special-class, in accordance with Clause 1.5.4; or

(b) by strength grade or other readily verifiable parameter by which compliance with the specification can be assessed.

NOTE: Standard strength grades should be specified wherever possible.

### 1.5.2 Standard strength grades

The standard strength grades are compressive strength grades and their corresponding design characteristic strengths shall be as given in Table 1.1.

For concrete strength up to 50 MPa, it shall be permissible to specify strength grades other than the standard grades, in which case the concrete shall be special-class and Clause 1.5.4 shall then apply. For concrete strength greater than 50 MPa, the concrete shall be of special-class concrete.

**TABLE 1.1**

**STANDARD STRENGTH GRADE**

| Standard grade | Design characteristic compressive strength after 28 days of standard curing ($f'_c$) MPa |
|---|---|
| 20 | 20 |
| 25 | 25 |
| 32 | 32 |
| 40 | 40 |
| 50 | 50 |
| 65 | 65 |
| 80 | 80 |
| 100 | 100 |

### 1.5.3 Normal-class concrete

#### 1.5.3.1 *General*

Normal-class concrete shall be specified only by the parameters given in Clause 1.5.3.2, and shall have the following attributes:

(a) A mass per unit volume in the range 2100 kg/m$^3$ to 2800 kg/m$^3$ when determined in accordance with AS 1012.12.1 in the saturated, surface-dry condition.

(b) Acid-soluble chloride and sulfate contents within the limits given in Clause 2.7, when determined in accordance with Clause 5.5.2.

(c) A shrinkage strain not exceeding $1000 \times 10^{-6}$, when determined in accordance with Clause 5.6 after 56 days drying.

NOTE: This maximum value of $1000 \times 10^{-6}$ is consistent with the use for design purposes of a median basic shrinkage strain value of $850 \times 10^{-6}$.

(d) A mean compressive strength at 7 days, assessed in accordance with Clause 5.7, of not less than the values shown in Table 1.2.

(e) A cement complying with AS 3972 alone or in combination with one or more supplementary cementitious materials.

(f) No lightweight aggregate as defined in AS 2758.1.

#### 1.5.3.2 *Basic parameters*

The following basic parameters shall be specified by the customer:

(a) A standard strength grade selected from Table 1.1 and designated as one of N20, N25, N32, N40 or N50.

(b) The slump at the point of acceptance, selected as one of 20 mm, 30 mm, 40 mm, 50 mm, 60 mm, 70 mm, 80 mm, 90 mm, 100 mm, 110 mm or 120 mm.

NOTES:

1 The customer should carefully consider that the specified slump of concrete suits the placement method.

2 For residential slabs and footings, if the slump is not specified by the customer, the specified slump should be considered to be 100 mm.

(c) The maximum nominal size of aggregate, selected as one of 10 mm, 14 mm or 20 mm. Unless otherwise specified, the default value shall be taken as 20 mm.

(d) The intended method of placement, including relevant details of equipment.

(e) If project assessment is required to be carried out by the supplier (see Note).

NOTE: If unspecified, it will be assumed that project assessment is *not* required.

(f) If required, a level of air entrainment up to a maximum of 5.0%.

**TABLE 1.2**

**MEAN 7 DAY COMPRESSIVE STRENGTHS**

| Grade designation | Mean 7 day strength (MPa) |
|---|---|
| N20 | 9 |
| N25 | 12 |
| N32 | 16 |
| N40 | 20 |
| N50 | 25 |

### 1.5.4 Special-class concrete

Concrete other than normal-class concrete shall be specified by the customer as special-class and, if applicable, by strength-grade.

Where concrete is specified as special-class and a strength-grade is applicable, the following shall be used as prefixes to the strength grade:

(a) S, where compressive strength testing is required.

(b) SF, where flexural strength testing is required.

(c) ST, where indirect-tensile strength is required.

Where concrete is specified a special class and one of the exposure classifications B1, B2, C1, C2 or U specified in AS 3600 is applicable, the following shall be used as prefixes to the strength grade:

(i) SB, for concrete in exposure classification B2.

(ii) SC, for concrete in exposure classification C1 or C2.

(iii) SU, for concrete in exposure classification U.

For concretes designated as SB, SC or SU, the properties specified shall include—

(A) the aggregate durability class in accordance with AS 2758.1; and

(B) the relevant requirements of AS 3600.

For concrete strength greater than 50 MPa, the concrete shall be special class and shall be subject to the provisions of this Clause.

Where concrete is specified as special-class and any property other than strength grade is specified as the principal criterion, or the proportions of the mix are specified, it shall be designated by an appropriate alphanumeric code, agreed between the supplier and the customer to indicate the criterion.

Any departures from the parameters or composition, or both, of normal-class concrete and any other criteria or limitations shall be specified by the customer in consultation with the supplier.

NOTE: A summary list of several such parameters, some or all of which may be specified for the production of special-class concrete for a project, is given in Appendix B.

Other requirements additional to these parameters may be specified.

## 1.6 METHODS OF ORDERING

Concrete shall be ordered as normal-class or special-class, as appropriate to its intended use and, if ordered as special-class, shall be further qualified as a performance order or a prescription order. The order shall specify the parameters given in Clauses 1.5.3.2 or 1.5.4, as appropriate.

## 1.7 BASIS OF SUPPLY

### 1.7.1 General

The basis of supply shall be as follows:

(a) Where normal-class or special-class performance concrete has been ordered—

  (i) the volume of plastic concrete, determined in accordance with Clause 1.7.2; and

  (ii) the quality of the supplied concrete, determined in accordance with the relevant clauses of Section 5.

(b) Where special-class prescription concrete has been ordered—

  (i) the volume of the plastic concrete, determined in accordance with Clause 1.7.2; and

  (ii) a warranty that the specified prescription has been met.

(c) Where the customer or his agent adds ingredients to the concrete, the basis of supply and any performance requirements shall be agreed between the parties concerned and the appropriate requirements of Item (a) or (b) shall apply. In the absence of such agreement, the basis of supply shall be that the proposed mix constituents be complied with.

### 1.7.2 Volume of plastic concrete

The volume, in cubic metres, of plastic concrete supplied shall be determined from the total mass of the concrete divided by the average mass per cubic metre. If the volume so determined is not less than 98% of the volume specified on the identification certificate, the specified volume shall be deemed to have been supplied.

When three or more deliveries are made and testing for volume has been specified, the average mass per cubic metre shall be calculated as the mean of the values of the mass per unit volume of at least three samples of the concrete, where each sample is taken from a different delivery and the mass per unit volume of each sample is determined in accordance with AS 1012.5.

If less than three deliveries are made the average mass per cubic metre shall be calculated as the mean of the values of the mass per unit volume of samples.

NOTES:

1 The method of determining the total mass will need to be specified if the supplied volume is intended to be verified at any time.

2 The in situ measured volume may differ from the volume of plastic concrete as determined above, as a result of handling and compaction and the effects of hardening, temperature changes, formwork deflection, spillage and other relevant factors.

### 1.7.3 Identification certificate

The customer shall be furnished with an identification certificate, pertaining to the particular quantity of concrete supplied, on which the following information is recorded as appropriate:

(a) Name of supplier, and place of manufacture.

(b) Serial number of certificate.

(c) Date of supply.

(d) Name of customer.

(e) Project name and location.

(f) Delivery vehicle identification, if applicable.

(g) Quantity of concrete covered by the certificate.

(h) Specified class and strength grade, or other mix identification.

(i) Specified slump, if applicable.

(j) Maximum nominal size of aggregate.

(k) Time of commencement of mixing.

(l) For concrete specified by water-cement ratio, the estimate of the quantity of water, if any, added after completion of batching and whether the addition occurred before, or after, commencement of discharge; or for concrete specified by slump, the estimate of quantity of water added after commencement of discharge.

(m) Any other detail that may be agreed between the customer and the supplier.

# SECTION 2 CONCRETE CONSTITUENTS

## 2.1 GENERAL

The materials used in the production of concrete shall comply with the appropriate clauses of this Section.

## 2.2 CEMENT CONSTITUENTS

### 2.2.1 Portland cement

Portland cement shall comply with AS 3972.

### 2.2.2 Blended cement

Blended cement shall comply with AS 3972.

### 2.2.3 Fly ash

Fly ash shall comply with AS 3582.1.

### 2.2.4 Ground slag

Ground slag shall comply with AS 3582.2.

### 2.2.5 Amorphous silica

Amorphous silica shall comply with AS 3582.3.

## 2.3 AGGREGATES

A2 Aggregates shall comply with AS 2758.1 and any durability requirements that may need to be specified, as provided in AS 2758.1 for a particular use or performance. Where risk of expansion due to alkali aggregate reaction has been identified, action shall be taken to minimize potential expansion as stated in Clause 2.8.

## 2.4 MIXING WATER

Mixing water shall be drawn from a source of acceptable quality.

Mixing water shall be deemed to be of acceptable quality if—

(a) test result and service records of concrete made with that water indicate that it is not injurious to the strength or durability of the concrete or of the materials embedded in it; or

(b) it has been suitably tested in a laboratory and the test results are within the limits given in Table 2.1 or Table 2.2.

In Table 2.1, the samples for comparison of properties shall be taken from two separate batches of concrete manufactured from identical weights and proportions of ingredients drawn from the same sources, except that the water used in the batch from which the control sample is taken shall be drawn from a stable reticulated drinking water supply.

Water recycled from mixer washout operations may be used as mixing water if it is first stored in accordance with Clause 3.2.3 and the water drawn from the storage outlet is of acceptable quality.

