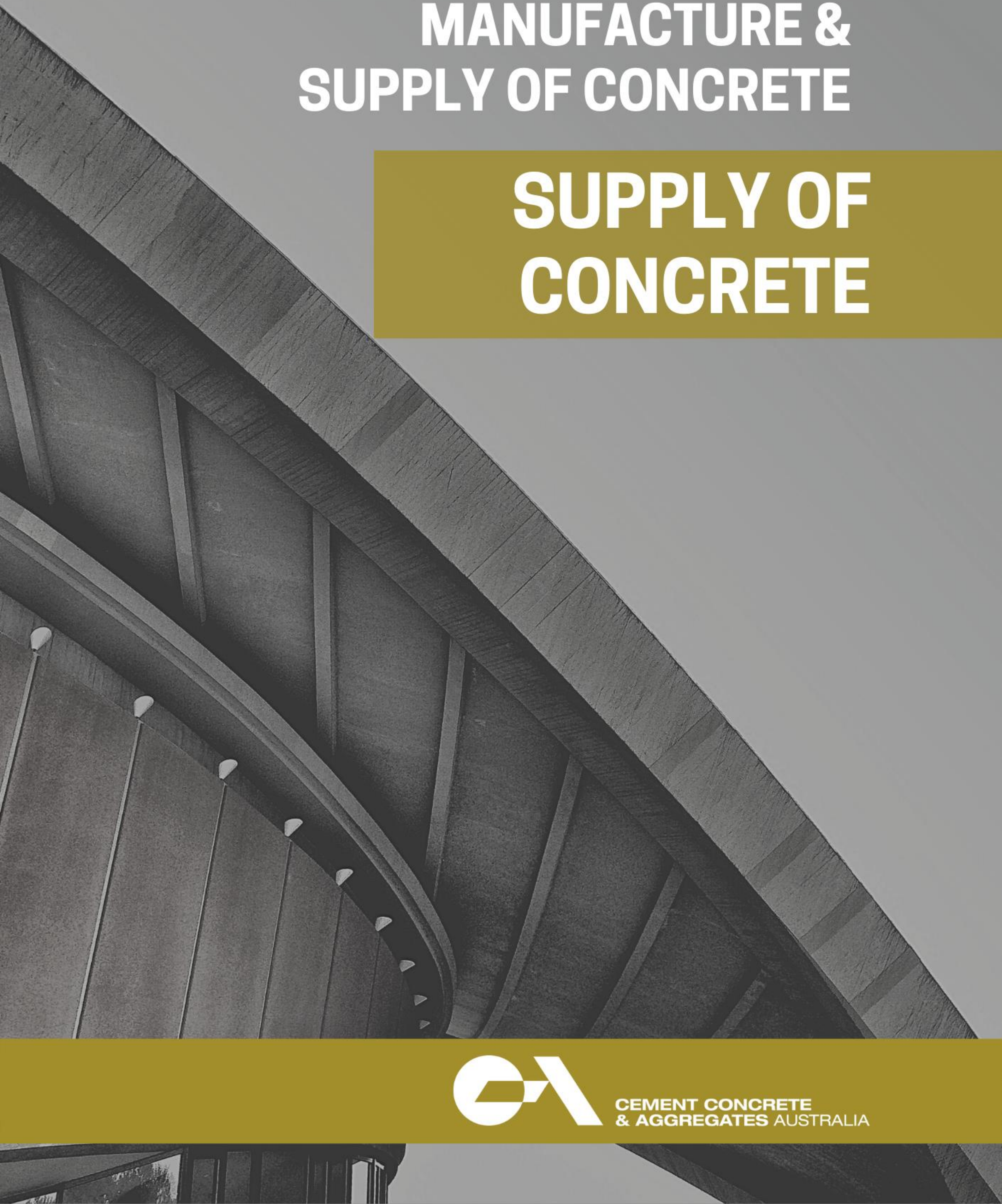
PART IV.
SPECIFICATIONS, MANUFACTURE & SUPPLY OF CONCRETE

SUPPLY OF CONCRETE



CEMENT CONCRETE & AGGREGATES AUSTRALIA

CONTENTS

1. OUTLINE

This section discusses various aspects of the supply of premixed concrete including management of delivery and different methods used to deliver product.

AS1379 *'Specification and supply of concrete'* covers the supply of premixed concrete. This Standard covers topics such as the basis of supply of concrete, the allowable temperature, consistency and time from mixing the concrete to delivery on site. Also covered in this Standard are minimum requirements for documentation related to a batch of concrete and control of water or other materials added during delivery.

This Section also reviews the types of equipment used to transport mixed concrete to sites where the method of placement allows or demands higher rates or more efficient methods of supply.

2. SUPPLY, DELIVERY AND TRANSPORT

2.1 SUPPLY

This Section is largely about the supply and delivery of premixed concrete in its various forms. The most common method used in the Australian building and construction industry is a process with the following set of steps in sequence:

- Concrete materials are weighed in a fixed plant;
- Materials are conveyed to a transit mixer mounted on a delivery truck;
- Materials are mixed in the transit mixer at the fixed plant under controlled conditions;
- The mixed concrete is checked prior to being delivered to the customer's building site by the delivery truck;
- On receipt of the concrete on site the concrete is emptied from the transit mixer either directly into the customer's forms or into one of many possible means of moving the concrete from the transit mixer to the customer's forms (pumping, wheelbarrow, motorised skip, crane and kibble etc.) (**Figure 10.1**).

