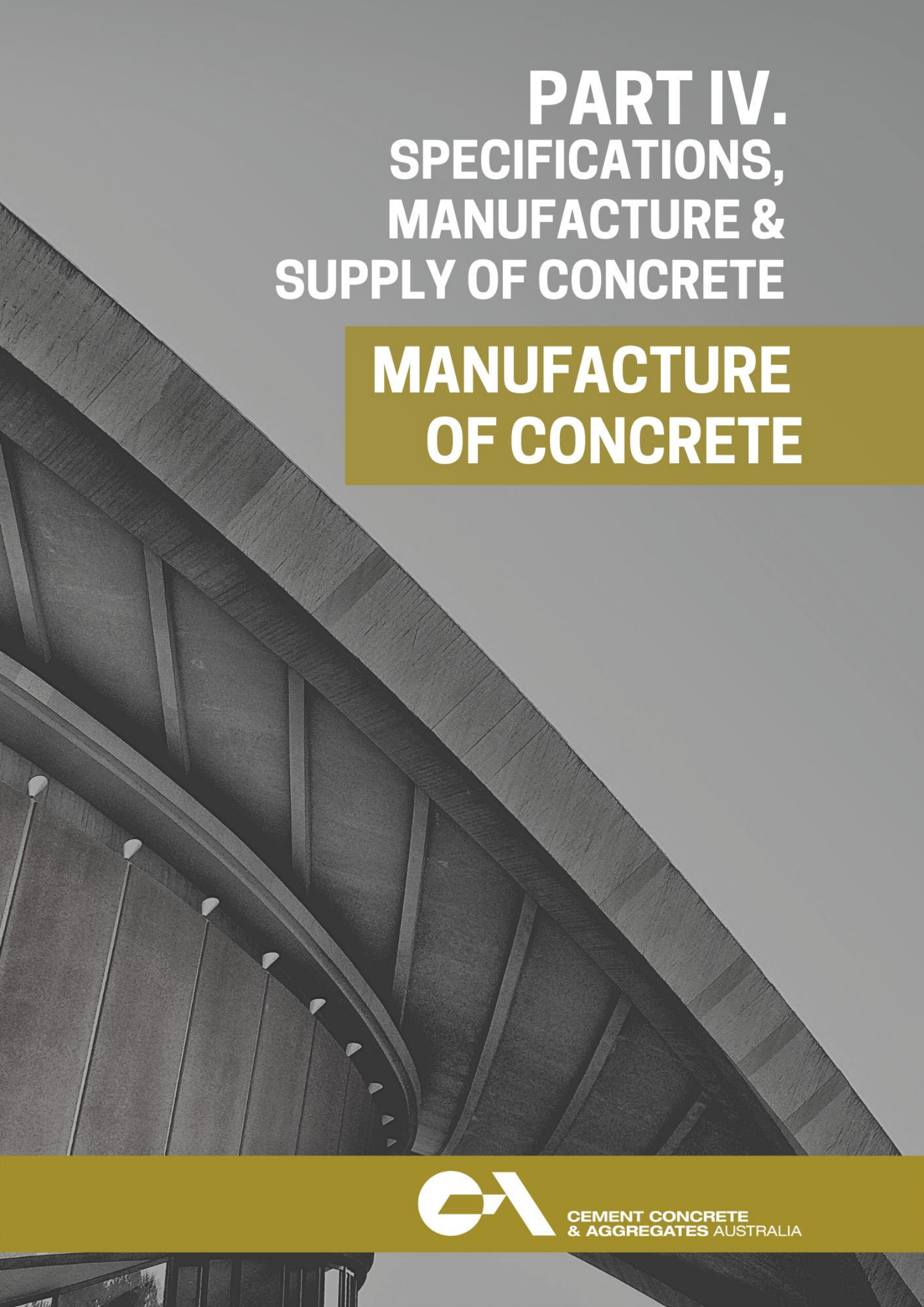
PART IV.
SPECIFICATIONS, MANUFACTURE & SUPPLY OF CONCRETE

MANUFACTURE OF CONCRETE



CEMENT CONCRETE & AGGREGATES AUSTRALIA

This section outlines the requirements for the manufacture of concrete. It is described only to the extent necessary to provide the reader with some background to the selection and proportioning of materials, to the various steps in the manufacturing process and to some of the quality-related requirements.