For sources other than water drawn from a stable reticulated drinking water supply, mixing water may contribute significant levels of undesirable dissolved salts such as chlorides and sulfates. Mandatory testing for reportable properties, when needed to calculate levels of chlorides and sulfates in accordance with Clause 2.7, are given in Table 2.3. The test result shall be valid for a period of 6 months after tests.

TABLE 2.1

PROPERTY LIMITS FOR CONCRETE MADE WITH WATER FROM A SOURCE WITH NO SERVICE RECORD

| Property | Limits | Test method |
|---|---|---|
| 7 d and 28 d compressive strength | ≥90% of control sample strength at the corresponding age | AS 1012.9 |
| Time of initial set | From 60 min earlier to 90 min later than control sample time | AS 1012.18 |

TABLE 2.2

LIMITS FOR IMPURITIES IN MIXING WATER

| Impurity | Maximum concentration | Test method |
|---|---|---|
| Sugar | 100 mg/L | AS 1141.35 |
| Oil and grease | 50 mg/L | APHA 5520 |
| pH | >5.0 | AS/NZS 1580.505.1 |

TABLE 2.3

REPORTABLE PROPERTIES FOR IMPURITIES IN MIXING WATER

| Property | Test method |
|---|---|
| Total dissolved solids | AS 3550.4 |
| Chloride as Cl | APHA 4500 |
| Sulfate as $SO_3$ | AS 1289.4.2.1 |
| Sodium equivalent | APHA 3500 |

## 2.5 CHEMICAL ADMIXTURES

Chemical admixtures shall comply with AS 1478.1 and shall be used in accordance with this Standard and the admixture manufacturer's recommendations.

Admixtures that are not compatible shall not be used in the same volume of mixed concrete.

## 2.6 OTHER MATERIALS

Other materials, such as fibres, pigments and special additives, shall be used in accordance with the material manufacturer's specifications. Materials that are not compatible shall not be used in the same volume of plastic concrete.

## 2.7 LIMITATIONS ON CHEMICAL CONTENT OF CONCRETE

### 2.7.1 Chemical admixtures

Chemical admixtures added to concrete shall comply with AS 1478.1.

Chemical admixtures that contain significant chlorides as defined in AS 1478.1 shall not be added to concretes in exposure classifications B1, B2, C1, C2 and U specified in AS 3600, or to any concretes that are prestressed, steam cured, colour controlled, contain dissimilar metals, metallic fibres or finishes, or are in contact with permanent metal formwork.

Other chemicals shall not be added to concrete unless it can be demonstrated that the resulting concentration of soluble ions does not adversely influence the concrete, reinforcement, tendons, ducts, cast-in insert or other embedded items.

### 2.7.2 Sulfate content

The acid-soluble sulfate-ion content of the hardened concrete, reported as $SO_3$, shall not exceed 50 g/kg of cement when sampled and tested in accordance with Clause 5.5.

### 2.7.3 Chloride content

For concretes designed to meet exposure classifications A1 and A2, and which contain reinforcement, tendons, ducts, cast-in inserts, embedded items or other items that require protection, the acid soluble chloride content of concrete shall not exceed 0.8 kg/m$^3$ when sampled and tested in accordance with Clause 5.5. For concretes designed to meet other exposure classifications and containing materials requiring protection, the acid soluble chloride content of concrete shall not exceed the lesser of 0.8 kg/m$^3$ or the customer's specified limits.

Concretes that do not contain reinforcement, tendons, ducts, cast-in inserts, embedded items or other items that require protection shall—

(a) be classified as special class; and

(b) have an acid soluble chloride ion content of concrete not exceeding 2.0 kg/m$^3$ or the customer's specified limits.

NOTES:

1 Other maximum chloride contents may be specified for concrete where appropriate.

2 Where large volumes or combinations of admixtures are added to concrete, admixtures complying with AS 1478.1 containing insignificant levels of chloride may contribute substantial chlorides to concrete. In this case, appropriate maximum chloride limits should apply.

## 2.8 ALKALI AGGREGATE REACTION

A2 Where concrete contains aggregates identified in AS 2758.1 as reactive or slowly reactive, suitable mitigative measures for the design of the concrete shall be implemented to mitigate the potential expansion due to alkali aggregate reactivity.

NOTE: A description of suitable measures to mitigate potential expansion can be found in HB 79.

# SECTION 3 PLANT AND EQUIPMENT

## 3.1 GENERAL

All equipment related to the storage of materials and manufacture of concrete shall be identified, arranged, designed, constructed and maintained to prevent contamination by any other materials that will have an adverse effect on the performance of the concrete or result in the uncontrolled intermingling or mixing of different types of constituents.

## 3.2 STORAGE CONTAINERS

### 3.2.1 Cement and supplementary cementitious material

Storage containers for holding cement or supplementary cementitious material shall be provided with a means of accurately controlling the discharge and shall be designed and constructed, as far as is practicable—

(a) to keep the contents dry and free from contamination; and

(b) to promote free flow and complete discharge of their contents.

A storage enclosure that may be used for more than one type of constituent shall be capable of being cleaned out thoroughly and inspected internally.

### 3.2.2 Aggregate

Storage containers for holding aggregates shall have sufficient compartments for each type and nominal size of aggregate required for the concrete being manufactured and shall be arranged to facilitate free drainage and to prevent uncontrolled intermingling or mixing of different types, or different nominal sizes. Each compartment shall be—

(a) provided with a means of controlling the discharge; and

(b) designed and constructed to promote free flow and complete discharge of the contents with minimum segregation.

### 3.2.3 Water

If storage of water is required, water shall be stored in a manner that will prevent contamination.

### 3.2.4 Chemical admixtures

Each chemical admixture shall be stored separately in a manner that will prevent deterioration and accidental misuse or contamination of, or by, other concrete materials. In the case of liquids, adequate provision shall be made to prevent precipitation and segregation, and to protect them in accordance with the manufacturer's specifications.

Where a storage container is intended to be re-used for the same or a different type of admixture, it shall be capable of being cleaned out thoroughly and inspected internally.

## 3.3 WEIGHING EQUIPMENT

### 3.3.1 Indicating devices

All weighing equipment shall be provided with a visual weight-indicating device that shall be clearly visible to the operator in control of the equipment. Indication of weight increments shall be compatible with the order of accuracy of the production process, and the total weight to be measured at any one weighing.

### 3.3.2 Accuracy

Weighing equipment shall be accurate to ±0.4% or less of the maximum scale value when statically load-tested.

Calibration for accuracy shall be carried out on a regular basis by an accredited organization and at a frequency that accounts for the type of equipment and the quantity of concrete produced in the period between calibrations but not less frequently than once every six months.

When requested by the customer, the supplier shall make available the most recent documentary evidence of the accuracy of the weighing equipment.

### 3.3.3 Weigh-hoppers

Weigh-hoppers for batch production shall be designed and constructed—

(a) to promote free flow and complete discharge of their contents; and

(b) to be capable of receiving their full rated load without contact between the materials being weighed and the charging mechanism.

### 3.3.4 Continuous feed weighers

Feed weighers for continuous production shall be designed and constructed—

(a) to minimize the effects of impact and vibration; and

(b) to prevent contact between the materials being weighed and any fixed part of the weighing mechanism.

## 3.4 LIQUID DISPENSING EQUIPMENT

### 3.4.1 Indicating devices

All liquid metering equipment shall be provided with a visual indicating device, which shall be clearly visible to the operator in control of the equipment.

### 3.4.2 Accuracy of metering

For water metering equipment installed at the manufacturing plant, the equipment installed at the manufacturing plant shall measure the volume or weight of water added to the mix to an accuracy of ±2%, or less, of the value shown on the indicating device. All other liquid metering equipment shall measure the volume, or weight of liquid, to an accuracy of ±5%, or less, of the indicated value.

Calibration for accuracy shall be carried out at a frequency that accounts for the type of equipment and the quantity of concrete produced in the period between calibrations, but not less frequently than once every six months.

When requested by the customer, the supplier shall make available the most recent documentary evidence of the accuracy of the metering equipment.

### 3.4.3 Maintenance

The equipment shall be cleaned at least as regularly as recommended by its supplier, and between changes in types of liquids, or between changes to different brands of the same type.

## 3.5 MIXERS

### 3.5.1 General

Batch mixers and continuous mixers shall comply with the following and Clause 3.5.2 or Clause 3.5.3, as appropriate:

(a) *Performance* When operated at or below their rated mixing capacity, mixers shall be capable of thoroughly mixing all the concrete materials within a specified interval of time, so that the ingredients are uniformly distributed throughout the volume of mixed concrete.

A mixer shall be deemed to comply with this requirement provided the following criteria have been met:

(i) It is one of a series or a model of which at least one prototype has been tested and found to comply with all the criteria of Paragraph A4, when assessed in accordance with Appendix A for three batches using a concrete mix with a slump in the range of 40 to 80 mm, and has not been altered as to design, or has not undergone a major repair (e.g., design alteration) of the components of the mixing mechanism, since original manufacture.

(ii) It has undergone a major repair of its components forming the mixing mechanism (e.g., design alteration) since original manufacture and, since that repair, has been tested and found to comply with all the criteria of Paragraph A4 when assessed in accordance with Appendix A for three batches using a concrete mix with a slump in the range of 40 to 80 mm.

(iii) It has been inspected at a frequency of 6 months or after 2300 $m^3$ of production, whichever comes first, and—

(A) the mixing mechanism has not become worn such that protection to the free edges has been lost;

(B) holes have not formed in the rotating parts;

(C) any concrete adhering to the mechanism, or to the interior surface of the mixing chamber, has been substantially removed; and

(D) the mixer can achieve the required revolutions per minute, in mixing mode, as stated on the mixer identification plate when loaded to not less than 90% of the manufacturer's rated mixing capacity.