CONTENTS

1. INTRODUCTION

AS 1379 *'Specification and supply of concrete'* provides requirements for site-mixed, factory-mixed, and truck-mixed concrete. In addition to specifying requirements for concrete materials, plant and equipment, the Standard also sets out procedures for the specification and ordering of concrete, its production and delivery, and its sampling and testing for compliance with the requirements of the Standard.

In today's construction industry, most construction sites are supplied with concrete from a central batching plant, operated either by the contractor or by a separate, independent supplier. Whilst obviously there will be some differences in procedures in ordering and testing concrete if the contractor owns their own plant, the principles governing manufacture and delivery are essentially the same in both situations. The aim is to ensure the supply of concrete that (a) meets the plastic- and hardened-state requirements of the project specification, and (b) performs consistently.

2. PLANT-MIXED CONCRETE

2.1 GENERAL

It is beyond the scope of this Guide to discuss, in great detail, the plant and equipment used in the manufacture of concrete. **Figure 9.1** illustrates the layout of a typical concrete batching plant and the following sub-sections describe the basic physical requirements and performance requirements of the main plant elements.

2.2 BINS AND SILOS

In modern concrete plants, bins and silos are used to store (a) the various aggregate materials used in the manufacture of concrete, (b) the cementitious materials, and sometimes (c) liquid admixtures. In older or project-based temporary concrete plants, ground storage may be used for coarse and fine aggregate storage. In these plants, front-end loaders are normally used to transfer the aggregates to the weigh hopper for batching.

The following general requirements apply to all storage units:

- They should be constructed so as to prevent contamination from other materials and, in the case of aggregate bins and silos, to keep aggregates of different types and sizes from intermingling;
- Aggregate storage units should facilitate the free drainage of the materials and be designed to minimise segregation;
- Each storage unit should be provided with a means of actively controlling the discharge from the unit;
- Bins and silos used for cement and other cementitious materials must be designed and constructed to keep the contents dry and to promote the complete discharge of the contents;

- Cement/ cementitious silos must include engineered systems to ensure that over-filling of the silo either (a) cannot occur or (b) triggers an alarm, and must also have a system to prevent dust emissions to the atmosphere;
- Bins and silos which are used to store more than one type of constituent shall be capable of being cleaned out thoroughly and inspected internally;
- Bin and silo contents must be clearly marked to prevent contamination when new loads are delivered.

Figure 9.1 – Typical Modern Concrete Batching Plant

2.3 WEIGHING EQUIPMENT

All weighing equipment in central batching plants should be provided with a visual weight-indicating device that is clearly visible to the operator in control of the equipment, and which should be graduated to a scale compatible with the accuracy required for the production process. The weighing equipment itself should be accurate to ±0.4% (or less) of the maximum scale value when statically loaded. The equipment should also be checked for accuracy, at least every six months, but more often if required for the particular type of equipment. Section 3.3 of AS 1379 describes the requirements in detail.

2.4 LIQUID-DISPENSING EQUIPMENT

All liquid-dispensing equipment (e.g. for dispensing admixtures) should also be equipped with a visual metering device that is clearly visible to the operator. The equipment should be capable of metering the volume (or mass) of liquid to an accuracy of at least ±5.0% of the indicated value, except for water which should be metered or weighed to an accuracy of at least ±2.0%.

As with weighing equipment, calibration of the equipment should be undertaken at least every six months, or more often if required for specific equipment.