(b) *Non-complying mixers* Non-complying mixers shall not be used for the supply of concrete. A mixer shall be deemed to be non-complying if, for a batch mixer, either one of the following applies, or for a continuous mixer Item (ii) only applies:

(i) The minimum mixing time, determined in accordance with Clause 3.5.2.4, exceeds 5 m.

(ii) The mixer is not capable of operating at more that half the rated mixing capacity.

(c) *Mixer maintenance and repair* In order to preserve a mixer's efficiency, mixers shall be regularly cleaned, examined and maintained to remove the build-up of hardened concrete in the mixing chamber and to rectify wear of the mixing mechanism. If non-uniformity of mixing due to wear is apparent, the mixer shall be repaired and, if the repair is major (i.e., design alteration), the mixer shall be retested as set out in Appendix A to confirm it meets the requirements of Clause 3.5.1(a)(ii) before being re-used (see Note).

If minor maintenance that does not alter the original design has been carried out on the mixer or routine periodic assessment for compliance with Item (a) is required, the mixer shall be deemed to comply if it is tested in accordance with Appendix A and the test results for slump, air content and mass per unit volume are within the corresponding limits given in Items (a), (b) and (c) of Table A1 of Appendix A.

NOTE: Uniformity of mixing can be seriously affected by the method of charging the mixer. If wear is minimal, this should be investigated before carrying out repairs or routine uniformity tests on the mixer.

(d) *Records* Records shall be maintained by the supplier to verify that the inspections, maintenance and testing have been carried out in accordance with Items (a)(ii), (a)(iii) and Item (c). These records shall be available to the customer on request.

(e) *Identification plates* Each mixer shall have permanently affixed to it (in a prominent place) a metal plate, which shall be clearly inscribed with at least the following:

(i) The equipment manufacturer's name.

(ii) A model and serial number that identifies the particular mixer.

In addition, identification plates for batch mixers and continuous mixers shall be inscribed with additional requirements specified in Clauses 3.5.2.5 and 3.5.3.2 respectively.

### 3.5.2 Batch mixers

#### 3.5.2.1 *Mixer controls*

Batch mixers shall be provided with the means for selecting appropriate speeds for mixing, discharging and, if applicable, agitating each batch.

#### 3.5.2.2 *Rated mixing capacity*

Unless it can be otherwise demonstrated by testing in accordance with Appendix A, the rated mixing capacity of a batch mixer shall be not more than 65% of the gross internal volume of the mixing chamber.

If a batch mixer is operated as an agitator, for this purpose only, the rated agitating capacity may be taken as not more than 80% of the gross internal volume of the mixing chamber.

#### 3.5.2.3 *Minimum mixing criteria*

The minimum number of revolutions of the mixing mechanism shall be as determined from the mixer manufacturer's recommendations, unless determined in accordance with Clause 3.5.2.4.

#### 3.5.2.4 *Determination of minimum mixing time or number of revolutions*

The mixer uniformity test referred to in Appendix A for slump, air content and mass per unit volume shall be carried out on a batch mixer for given concrete mixes—

(a) to confirm the mixer manufacturer's recommended minimum number of revolutions or minimum mixing time at the mixer manufacturer's rated capacity and mixing speed; or

(b) to determine an acceptable minimum number of revolutions or minimum mixing time at the mixer manufacturer's rated capacity, or at a different working capacity, at the mixer manufacturer's recommended mixing speed.

If the uniformity test is used to confirm a recommended minimum mixing time, the required samples shall be obtained immediately after the nominated mixing time. If the uniformity test is used to determine an acceptable minimum mixing time, the acceptable time for a given capacity shall be taken as the least time at which the uniformity requirements of Appendix A are met, but in no case shall this be more than 5 min.

#### 3.5.2.5 *Identification plates*

Identification plates for batch-mixers shall be in accordance with Clause 3.5.1(d) and inscribed with the following additional information (see also Figure 3.1):

(a) The gross internal volume of the mixing chamber ($m^3$).

(b) The rated mixing capacity ($m^3$).

(c) The recommended minimum—

  (i) number of revolutions of the mixing mechanism required to achieve uniformity; or

  (ii) mixing time, in minutes, and the corresponding rotational speed of the mixing mechanism, in revolutions per minute.

(d) If the mixer is designed to be used also as an agitator, the rated agitating capacity and speed of the mixing mechanism in revolutions per minute.

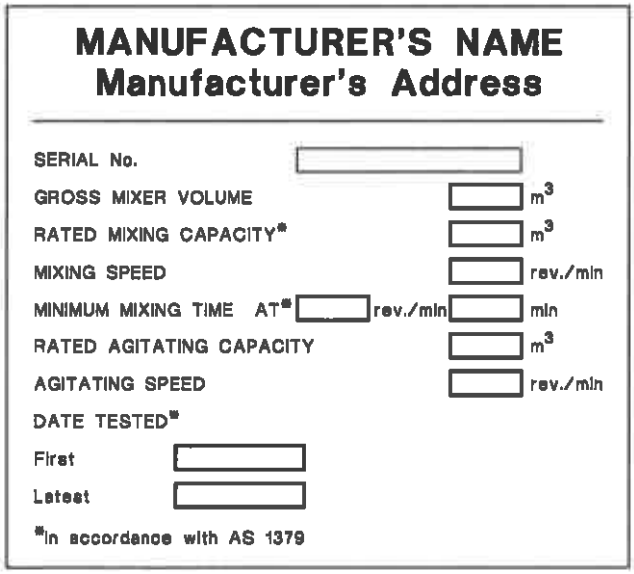


FIGURE 3.1 SAMPLE IDENTIFICATION PLATE FOR BATCH MIXERS

### 3.5.3 Continuous mixers

#### 3.5.3.1 *Charging rate*

The rate of charging ingredients into a continuous mixer shall be adjusted so that—

(a) the mixer manufacturer's specified discharge capacity is not exceeded; and

(b) the mixer uniformity tests carried out in accordance with Appendix A are passed.

#### 3.5.3.2 *Identification plates*

Identification plates for continuous mixers shall be in accordance with Clause 3.5.1(d) and inscribed with the maximum discharge rate, in tonnes per hour.

# SECTION 4 PRODUCTION AND DELIVERY

## 4.1 GENERAL

### 4.1.1 Production processes

Concrete shall be produced either by—

(a) the batch-production process, in accordance with Clause 4.2; or

(b) the continuous production process, in accordance with Clause 4.3.

### 4.1.2 Method of measuring quantities of ingredients

In both batch and continuous production processes, the quantities of ingredients to be used, other than liquid ingredients, shall be measured by mass, except that where the required 28 day characteristic compressive strength is 15 MPa or less, the quantities of ingredients to be used may be measured by volume. The quantities of liquid ingredients may be measured by mass or by volume.

### 4.1.3 Bases for determinations of mass

The mass of each ingredient shall be determined as follows:

(a) The mass of cement shall be determined on an air-dry basis.

(b) The mass of aggregates shall be determined on a saturated surface-dry basis.

(c) The total mass of added water required shall be determined taking due account of the presence or absence of—

(i) free moisture on the surfaces of the aggregates; and

(ii) water in the mixing chamber.

The mass of water to be added to the solid ingredients shall be adjusted accordingly.

### 4.1.4 Method of batching ingredients

Cumulative batching in one weighing device is permissible only if the required mass of each ingredient is consecutively introduced to the weighing device.

### 4.1.5 Sequence of introduction of materials

The sequence and timing of the introduction of ingredients into the mixer shall be such as to realize the required properties of the concrete. Chemical admixtures and additives shall be added—

(a) in accordance with the manufacturer's specification;

(b) so that liquid admixtures do not come in contact with dry ingredients;

(c) so that in their concentrated form they do not come into contact with other incompatible admixtures or additives;

(d) so as to achieve full dispersion within the mix; and

(e) in such a way as to not cause any adverse consequences in the mixed concrete.

### 4.1.6 Records

Records shall be maintained, for at least 12 months, of the source, type and target quantity of each ingredient used in the production of each volume of concrete identified by the serial number of the relevant identification certificates (see Clause 1.7.3). Records shall also be kept of the date and time of any plant malfunction.

## 4.2 BATCH PRODUCTION

### 4.2.1 Tolerances on batch ingredients

#### 4.2.1.1 *Ingredients other than water*

The quantity of each ingredient in a batch shall be measured and controlled within the tolerances given for each ingredient in Table 4.1, in which $Q$ is the volume of plastic concrete produced from the batched ingredients.

NOTE: Where different nominal size aggregates are combined to form either the coarse or fine aggregate fractions, the tolerance for each fraction given in Table 4.1 applies to the fraction as a whole and not to its individual size components. The tolerance on the total quantity of all aggregates is an additional overall requirement.

**TABLE 4.1**

**PERMISSIBLE TOLERANCES ON BATCH INGREDIENTS OTHER THAN WATER**

| Ingredient | Tolerance | | | |
|---|---|---|---|---|
| | Weight batching for batch size $Q$ | | | Volume batching |
| | $Q < 2$ m$^3$ | $2 \le Q \le 4$ m$^3$ | $Q > 4$ m$^3$ | |
| Each cementitious ingredient | −5 +30 kg | −10 +30 kg | −20 +40 kg | ±1% |
| Total cementitous materials | −5 +30 kg | −10 +30 kg | −20 +40 kg | ±1% |
| Fine aggregate | −75 +50 kg | ±75 kg | ±100 kg | ±2% |
| Coarse aggregate | −75 +50 kg | ±75 kg | ±100 kg | ±2% |
| Total aggregate | −75 +50 kg | ±75 kg | ±100 kg | ±2% |
| Chemical admixtures | ±5%* | ±5%* | ±5%* | ±5%* |

* or 20 mL, whichever is greater

#### 4.2.1.2 *Water*

Control of the quantity of water added to a batch shall be achieved by one of the following methods:

(a) *By control of slump* Unless otherwise specified, the addition of water to the batch shall be controlled so that the specified slump is achieved within the tolerances given in Clause 5.2.3. The specified slump shall be the supplier's target.

(b) *By control of water-cement ratio* Where the ratio of total water to cement has been specified, the quantity of added water shall be controlled so that the ratio in the mix is maintained within ±10% of the specified value. If a maximum water-cement ratio has been specified, this value shall not be exceeded.

Where water-cement ratio is specified, regular moisture content of aggregate calibrated to standard test in accordance with AS 2758.1 shall be taken.

### 4.2.2 Batch mixing

#### 4.2.2.1 *General*

Batch mixing shall be carried out by one of the following methods:

(a) Central mixing, in accordance with Clause 4.2.2.2.

(b) Mobile mixing, in accordance with Clause 4.2.2.3.

(c) Staged mixing, in accordance with Clause 4.2.2.4.

Mixers shall be charged and operated within the limits of capacity and mixing times determined in accordance with Clause 3.5.2.

Truck-mounted mixers shall be discharged to the point where only water and possibly a coating of mortar remains in the drum before charging with a new batch, except that fresh concrete may be added to concrete remaining in a truck-mounted mixer from a previous batch, provided the resulting composite batch satisfies all conditions of the specification for that concrete.

**4.2.2.2** *Central mixing*

Central mixing shall be carried out entirely in a mixer permanently located adjacent to the supplier's batching equipment. The mixer shall be charged with all the batch ingredients to not more than its rated capacity and operated at the specified mixing speed for at least the predetermined—

(a) minimum number of mixing revolutions; or

(b) minimum mixing time,

before being discharged.

The supplier shall maintain controls to ensure that Item (a) or (b) has been carried out.

The mixing time for each batch shall be measured from the time all the solid ingredients, 90% of the mixing water and all admixtures, except those are to be added at a later time, are in the mixer.

If there is an indication that adequate mixing is not being achieved, the mixer shall be tested in accordance with Clause 3.5.2.4 to determine—

(i) that the predetermined number of revolutions or mixing time complies with Appendix A; or

(ii) a revised number of revolutions or mixing time which complies with Clause 3.5.1(b) and Appendix A.

**4.2.2.3** *Mobile mixing*

Mobile mixing shall be carried out entirely in a truck-mounted drum mixer. The mobile mixer shall be charged with all the batch ingredients at the supplier's central batching plant to not more than its rated capacity and shall be operated at the specified mixing speed for at least the predetermined—

(a) minimum number of mixing revolutions; or

(b) minimum mixing time,

before being discharged.

The supplier shall maintain controls to ensure that Item (a) or (b) has been carried out.

The mixing time for each batch shall be measured from the time all the solid ingredients, 90% of the mixing water and all admixtures, except those to be added at a later time, are in the mixer.

If there is an indication that adequate mixing is not being achieved, the mixer shall be tested in accordance with Clause 3.5.2.4 to determine—

(i) that the predetermined number of revolutions or mixing time complies with Appendix A; or

(ii) the revised number of revolutions or mixing time required to comply with Clause 3.5.1(c).

#### 4.2.2.4 *Staged mixing*

Staged mixing may be carried out by either one of the following procedures:

(a) Partially mixing all the batch ingredients by central mixing, transferring the partially mixed batch to a mobile mixer and completing the mixing in the mobile mixer prior to discharge. At each stage, the mixer shall be operated at the specified mixing speed so that the total mixing time for the batch is not less that the greater of the minimum mixing time for each of the mixers.

(b) Charging a mobile mixer with some of the ingredients at the supplier's central batching plant and adding the remaining ingredients and remixing the batch in the mobile mixer at another location. At each stage, the mixer shall be operated at the specified mixing speed for the minimum mixing time.

The mixing time for each stage shall be measured from the time all the solid ingredients, 90% of the mixing water and all admixtures for that stage, except those to be added at a later time, are in the mixer.

For any subsequent mixing prior to discharge, the mobile mixer shall be operated at the specified mixing speed.

### 4.2.3 Addition of water to a mixed batch

Water may be added to a mixed batch only by the supplier unless otherwise specified (see Clause 1.8) at any time, but no later than 75 min or 80% of an agreed extended period for completion of discharge in accordance with Clause 4.2.5, whichever is the greater, from the time that all ingredients are in the mixer, and provided all the relevant following conditions are satisfied:

(a) Immediately after the addition of water, the mixer shall be operated at the rated mixing speed for a time equivalent to at least 30 revolutions of the mechanism, and for such additional time as may be necessary to re-establish uniformity of the mix.

(b) If water is added after the commencement of discharge of a batch, this fact and the estimated quantity of water so added shall be recorded on the identification certificate for that batch. The discharge of the minimum quantity needed to enable a sample to be taken for a slump test or to assess the slump shall not be deemed to constitute commencement of discharge.

(c) If a slump has been specified, then immediately after condition (a) has been satisfied, the slump of the remaining portion of the batch shall be assessed and the requirements of Clause 5.2.3 shall apply.

(d) If the batch is to be sampled and tested, then the sample shall be taken after the addition of water.

(e) If a water-cement ratio or maximum water-cement ratio has been specified, the quantity of water added shall be such that the tolerance on the specified ratio or the maximum specified ratio is not exceeded.

### 4.2.4 Addition of admixtures and other materials to a mixed batch

Admixtures or other materials may be added to a mixed batch only by the supplier (unless otherwise specified) at any time prior to the completion of discharge of the batch, provided all the relevant following conditions are satisfied:

(a) The addition shall be performed in accordance with the specifications of the supplier of the admixture or other materials.

(b) Immediately after the addition, the mixer shall be operated at the rated mixing speed for a time equivalent to at least 30 revolutions of the mechanism, and for such additional time as may be necessary to re-establish uniformity of the mix.

(c) The type of addition and quantity shall be recorded on the identification certificate for that batch.

(d) If the addition is to modify slump, then immediately after condition (b) has been satisfied, the slump of the remaining portion of the batch shall be assessed and the requirements of Clause 5.2.3 shall apply.

(e) If the batch is to be sampled and tested, the sample shall be taken after the addition.

(f) The requirements of Clause 1.7.1(c) shall be applied where the customer carries out the addition.

#### 4.2.5 Period for completion of discharge

Discharge of all the concrete in a batch shall be completed within 90 min from the commencement of mixing as specified in Clause 4.2.2.2, Clause 4.2.2.3 or Clause 4.2.2.4, or before proper placement and compaction of the concrete can no longer be accomplished, whichever occurs first.

The 90 min limitation may be waived by agreement between the customer and the supplier if, after that period, the consistency of the concrete is such that it can be properly placed and compacted without the addition of any more water to the mixer.

NOTE: In hot dry weather, or other ambient conditions contributing to premature stiffening, initial set may occur at less than 90 min from commencement of mixing and the period available for placement and compaction may be likewise reduced. Conversely, in cold weather it may be possible to increase the limit.

### 4.3 CONTINUOUS PRODUCTION

#### 4.3.1 Feeding materials

##### 4.3.1.1 *Solid ingredients*

Solid ingredients shall be drawn from appropriate storage containers and discharged via continuous feeders onto a charging feeder. The storage containers and their associated feeders shall be arranged so that the mass flow rate of each ingredient, in kilograms per unit time, can be continuously measured and controlled. The charging feeder shall be arranged to feed all the solid ingredients, in the required proportions, into the mixing chamber at an appropriate charging rate.

##### 4.3.1.2 *Liquid ingredients*

Liquid ingredients shall be introduced into the mixing chamber via metering equipment that allows continuous measurement and control of the flow rate.

##### 4.3.1.3 *Accuracy of flow rates for cementitious materials*

Mass flow rates for each individual cementitious material and for the total of all cementitious materials shall be within −1% to +5% of the required rate.

##### 4.3.1.4 *Accuracy of flow rates for coarse, fine and total aggregates*

Mass flow rates for coarse, fine, and total aggregates shall be within −4% to +2% of the required rate.

#### 4.3.2 Mixing

The mixer shall be run so that it produces plastic concrete at a rate not greater than the equipment manufacturer's specified capacity.

If there is an indication, either by the appearance or consistency of the concrete, that adequate mixing is not being achieved, appropriate corrective action shall be taken and the mixer tested for uniformity, in accordance with Appendix A, until the conditions for adequate mixing have been re-established.

## 4.4 DELIVERY

### 4.4.1 General

Where the supplier contracts, or otherwise agrees, to deliver plastic concrete to a point of acceptance other than the place of manufacture, the concrete shall be transported to the acceptance point in a manner that will prevent segregation, loss of material or premature stiffening.

### 4.4.2 Temperature at point of delivery

Unless otherwise specified, delivered concrete shall have a temperature at the acceptance point of not less than 5°C nor greater than 35°C.

NOTE: Where the ambient temperature is below 10°C or above 30°C, appropriate measures may need to be adopted to comply with the requirements of this Clause.

### 4.4.3 Duration of delivery

The duration of delivery shall be limited to the extent that the requirements of Clause 4.2.5 are satisfied.

# SECTION 5 SAMPLING AND TESTING OF CONCRETE

## 5.1 GENERAL

### 5.1.1 Sampling and testing

Concrete shall be sampled in the plastic state and tested for compliance with particular quality parameters, in accordance with the following:

(a) The frequency of sampling shall be as given in this Section and, unless otherwise specified herein, the method of sampling shall be in accordance with AS 1012.1.