Liquid-dispensing equipment should be cleaned between changes in types of liquid products including changes in brands of the same type of product, and at a frequency not less than that recommended by the manufacturer.

2.5 MIXERS

General – A variety of mixers – ranging from the simple tilting-drum mixer (used almost universally to produce bricklaying mortar on housing sites) to the much more sophisticated split-drum mixers as used on major concrete road projects – are used to mix concrete. In the simpler mixers, the materials are generally batched by volume which is less precise. In more complex plants, the materials are batched accurately by mass with a relatively high degree of precision. It should be noted though that concrete is invariably supplied to customers and users by volume.

Although the tilting-drum mixer and its companion, the horizontal-drum mixer, were once widely used to mix concrete on construction sites, they have now largely been replaced by the inclined-drum mixer and the split-drum mixer. By far the most widely-used method for manufacture of concrete used by the construction industry today is mixing in inclined-drum mixers mounted on trucks – known as transit mixers. (Transit mixers (**Figure 9.2**) are also known colloquially as 'agitators' or 'agi's – terms which do not fully describe the mixing action that occurs in these mixers.)

Figure 9.2 – Transit Mixer (aka concrete Agitator or 'Agi')

The transit mixers are loaded with accurately weighed dry materials (aggregates and cementitious products) and liquid materials (water and admixtures) at a central batching plant and, while operating at mixing speed, mix the batch of concrete for sufficient time to achieve complete mixing of the materials (which means producing a plastic concrete product that has similar properties (workability and cement and aggregate content) throughout the whole batch). This process is generally known as 'dry batching'. A complex blade and fin system within the mixing 'bowl' or drum operates to (a) mix the batched materials thoroughly when the drum is rotated in the 'mixing direction', and (b) allows the mixed concrete to be discharged continuously from the drum when it is rotated in the reverse direction.

While concrete batching can be carried out in relatively small and simple plants, it is now the case that in larger cities, large 'central batching plants' are common. These plants allow high volume, high quality concrete production with a relatively small plant footprint. The use of multiple silos for a variety of cementitious materials and multiple overhead bins for aggregate materials – coupled with the ability to batch more than one transit mixer at a time – allow these modern concrete plants to achieve very high throughput and to produce a wide variety of concrete mixes while also meeting stringent environmental control requirements around dust and noise emissions.

For some major projects where there are requirements for high production rates and very consistent quality, split-drum mixers are preferred. These split-drum (high energy, high efficiency) mixers can produce high throughput and very consistent quality. For major projects like concrete road paving, this type of performance is critical. The split-drum mixers can also mix concrete with maximum size aggregates as large as 150 mm with mixing times of 60-70 seconds, which is advantageous for high volume projects like concrete dam construction. With split-drum mixers, all of the materials (cementitious + aggregates + water + admixtures) are added together in the drum prior to mixing. Once the concrete is mixed the drum 'splits' open and the plastic concrete is discharged into a conventional concrete truck (Transit mixer/ Agitator) or in some cases, where low slump (20-40 mm) concrete is being produced (typically for road paving machines), the concrete is discharged into tipper trucks which are adequate for short transport distances. This batching process is known as 'wet batching'.

Continuous mixers (e.g. pugmills) (**Figure 9.3**) are also used from time to time – mainly for the production of high volumes of low slump concrete (e.g. roller compacted concrete) for dam and road or hardstand construction.

Figure 9.3 – Continuous Mixer (aka 'Pug Mill')

Australian Standard Requirements – AS 1379 sets out a number of requirements to govern the performance of both batch and continuous mixers. These include:

- A requirement that batch mixers have mounted on them an identification plate which provides information on:
  - the gross internal volume of the mixing chamber (m^3);
  - the rated mixing capacity (m^3);
  - the recommended minimum –

    number of revolutions of the mixer required to achieve uniformity in the concrete; or

    mixing time (in minutes) at a given rotational speed of the mixer (in revolutions per minute).