(b) The particular quality parameters required or specified to be determined by testing are—

(i) slump, in accordance with Clause 5.2;

(ii) strength, in accordance with Clause 5.3;

(iii) air content, in accordance with Clause 5.4;

(iv) chloride and sulfate content in accordance with Clause 5.5;

(v) drying shrinkage, in accordance with Clause 5.6;

(vi) 7 day strength of normal-class concrete in accordance with Clause 5.7; and

(vii) other parameters in accordance with Clause 5.8.

(c) For the purposes of Items (b)(iv) and (b)(v) above, the most frequently supplied grade in a plant shall be sampled and tested every 6 months and whenever there is a significant change in the relevant attributes of a mix ingredient. Where the change is a reversion to an ingredient previously used in a mix and for which compliance has already been established, an exception shall be made.

NOTE: Alternative means of demonstrating compliance with this Standard are described in Appendix C.

### 5.1.2 Grouping of plants

For the purposes of—

(a) Clause 5.1.1(b)(ii), grouping of plants is permissible under the provisions of Clause 6.3.6; and

(b) Clause 5.1.1(b)(iv) and Clause 5.1.1(b)(v), where a supplier operates a group of plants for which there is an established service record under common local management and control, which use the same cement, similar admixtures and similar aggregates and which maintain similar mix proportions and similar production techniques in the manufacture of the standard grades, the group of plants may be treated as one plant.

### 5.1.3 Customer access

The customer shall be afforded all reasonable access for any agreed sampling and testing of the supplier's materials, or for inspection and testing of the plant and equipment. All such sampling, testing and inspections shall be conducted so as not to unnecessarily interfere with production.

## 5.2 SLUMP

### 5.2.1 Frequency of testing

The frequency of testing for slump shall be as follows:

(a) Where a strength grade is specified, a slump test shall be performed on each strength sample. Additional slump tests shall be performed when so required by Clause 4.2.3(c).

(b) Where slump is specified as the principal compliance criterion, the frequency of sampling shall also be specified.

### 5.2.2 Determination of slump

The slump of each sample of the concrete shall be determined from a slump test in accordance with AS 1012.3.1.

### 5.2.3 Compliance

The concrete represented by a sample shall be deemed to comply with the specified slump if the measured slump is within the limits given in Table 5.1 for the corresponding specified slump.

**TABLE 5.1**

**PERMISSIBLE TOLERANCE ON SLUMP**

| Specified slump, mm | Tolerance, mm |
|---|---|
| <60 | ±10 |
| ≥60 ≤80 | ±15 |
| >80 ≤110 | ±20 |
| >110 ≤150 | ±30 |
| >150 | ±40 |

### 5.2.4 Repeat tests for slump

If the initial measured slump is not within the limits specified in Clause 5.2.3, one repeat test shall be made immediately from another portion of the same sample or on another sample taken immediately. If the value obtained from the repeat test falls within the limits given in Table 5.1, the concrete represented by the sample shall be deemed to comply with the appropriate specified value.

## 5.3 STRENGTH

### 5.3.1 28 day characteristic strength

Sampling, testing and assessment of concrete for strength shall be carried out in accordance with the following:

(a) For concrete specified by compressive strength grade, in accordance with Section 6.

(b) For concrete specified by flexural or indirect (principal) tensile strength, in accordance with Section 6 for an equivalent mean compressive strength, provided—

  (i) the equivalent mean compressive strength is first determined from a relationship between mean compressive strength and mean flexural or indirect tensile strength, established from tests on at least one sample from each of three different compressive strength grades;

(ii) thereafter the relationship is monitored by taking and testing at least two samples in each production interval of concrete with the equivalent mean compressive strength and if markedly different, re-establish the relationship as in Item (i); and

(iii) from each sample required by Items (i) and (ii) above not less than two compressive test specimens and three flexure-test or three indirect tensile-test specimens are made and cured in accordance with AS 1012.8.1 and AS 1012.8.2, and tested in accordance with AS 1012.9, AS 1012.10 or AS 1012.11 as appropriate.

### 5.3.2 Strength other than 28 day characteristic strength

Where a strength other than a 28 day characteristic strength is required as the principal quality parameter this requirement shall be clearly and expressly stated in both the specification and the order. The specification shall contain the following information, in addition to the requirements of Clause 1.5.4 and Clause 1.6:

(a) The frequency of sampling in the production interval.

(b) The number and type of specimens to be obtained from each sample.

(c) Whether other than standard curing of the specimens is required and, if so, details of the conditions under which the specimens are to be cured.

(d) The name and number of the relevant Standard test to be carried out on the specimens.

(e) The method of control, which shall provide a reliable statistical operating characteristic so that—

(i) concrete with a proportion defective of 0.05 has a probability of acceptance of at least 50%; and

(ii) concrete with a proportion defective of 0.30 has a probability of rejection of at least 98%.

### 5.3.3 Compliance

The concrete represented by the strength samples shall be deemed to comply with the specified strength if—

(a) for concrete specified by compressive strength the relevant requirements of Section 6 are satisfied; or

(b) for concrete specified by flexural or indirect tensile strength the relevant requirements of Section 6, as applicable to the equivalent compressive strength, are satisfied.

### 5.3.4 Action to be taken on non-compliance

Concrete that does not comply with Clause 5.3.3 may be accepted as satisfactory for its intended purpose if—

(a) the supplier has a third-party audited and registered quality control system that complies with appropriate Australian or International standards, and can provide evidence from the production process that demonstrates that the low test results are within the limits of probable random variation;

(b) the supplier can demonstrate that the non-compliance was due to low test results during a specific interval and that the causes have been established so that concrete supplied outside that interval may be judged to comply with the requirements of Section 6; or

(c) alternative methods, mutually acceptable to all parties involved, can demonstrate the structure is fit for purpose.

The application of this Clause shall not be taken to mean compliance of the supplied concrete with the specified strength grade, only the acceptance of the concrete in place.

## 5.4 AIR CONTENT

### 5.4.1 Frequency of sampling

If a percentage of entrained air is specified, air-content samples shall be taken with every alternate strength sample.

### 5.4.2 Determination of air content

The air content of the concrete sample shall be determined in accordance with AS 1012.4.1.

### 5.4.3 Compliance

The concrete represented by a sample shall be deemed to comply with the specified air content if the measured air content is within 1.5% of the specified air content.

### 5.4.4 Repeat tests for air content

If the initial measured air content is not within the limits specified in Clause 5.4.3, one repeat test shall be made within 20 min from another portion of the same sample or on another sample. If the value obtained from the repeat test falls within the limits required by Clause 5.4.3, the concrete represented by the sample shall be deemed to comply with the appropriate specified values.

## 5.5 CHLORIDE AND SULFATE CONTENT

### 5.5.1 Frequency of sampling

The frequency of sampling for the determination of chloride and sulfate content shall be in accordance with Clause 5.1.1(c).

### 5.5.2 Determination of content

At the required frequency, one sample of the concrete mix to be tested shall be taken, from which two standard cylinder specimens shall be made and cured for 7 days in accordance with AS 1012.8.1.

The mass per unit volume ($P$), in kg/m$^3$ of the hardened cylinder specimens, shall be determined in accordance with AS 1012.12.1. Test specimens shall be prepared from the cylinder specimens and tested in accordance with AS 1012.20. The results so obtained shall be used to calculate—

(a) the chloride content (kg/m$^3$), by multiplying the percentage chloride content obtained from the AS 1012.20 test by the corresponding mass per unit volume obtained from the AS 1012.12.1 test; and

(b) the sulfate content, by dividing the percentage sulfate content obtained from the AS 1012.20 test by the ratio of weight of cement to the total dry weight of materials, these being calculated from the batch records for the sampled mix.

NOTE: Chloride and sulfate content may be obtained by proportional addition of the respective contents obtained from testing individual ingredients in the concrete in accordance with this Clause.

### 5.5.3 Compliance

The concrete represented by the samples shall be deemed to comply with the limitations on chemical content if the chloride and sulfate contents do not exceed the corresponding values given in Clause 2.7.

## 5.6 DRYING SHRINKAGE

### 5.6.1 Drying shrinkage of normal-class concrete

#### 5.6.1.1 *Frequency of sampling*

The frequency of sampling for the determination of drying shrinkage of normal-class concrete shall be in accordance with Clause 5.1.1(c).

#### 5.6.1.2 *Determination of shrinkage by field sampling*

Freshly mixed concrete shall be sampled, in accordance with AS 1012.1, at the point of discharge under the supplier's supervision. Casting, curing, storage, transport and demoulding of shrinkage specimens shall be carried out in accordance with AS 1012.13.

The drying shrinkage after 56 days drying shall then be determined in accordance with AS 1012.13, in a laboratory registered for that purpose.

#### 5.6.1.3 *Determination of shrinkage by laboratory mixing and testing*

A laboratory mix simulating as closely as possible the relevant field mix and conditions shall be prepared and sampled in accordance with AS 1012.2. Casting, curing, storage, transport and demoulding of shrinkage specimens shall be carried out in accordance with AS 1012.13.

The drying shrinkage after 56 days drying shall then be determined in accordance with AS 1012.13, in a laboratory registered for that purpose.

#### 5.6.1.4 *Compliance*

The concrete represented by a sample shall be deemed to comply with the shrinkage limitation if the mean value of the shrinkage strain, rounded to the nearest $50 \times 10^{-6}$, does not exceed the value given in Clause 1.5.3.1.

### 5.6.2 Drying shrinkage of special-class concrete

If a drying shrinkage less than that specified in Clause 1.5.3.1 is required, this requirement shall be clearly stated in the specification and the following shall apply:

(a) The concrete shall be sampled in accordance with AS 1012.1 or AS 1012.2, unless otherwise specified.

(b) Test specimens shall be prepared and the drying shrinkage determined in accordance with AS 1012.13.

(c) The specification shall also include the following:

  (i) The frequency of sampling.

  (ii) The duration of air-drying at which the shrinkage is to be determined (usually 56 days).

  (iii) An acceptable tolerance on the specified shrinkage strain.

## 5.7 7 DAY STRENGTH OF NORMAL-CLASS CONCRETE

The mean value of 7 day compressive strength for normal-class concrete required by Clause 1.5.3.1(d) shall be determined at the end of a production interval for the controlled grades using the mean of the available samples or on the basis of a moving average of three tests for other grades.

This value shall not be used for compliance with the strength grade but if below the value shown in Table 1.2, appropriate adjustment shall be made to the mix proportions.

## 5.8 OTHER PARAMETERS

If quality parameters other than those stated in Clauses 5.2 to 5.7 are specified, the method of production control and the criteria for compliance shall also be specified.

# SECTION 6 SAMPLING, TESTING AND ASSESSMENT FOR COMPLIANCE OF CONCRETE SPECIFIED BY COMPRESSIVE STRENGTH

## 6.1 GENERAL

All concrete specified by a compressive strength grade equal to or greater than 20 MPa, shall be—

(a) sampled in the plastic state and tested in accordance with Clause 6.2; and

(b) subject to production assessment by the supplier in accordance with Clause 6.3 or subject to an alternative method of assessment in accordance with Clause 6.6, as appropriate.

Production assessment shall be recorded, reported and disseminated by the supplier in accordance with Clause 6.4.

Where additional project assessment has been specified, the concrete supplied to the particular project(s) shall be assessed in accordance with Clause 6.5.

All concrete specified by compressive strength grade less than 20 MPa or specified with a principal characteristic strength at an age other than 28 days, where not covered elsewhere in the Standard, shall be sampled and tested in accordance with Clause 6.2 and subject to project assessment in accordance with Clause 6.5 or 6.6, as appropriate.

For the purpose of this Section, one month shall be taken as a period of not less than four or not more than five consecutive weeks.

## 6.2 SAMPLING AND TESTING

### 6.2.1 General

Sampling of plastic concrete and the making, curing and testing of cylinder specimens obtained from the samples shall be carried out in accordance with Clauses 6.2.2 to 6.2.4 respectively. The treatment of the resulting test data, for the purpose of determining sample strengths shall be in accordance with Clause 6.2.5.

### 6.2.2 Sampling

Manufactured concrete shall be sampled as follows:

(a) Samples shall be taken from the concrete as and when discharged after completion of mixing, but prior to any site handling.

(b) A sampling procedure in accordance with AS 1012.1 shall be adopted.

(c) The frequency of sampling shall be in accordance with Clause 6.3.3 or Clause 6.5.2, as appropriate.

### 6.2.3 Making and curing of cylinder specimens

From each sample intended for strength grade assessment, at least two standard cylinder specimens shall be made and cured in accordance with AS 1012.8.1 and AS 1012.8.2.

### 6.2.4 Testing of cylinder specimens

The compressive strength of each cylinder specimen shall be determined, recorded and reported in accordance with AS 1012.9.

If a cause for an unexpectedly high or low cylinder strength can be ascertained, or a cylinder strength is liable to be excluded from a sample strength in terms of Clause 6.2.5, or both, this information shall be included in the report and the relevant tested cylinders retained, for at least 14 days after the results are reported, to permit further examination.

### 6.2.5 Test strength of samples

#### 6.2.5.1 *Strength of sample*

The test strength of a sample shall be the average strength of those cylinders, taken from the sample and tested at the same age, which remain after the criteria in Clause 6.2.5.2 for acceptance of cylinder results has been applied.

#### 6.2.5.2 *Difference in strength*

If there is a difference between any two cylinder strengths in the sample exceeding 2 MPa for two cylinders in the sample or 3 MPa for three or more cylinders in the sample, the following actions shall be taken:

(a) If a cause for excessive differences between cylinder strengths can be ascertained and its effects assigned to particular cylinders, the strengths of the affected cylinders shall be excluded from the sample strength determination.

(b) If a cause for excessive differences between cylinder strengths can be ascertained, but its effects cannot be assigned to particular cylinders, cylinders that have less than 90% of the strength of the highest strength cylinders in the sample shall be excluded from the strength determinations for that grade.

(c) If no cause for excessive differences between cylinder strengths can be ascertained, the lowest cylinder strength shall be excluded from the sample strength determination.

## 6.3 PRODUCTION ASSESSMENT

### 6.3.1 Basic requirements of production control

#### 6.3.1.1 *General requirement*

The strength of a grade of concrete during a production interval shall be assessed for compliance in accordance with Clauses 6.3.1.2 to 6.3.1.5 and Clauses 6.3.2 to 6.3.6.

#### 6.3.1.2 *Designation of grades*

For the purpose of this Section, one strength grade in a plant, or in a group of related plants that comply with Clause 6.3.6 shall be designated by the supplier as a 'controlled grade'. All other strength grades shall be designated as 'associated grades'.

A controlled grade for the plant or group of plants shall be selected as a grade expected to be frequently tested over a 6 month period.

The number of samples available for a controlled grade during the production interval shall be designated $n_c$.

#### 6.3.1.3 *Frequency of assessment*

An assessment shall be made of each controlled and associated grade at each plant at the end of the production interval for the controlled grade on the basis of all the samples available from the start of the production interval.

#### 6.3.1.4 *Assessment factor*

The assessment factor ($k_c$) shall be determined from Table 6.1 for all controlled and associated grades at the plant or group of plants on the basis of the number of available samples ($n_c$) for the controlled grade.

#### 6.3.1.5 *Assessment of grade*

The mean compressive strength for ($f_{cm}$) of each grade of the plant shall satisfy the following criterion:

$$f_{cm} \geq f'_c + k_c s \quad \ldots 6.3.1.5$$

where

$f_{cm}$ = mean value of the compressive strength of concrete at the relevant age determined over the production interval

$k_c$ = assessment factor determined from the number of controlled grade samples, $n_c$ in accordance with Clause 6.3.1.4

$s$ = standard deviation for the grade being assessed ($s_c$ or $s_a$) calculated or estimated in accordance with Clause 6.3.5

### 6.3.2 Grade being assessed

For the purpose of this Section, a grade being assessed shall consist of a single mix at a single plant. However, provided the quality control practices are the same, different mixes at a plant of the one strength grade may be considered as one grade for the purposes of assessment.

In some circumstance, the compliance levels may be based on groups of plant as in Clause 6.3.6.

Where not all mixes of the one strength grade are treated as one grade for assessment purposes, each of the subsets of mixes within that strength grade shall be clearly identified by an appropriate suffix (e.g., N32(GP):N32(Pool) and the like). Such subsets of a grade shall be treated as separate grades for assessment purposes.

**TABLE 6.1**

**ASSESSMENT FACTOR $k_c$ FOR DIFFERENT NUMBERS OF SAMPLES IN CONTROLLED GRADE**

| No. of samples available in controlled grade ($n_c$) | Factor $k_c$ |
|---|---|
| 4 or less | 3.2 |
| 5 | 2.5 |
| 6 | 2.1 |
| 7 | 1.9 |
| 8 | 1.7 |
| 9 | 1.5 |
| 10 | 1.5 |
| 11 | 1.4 |
| 12 | 1.4 |
| 13 | 1.3 |
| 14 | 1.3 |
| 15 or more | 1.25 |

### 6.3.3 Sampling frequency

Each grade at a plant shall be sampled at a frequency of at least one sample per 100 $m^3$ of that grade produced except that, for Grade 20 concrete when 15 or more samples per month are obtained, the frequency may be reduced.

For controlled grades, an additional cylinder specimen shall be taken from each sample or at such a rate as to provide 10 specimens per production interval and tested at an early age after standard curing, or after accelerated curing.

### 6.3.4 Production interval

For assessment purposes, the production interval shall be selected by the producer within the range 2 weeks to 3 months so that at least 10 samples are available in the production interval. For plants with an expected production less than 1000 $m^3$ of the controlled grade per 3 months, the production interval may be taken as 3 months and the assessment based on the number of samples available in that production interval.

If a significant change in mix design or plant performance has occurred at a plant due to maintenance or upgrade or the like, the supplier shall commence a new production interval from the date of implementation of the change.

### 6.3.5 Standard deviation

#### 6.3.5.1 *Standard deviation of a controlled grade*

The standard deviation of the controlled grade shall be calculated at the end of a production interval for the sample defined in Clause 6.3.5.2 using the following equation:

A1

$$s_c = \sqrt{\frac{\Sigma(x-\bar{x})^2}{n-1}} \quad \ldots 6.3.5.1$$

where

$s_c$ = standard deviation of a controlled grade

$x$ = sample strength

$\bar{x}$ = mean strength

$n$ = number of samples

#### 6.3.5.2 *Sample size for the standard deviation of a controlled grade*

The standard deviation of a controlled grade ($s_c$) shall be determined using—

(a) all the results from the current production interval where the total number is greater than 30; or

(b) the last 30 consecutive results provided the period does not exceed 6 months; or

(c) all the results from the last 6 months.

Where the number of results is five or fewer, the standard deviation shall be taken as not less than 3 MPa.