  - if the mixer is designed to be used as an agitator -

    the recommended capacity of the mixer used as an agitator; and

    the recommended speed of the mixer (in revolutions per minute) when used as an agitator.

- Limits on the capacity of the mixer to no more than 65% of the gross internal volume of the bowl when used as a mixer, and no more than 80% when used as an agitator unless testing in accordance with the Standard permits a higher figure;
- Procedures for determining or confirming the minimum mixing time or number of revolutions at mixing speed for batch mixers.

Continuous mixers are also required to carry an identification plate that indicates both (a) the name of the manufacturer, and (b) the maximum discharge rate in tonnes per hour.

2.6 PRODUCTION AND DELIVERY

AS 1379 sets out a number of requirements governing the production and delivery of concrete from both batching plants and continuous mixers.

The following are of particular note:

- Where the characteristic compressive strength of the concrete is more than 15 MPa at 28 days, all ingredients, other than liquids, have to be proportioned by mass. Volume proportioning may be used for concrete having a characteristic strength of 15 MPa or less at 28 days;
- The quantity of each ingredient in a batch should be measured within the tolerances shown for the ingredient in **Table 9.1**;
- Water may be added to a mixed batch of concrete, prior to its complete discharge, only if the following relevant conditions are satisfied:
  - The supplier's approval is obtained. (Only the supplier's representative can add water or admixtures to a mixed batch prior to its discharge. This is because the supplier is responsible for the quality of the concrete up to the point of acceptance of delivery. The addition of water and/or admixtures will affect the quality of the concrete and may cause it to fail to meet the specified properties.);

- Immediately after the water is added, the mixing bowl is rotated for 30 revolutions at mixing speed, or for such time as is necessary to re-establish the uniformity of the mix;
- If slump has been specified, then immediately after uniformity of the mix has been re-established following water addition the slump is measured, and any slump requirement is met;
- If a sample is to be tested, then the sample is to be taken after the addition of any extra water and uniformity re-established;
- If water is added once discharging has commenced, this fact is noted on the identification certificate for the batch;
- If a maximum water/cement ratio has been specified, the quantity of water added does not cause the specified maximum ratio to be exceeded.

- Discharge of all concrete from the batch should be completed within 90 minutes of mixing having been commenced (or sooner if proper placement and compaction cannot otherwise be achieved). This requirement may be waived, however, if the consistency of the concrete can be maintained for a longer period without the addition of extra water to the mix;
- Unless otherwise specified, concrete at the point of delivery should have a temperature not less than 5°C and not more than 35°C. (For additional precautions in extreme weather conditions, see Section 18 *'Hot- and Cold-Weather Concreting'*.)

Table 9.1 – Permissible Tolerances on Batch Ingredients (excluding water) – Table 4.1 in AS 1379

Ingredient	Tolerance			
	Weight batching for batch size, Q			Volume batching
	Q <2 m^3	2 ≤ Q ≤4 m^3	Q >4 m^3	
Each cementitious ingredient	-5 + 30 kg	-10 + 30 kg	-20 + 40 kg	±1%
Total cementitious 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%*

NOTE: * or 20 mL whichever is the greater

3. SITE-MIXED AND PACKAGED CONCRETE

3.1 SITE MIXING

While it is now rare for mixing to be done on project sites (except for very large or remote projects where a dedicated batching/ mixing plant may be established), there are occasions when site mixing is necessary (e.g. small quantities of concrete may be required in which special aggregates are incorporated). In some cases, small but significant projects may be located in areas remote from normal sources of supply. In such cases, some knowledge of the proper proportioning of concrete mixes is necessary. An informative text such as *'Australian Concrete Technology'* (edited by W G Ryan and A Samarin, published by Longman Cheshire, Melbourne) should be consulted if

detailed information is required to facilitate technically-sound 'site mixing'.