#### 6.3.5.3 *Standard deviation for an associated grade*

The standard deviation for an associated grade ($s_a$) shall be—

(a) where the total number of sample test strengths for the associated grade determined in accordance with Clause 6.3.5.2 is 30 or more determined directly in accordance with Clause 6.3.5.1 above; or

(b) where the total number of sample test strengths is less than 30, estimated from the standard deviation of a controlled grade using the appropriate factors from Table 6.2.

The estimate is obtained by dividing the standard deviation for the controlled grade ($s_c$) by the factor corresponding to its strength grade and multiplying the result by the factor corresponding the strength grade of the associated grade.

TABLE 6.2

RELATIVE FACTOR FOR THE ESTIMATION OF THE STANDARD DEVIATION FOR AN ASSOCIATED GRADE ($s_a$) FROM THE VALUE FOR A CONTROLLED GRADE ($s_c$)

| Strength grade MPa | Relative factor |
|---|---|
| <20 | 0.9 |
| 20 | 1.0 |
| 25 | 1.1 |
| 32 | 1.2 |
| 40 | 1.3 |
| 50 | 1.4 |

### 6.3.6 Grouping of plants to determine $n_c$ and $s_c$

For the purposes of determining $n_c$ and $s_c$ for a controlled grade, test results from a group of plants operated by a single supplier may be grouped provided—

(a) the controlled strength grade includes at least five samples from each plant in the group during the production interval; and

(b) the results for all plants are treated identically.

### 6.3.7 Action on non-compliance

#### 6.3.7.1 *Check on adequacy of concrete*

Where the concrete grade assessed in accordance with Clause 6.3.1.5 does not comply with the requirements for mean grade strength ($f_{cm}$), the concrete represented by the samples shall be treated in accordance with Clause 5.3.4.

#### 6.3.7.2 *Adjustment to mix designs*

When the mean grade strength ($f_{cm}$) of a controlled grade does not comply with Clause 6.3.1.5, then immediate steps shall be taken to ensure the adequacy of the strength of that grade and all the associated grades in the plant or group of plants for which the controlled grade applies.

### 6.3.8 Early age assessment of controlled grades

If the strengths of the additional cylinder specimens required by Clause 6.3.3 indicate at an early age that the mean grade strength ($f_{cm}$) is not likely to comply, the supplier shall take immediate action to ensure an appropriate increase in the subsequent mean grade strength of the relevant grades at the particular plant and in the group of plants if applicable.

## 6.4 RECORDING AND DISSEMINATION OF PRODUCTION ASSESSMENT INFORMATION

### 6.4.1 Records and reports of test results

The records and reports of test results required by a part or parts of AS 1012 shall be maintained for at least 12 months by the organization responsible for the testing. Certified copies of the reports shall be sent to the supplier and be available for inspection by the customer or the customer's representative.

### 6.4.2 Reports for production assessment

Reports for concrete subject to production assessment shall be prepared at the end of each production interval by the supplier for each plant and shall be kept readily available for inspection.

The reports shall include, for each relevant strength grade and for each production interval, the following information as applicable:

(a) The name and address of the organization holding the full records and reports of the sample strength tests.

(b) The production interval.

(c) The strength grade or grade and description for subsets of one grade.

(d) The mean grade strength determined in accordance with Clause 6.3.1.5.

(e) The minimum mean grade strength required by Clause 6.3.1.5 for compliance.

(f) The number of samples tested during the reporting period.

(g) The standard deviation calculated in accordance with Clause 6.3.5.

(h) The number of sample strengths below $f'_c$.

(i) The number of cylinder strengths excluded in terms of Clause 6.2.5.

(j) Any significant change in the source or nature of the mix ingredients.

(k) The average strength of the early-age or accelerated-age samples, and the type of test for all controlled grades.

(l) For controlled grades, any other relevant data required to indicate compliance with the requirements of other sections of this Standard.

### 6.4.3 Dissemination of production assessment information

Customers who wish to receive production assessment information from their supplier shall register relevant projects for that purpose with the supplier and nominate for each project a person who is to receive the information. The supplier shall maintain a register of such projects and the corresponding nominees, for the duration of each project.

If production assessment information is requested for a registered project, the supplier shall send to the registered nominee copies of reports prepared in accordance with Clause 6.4.2, within 15 working days of the end of the reporting period.

### 6.4.4 Notification of potentially low strength

The supplier shall notify the relevant customers, within two working days of the report becoming available, if a particular quantity of concrete produced by the plant is likely to be below the specified strength.

## 6.5 PROJECT ASSESSMENT OF STRENGTH GRADE

### 6.5.1 General

Where project assessment has been specified, the concrete in the project shall be assessed for compliance in accordance with Clause 6.5.2 or Clause 6.6. The records and reports of test results required by a part or parts of AS 1012 shall be maintained for at least 12 months by the organization responsible for the testing. Certified copies of the reports shall be sent to the supplier.

The organization in control of the testing shall ensure that all test reports produced for project assessment are made available to the supplier within 10 working days of their production, except that if a certificate indicates a particular quantity of concrete is likely to be below the specified strength, the organization shall ensure that the customer and supplier are notified within two working days of the information becoming available.

### 6.5.2 Additional project assessment for plants subject to production assessment

Where additional project assessment for plants subject to production assessment has been specified, each grade of concrete used in the project shall be treated as follows:

(a) The concrete shall be sampled at the project site but prior to site handling and otherwise in accordance with AS 1012.1.

(b) The frequency of sampling shall provide at least one sample from each 50 $m^3$ of concrete.

(c) The strength of each sample shall be determined in accordance with Clause 6.2.3 to 6.2.5.

(d) The concrete represented by a group of project samples shall be deemed not to comply with the requirements for strength grade if the moving average strength of three consecutive samples is less than $f'_c$.

(e) Where less than three samples are available for the project, the concrete may be assessed on the basis of a single sample only. The concrete represented by the sample shall be deemed **not** to comply if the sample strength is less than $0.85f'_c$. If the sample strength is between $0.85f'_c$ and $f'_c$, additional investigation shall be carried out if requested by the customer.

## 6.6 ASSESSMENT BY ALTERNATIVE METHODS WITH AN ACCEPTED OPERATING CHARACTERISTIC

Alternatively, assessment of concrete may be carried out by methods that demonstrate compliance with this Standard as described in Appendix C.

For methods based on statistical sampling, reliable statistical operating characteristic shall be selected so that—

(a) concrete with a proportion defective of 0.05 has a probability of acceptance of at least 50%; and

(b) concrete with a proportion defective of 0.30 has a probability of rejection of at least 98%.

# APPENDIX A

# UNIFORMITY OF MIXING

(Normative)

## A1 GENERAL

This Appendix sets out the methods for determining an acceptable degree of uniformity of mixing in different types of mixers.

The purpose of the test is to determine whether, after a specified amount of mixing, all the ingredients are uniformly distributed throughout the volume of discharged plastic concrete.

## A2 TEST PROCEDURES

### A2.1 Mix used for uniformity tests

The mix used for uniformity tests shall be selected so as to reflect typical mixes proposed for the mixer.

### A2.2 Batch mixers

The procedure for testing for the uniformity of mixing in batch mixers shall be as follows:

(a) The mixer shall be charged with a specified volume of ingredients to not less than 90% of the mixer manufacturer's recommended rated capacity.

(b) Between completion of charging and discharge, the mixer shall be operated for—

  (i) a specified number of revolutions of the mixing mechanism; or

  (ii) a specified interval of time at the recommended mixing speed.

(c) Two samples of plastic concrete, of approximately 50 L each, shall be taken from as widely spaced locations in the mix as possible, in accordance with Paragraph A2.4, during or immediately after discharge, as appropriate.

(d) The relevant properties of each sample shall be determined in accordance with Paragraph A3 and the results of each determination recorded.

(e) The differences between the values for the corresponding properties of each sample shall be calculated and compared with the limits on the differences given in Table A1.

### A2.3 Continuous mixers

The procedure for testing for the uniformity of mixing in continuous mixers shall be as follows:

(a) The charging and mixing mechanisms shall be operated concurrently at the specified rates until plastic concrete is being continuously discharged from the mixer.

(b) During the ensuing discharge, two samples of plastic concrete, of approximately 50 L each, shall be taken from the discharge end of the mixer, in accordance with Paragraph A2.4.

(c) Each sample shall be tested in accordance with Paragraph A3 and the results of each test recorded.

(d) The differences between the values of the corresponding tests on each sample shall be calculated and compared with the limits on the differences given in Table A1.

### A2.4 Sampling procedures

#### A2.4.1 *End-discharge batch mixers*

For stationary or mobile drum-mixers, which discharge only from one end of the mixer, the two samples shall be taken as widely separated as practicable during discharge of the plastic concrete but no sample shall be taken before 10% or after 90% of the test batch has been discharged.

#### A2.4.2 *Split-drum mixers*

For stationary mixers of the split-drum type, which discharge simultaneously from the entire drum, the mixer shall be discharged into a receptacle (such as a long-bodied truck) so that the test batch is spread uniformly over the plan area of the receptacle. The two test samples shall be drawn from opposite ends of the receptacle but not closer to either end than 10% of the length of the receptacle.

#### A2.4.3 *Continuous mixers*

For continuous mixers, the mixer shall be stabilized at the operating rate and then two samples taken from the discharge, separated by a time interval equivalent to at least 2 $m^3$ of throughput. The operating rate and the time interval between samples shall be recorded.

## A3 DETERMINATION OF PROPERTIES OF PLASTIC CONCRETE SAMPLES

### A3.1 General

The relevant properties of each sample of plastic concrete shall be determined in accordance with Paragraphs A3.2 to A3.6, as appropriate.

### A3.2 Slump

The slump of the concrete in the sample shall be determined in accordance with AS 1012.3.1.

### A3.3 Air content

The air content of the concrete in the sample shall be determined as a percentage ($p$) in accordance with AS 1012.4.1.

### A3.4 Mass per unit volume of the concrete

The mass per unit volume of the plastic concrete in the sample ($m_c$) shall be determined in accordance with AS 1012.5 and the tested volume of concrete retained.

### A3.5 Coarse aggregate content

The volume of concrete ($V$) used in the test required in Paragraph A3.4 shall be washed on a 4.75 mm test sieve, until all the mortar has been removed. The oven-dry mass of the retained coarse aggregate ($m_{ac}$) and the density of the coarse aggregate particles ($\rho$) shall be determined in accordance with AS 1141.6.1. The coarse aggregate content per unit volume ($\beta_{ac}$) shall be calculated from—

$$\beta_{ac} = m_{ac} / V \quad \text{. . . A3.5}$$

### A3.6 Mass per unit volume of the air-free mortar

The mass per unit volume of the air-free mortar ($m_{ma}$) shall be calculated from the following equation:

$$m_{ma} = \frac{m_c - \beta_{ac}}{1 - \left( \frac{p}{100} + \frac{\beta_{ac}}{\rho} \right)} \quad \text{. . . A3.6}$$

where

$m_{ma}$ = mass per unit volume of the air-free mortar

$m_c$ = mass per unit volume of the sample

$\beta_{ac}$ = mass of coarse aggregate per unit volume of the sample

$p$ = percentage air content

$\rho$ = density of the coarse aggregate particles

## A4 COMPLIANCE WITH UNIFORMITY

A series or model of mixer shall be deemed to have passed the uniformity test if the differences between the corresponding properties of the two samples do not exceed the limiting values given in Table A1.

**TABLE A1**

**LIMITS ON DIFFERENCES BETWEEN PROPERTIES OF PAIRED SAMPLES**

| Property | | Limit on differences between sample values |
|---|---|---|
| (a) | Slump, where the average slump is— | |
| | (i) <60 mm | 10 mm |
| | (ii) ≥60, ≤80 mm | 15 mm |
| | (iii) >80 mm | 20 mm |
| (b) | Air content | 1.0% |
| (c) | Mass per unit volume of plastic concrete | 50 kg/m$^3$ |
| (d) | Coarse aggregate content | 6% of mean value |
| (e) | Mass per unit volume of the air-free mortar | 1.6% of mean value |

# APPENDIX B

# GUIDE TO THE SPECIFICATION OF SPECIAL-CLASS CONCRETE

(Informative)

This Appendix sets out a guide to the specification of special-class concrete. Table B1 sets out a range of practical parameters.

The philosophy of arriving at the values specified in the main Standard for normal-class concrete was to find values suitable to ensure adequate quality for concrete needed in common construction, and which in practice could be achieved in plants throughout Australia, using materials and practices meeting the relevant Australian Standards.

Values listed in the fourth column of Table B1 provide a guide to specifiers on projects requiring criteria additional to or different from those for normal-class concrete. Specifiers are encouraged to examine the suitability of normal class concrete before deciding that a project requires special class concrete. Concrete satisfying the additional criteria of a special class may not be capable of being produced at all plants or locations in Australia.

The economically viable materials available in certain locations may make compliance with some criteria more difficult than compliance with those specified for normal-class concrete. Similarly some plants, more sophisticated than others, may be able to offer performance criteria above that generally available.

It is prudent before specifying criteria for special-class concrete to enquire about the availability of concrete that will satisfy those criteria, and to be aware of and to accept the consequences of such a specification.

These consequences may include the following:

(a) Increases in the cost of production by importing materials dearer than locally available materials.

(b) Reduction in the number of suppliers able to compete for supply.

(c) Impact on the cost, availability and perhaps the continuity of supply due to the logistics of providing special resources.

## TABLE B1

## ATTRIBUTES OF NORMAL AND SPECIAL CLASS CONCRETE

| Basic ordering parameter | Clause | Normal class | Special class |
|---|---|---|---|
| Grade $f'_c$ (MPa) | 1.5.3.2(a) | 20, 25, 32, 40 and 50 | Any other |
| Slump (mm) | 1.5.3.2(b) | 20 to 120 in 10 mm intervals | Any other |
| Maximum nominal aggregate size (mm) | 1.5.3.2(c) | 10, 14 and 20 | Any other |
| Placement method | 1.5.3.2(d) | To be specified when concrete is ordered | |
| Project assessment | 1.5.3.2(e) | As per specification | As per specification |
| Air content by volume (%) | 1.5.3.2(f) | ≤5 | >5 |
| **Additional ordering parameters** | | | |
| Cement type | 1.5.3.1(e) | Any cement complying with AS 3972 | Any specified combination |
| Early age strength | 1.5.3.1(d) | See Table 1.2 | Higher values as required<br>Ages up to 4 days should be specified in hours to eliminate uncertainties arising from late pours and early testing |
| Mass per unit volume (kg/m$^3$) | 1.5.3.1(a) | 2100 to 2800 | Any specified value. This may incur special procedures and additional cost |
| Drying shrinkage at 8 weeks microstrain | 1.5.3.1(c) | ≤1000 | Any specified value less than 1000 or age other than 8 weeks |
| Chloride content (kg/m$^3$) | 1.5.3.1(b), 2.7.3 | ≤0.8 | Any other specified value |
| $SO_3$ by weight of cement (g/kg) | 1.5.3.1(b), 2.7.2 | ≤50 | Any specified value. Maximum less than 50 |
| Flexural strength | 1.5.4(b) | — | As required |
| Indirect tensile strength | 1.5.4(c) | — | As required |
| Exposure classification | 1.5.4 | — | Nominate SB, SC, SU where applicable, aggregate durability class |
| Water-cement ratio | 4.2.1.2(b) | — | As required |
| Water, admixture and additives addition to a mixed batch | 4.2.3 and 4.2.4 | See Clause 4.2.3 | As required |
| Discharge time after mixing (minutes) | 4.2.5 | Nominal 90 | As required |
| Temperature at discharge (°C) | 4.4.2 | $5 < t < 35$ | Any specified value |
| Testing of concrete | 6.3 | See Section 5 and Clause 6.3 | As required |
| Other materials | 2.6 | — | As required, fibres, pigments, special additives |
| **Other parameters** | | | |
| Raw material verification by test | 2.2 to 2.4 | — | As required |
| Records and docket | 4.1.6 | See Clauses 4.1.6 and 1.7.3 | Any addition to Clause 1.8.3 |

# APPENDIX C

# MEANS OF DEMONSTRATING COMPLIANCE WITH THIS STANDARD

(Informative)

## C1 SCOPE

This Appendix sets out the following different means by which compliance with this Standard can be demonstrated by the manufacturer or supplier:

(a) Evaluation by means of statistical sampling.

(b) The use of a product certification scheme.

(c) Assurance using the acceptability of the supplier's quality system.

(d) Other such means proposed by the manufacturer or supplier and acceptable to the customer.

## C2 STATISTICAL SAMPLING

Statistical sampling is a procedure which enables decisions to be made about the quality of batches of items after inspecting or testing only a portion of those items. This procedure will only be valid if the sampling plan has been determined on a statistical basis and the following requirements are met:

(a) The sample needs to be drawn randomly from a population of product of known history. The history needs to enable verification that the product was made from known materials at essentially the same time, by essentially the same processes and under essentially the same system of control.

(b) For each different situation, a suitable sampling plan needs to be defined. A sampling plan for one manufacturer of given capability and product throughput may not be relevant to another manufacturer producing the same items.

In order for statistical sampling to be meaningful to the customer, the manufacturer or supplier needs to demonstrate how the above conditions have been satisfied. Sampling and the establishment of a sampling plan should be carried out in accordance with AS 1199.1, guidance to which is given in AS 1199.0.

## C3 PRODUCT CERTIFICATION

The purpose of product certification is to provide independent assurance of the claim by the manufacturer that products comply with the stated Standard.

The certification scheme should meet the criteria described in HB 18.28 in that, as well as full type testing from independently sampled production and subsequent verification of conformance, it requires the manufacturer to maintain effective quality planning to control production.

The certification scheme serves to indicate that the products consistently conform to the requirements of the Standard.

## C4 SUPPLIER'S QUALITY MANAGEMENT SYSTEM

Where the manufacturer or supplier can demonstrate an audited and registered quality management system complying with the requirements of the appropriate or stipulated Australian or international Standard for a supplier's quality management system or systems, this may provide the necessary confidence that the specified requirements will be met. The quality assurance requirements need to be agreed between the customer and supplier and should include a quality or inspection and test plan to ensure product conformity.

Information on establishing a quality management system is set out in AS/NZS ISO 9001 and AS/NZS ISO 9004.

## C5 OTHER MEANS OF ASSESSMENT

If the above methods are considered inappropriate, determination of compliance with the requirements of this Standard may be assessed from the results of testing coupled with the manufacturer's guarantee of product conformance.

Irrespective of acceptable quality levels (AQLs) or test frequencies, the responsibility remains with the manufacturer or supplier to supply products that conform to the full requirements of the Standard.

# AMENDMENT CONTROL SHEET

## AS 1379—2007

## Amendment No. 1 (2009)

**CORRECTION**

SUMMARY: This Amendment applies to Equation 6.3.5.1.

Published on 1 June 2009.

## Amendment No. 2 (2015)

**REVISED TEXT**

SUMMARY: This Amendment applies to Clauses 2.3 and 2.8

Published on 30 March 2015.

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