Materials handling and storage on a project site should be sufficient to:

- Prevent contamination of concrete materials by extraneous materials;
- Prevent segregation of the aggregates or intermingling of the different aggregate sizes;
- Ensure that cementitious materials are kept dry by storing them in either (a) weathertight silos; (b) enclosed weathertight buildings; or (c) on pallets that are off the ground and protected from wet weather;
- Ensure that SCM's such as fly ash or GGBFS, if used, are clearly identified and separated from the type GB cement;
- Ensure that admixtures are clearly identified, protected from extremely hot or cold weather and properly dispensed.

Mixing on-site for small projects can be done in either tilt-drum or horizontal-drum mixers. The former may range in size from as little as 50 litres (0.05 m^3) to as large as 6-10 m^3; while the latter are typically used on large volume projects such as dams. Horizontal-drum mixers range in size from 100 litres to 5 m^3 (**Figure 9.4**).

Figure 9.4 – Typical Small On-site Plant with Capacity of about 10 m^3 per hour.

The order of loading materials when batching is important. Ideally, the coarse aggregate plus a little of the mixing water should be loaded first as this helps clean the mixer drum. This is then followed by the sand, the cement and finally the remaining water. Where a loading skip is employed, a layer of coarse aggregate, followed by a layer of cement, and finally a layer of sand will help prevent the fine cement being blown away.

Efficient mixing will be promoted if the mixer is not overloaded. Loading above the rated capacity will increase mixing time disproportionately or result in incomplete mixing leading to low and variable strengths. Similarly, too short a mixing time will result in patchy, non-uniform and low-strength concrete. Excessive mixing times may also be undesirable and may lead to grinding of any soft aggregates which can produce more fines and increase the water demand of the concrete. A good rule is to allow 1.5 minutes for mixing 1 m^3 plus 0.5 minutes for each additional 0.5 m^3.

3.2 PACKAGED CONCRETE MIXES

Where reasonably small quantities of concrete are required, bagged concrete can provide an alternative to batching on-site. Packaged to provide approximately 10 litres (or 0.01 m^3) of plastic concrete, bagged concrete mixes may be expected to achieve strengths of around 15 MPa at 7 days when slump is in the range of 75-100 mm. The quantity of water required to achieve this slump is normally marked on the bag. Some caution should be exercised, however, in relying on packaged concrete to achieve specified strengths.

4 REFERENCES

1) AS 1012 – *Methods of testing concrete*
2) AS 1379 – *Specification and supply of concrete*
3) AS1478 – *Chemical admixtures for concrete, mortar and grout*
4) AS 1478.1 – *Admixtures for concrete*
5) AS 2758 – *Aggregates and rock for engineering purposes*
6) AS 2758.1 – *Concrete aggregates*
7) AS 3582 – *Supplementary cementitious materials*
8) AS 3582.1 – *Fly ash*
9) AS 3582.2 – *Slag – ground granulated blast- furnace*
10) AS 3582.3 – *Amorphous Silica*
11) AS 3600 – *Concrete structures*
12) AS 3972 – *General purpose and blended cements*

CCAA OFFICES

NATIONAL OFFICE (NSW)
Level 10
163 -175 O'Riordan Street
Mascot NSW 2020

POSTAL ADDRESS
PO Box 124
Mascot NSW 1460
Telephone: (02) 9667 8300

QUEENSLAND
Level 14, 300 Ann Street,
Brisbane QLD 4000
Telephone: (07) 3227 5200

VICTORIA
Suite 910/1 Queens Road
Melbourne VIC 3004
Telephone: (03) 9825 0200

WESTERN AUSTRALIA
45 Ventnor Avenue
West Perth WA 6005
Telephone: (08) 9389 4452

SOUTH AUSTRALIA
Level 30, Westpac House
91 King William Street
Adelaide SA 5000
Telephone: (02) 9667 8300

TASMANIA
PO Box 1441
Lindisfarne TAS 7015
Telephone: (03) 6491 2529

ONLINE DETAILS
www.ccaa.com.au
Email: info@ccaa.com.au