Figure 10.1 – Truck Mounted Transit Mixers delivering Concrete to a Pump on Site

While this appears to be a fairly simple process it ignores some of the complexities that are part of concrete supply.

A customer orders concrete to meet various specified requirements as detailed in Part IV, Section 8 of this Guide. One of the key requirements of the customer is that the concrete must be delivered to the forms on site in a condition that is capable of being compacted with the equipment available to the customer or the placing sub-contractor. This is largely the reason for the concrete requiring a specified slump on site at the time of delivery.

For this requirement to be met, the elements that impact on the slump of concrete need to be recognised and carefully controlled. Slump of a batch of concrete at a point in time is dependent on several factors:

- The correct mix design being batched – including the initial mixing water;
- The time since water was added to the concrete. Freshly mixed concrete has chemical reactions starting from when water is added causing ‘absorption’ of water from the mix. Dry aggregates can also slowly absorb water from the mix. Water can be lost from concrete to the atmosphere during delivery. In each case the reduction of free water in the mix will lead to loss in slump;
- The ambient and concrete temperatures both affect the rate of water loss into the atmosphere as well as the rate of reactions.

From these factors it can be seen that for control of slump the delivery must be made using careful controls on batching, delivery time and concrete temperature. These are further discussed in sub-section 3 of this document.

One other step in the supply of concrete is the need for the concrete supplier to provide their customer with a certificate verifying the quantity and specified requirements for each delivery of concrete. This is necessary for both the suppliers’ and customers’ quality systems and is also required by AS 1379 *‘Specification and supply of concrete’*. AS 1379 refers to this certificate as the ‘Identification Certificate’ but is also commonly referred to as ‘ticket’, ‘docket’ or ‘manufacturer’s warranty’. This is also discussed in sub-section 3 of this document.

2.2 TRANSPORT OF CONCRETE

Every concrete supplier and plant will have a specific method for managing transport of the premixed concrete to their customer’s site. The transport component of supply starts from when the concrete leaves the plant and travels to the defined point of ownership by the customer. It is common in Australia for the point of ownership by the customer to be where the concrete leaves the truck chute (e.g. in the case of the process outlined in 2.1). There are other methods of transporting concrete which can include:

a) Pumping of concrete to a form or secondary pump;
b) Conveyor to a fixed pump or crane and kibble system;
c) Transport of concrete in a rear or side tipper system;
d) Transport of concrete using a bucket and cable crane system.

The options noted are not all of the possibilities and each of a) to d) require the concrete plant to have a fixed ‘central mixer’ to work efficiently. The reasons for using some of the alternative delivery systems are explored in sub-section 4.

When concrete supply plants deliver using trucks and transit mixers have large numbers of customers and high output volume, the means of efficiently controlling the transport fleet becomes a key part of managing supply of concrete. Some Australian concrete suppliers have multiple concrete plants in the major cities and utilise truck tracking management systems to improve reliability and efficient use of transport. In this case a team of ‘dispatchers’ remotely monitor each truck location and activity (e.g. in transit to site, on site, unloading concrete or in transit back to the batch plant).

Where concrete is delivered by truck and transit mixer the driver has the responsibility to report back to the supplier’s plant management on any variation in procedures that may impact product quality on site or in transit to the site. Common variation to procedures includes management of water additions to the concrete in the transit mixer or addition of any admixtures or additives. AS 1379 does specify requirements to be met in the case of these additions and they are discussed in 3.2.

3. SUPPLY OF CONCRETE – BASIC REQUIREMENTS

3.1 CONTROL OF VOLUME

In Part III of this Guide it can be seen that concrete 'yield' is a key part of good mix design practice. AS 1379 details the methods of assessing the yield of concrete that can give some confidence in the mix design for the supplier. This method also gives some confidence that the customer is getting the volume of concrete that was ordered.

Because concrete is used to fill a certain 'mould' on site, it has always been ordered by volume. When concrete is batched this involves weighing up individual dry ingredients and sometimes weighing or measuring out liquid ingredients. The 'recipe' for these ingredients comes from a mix design and the concrete plastic density compared to the batched mass of ingredients per cubic metre gives the 'yield' (in batched cubic metres per actual cubic metres) of the concrete mix supplied.

The procedure for assessing a concrete mix yield as per AS 1379 is as given in the following steps:

1. Assess the mass of total ingredients in three batches of the concrete mix (kg);
2. For each batch of concrete carry out an assessment of the plastic density (mass per unit volume) of the mix using the method AS 1012.5;
3. Calculate the average plastic density (kg/m^3) from step 2;
4. Calculate the batch yield of each batch in step 1 by dividing its total mass by the average plastic density from step 3 (gives batch yield in m^3);
5. Calculate the mix yield of each batch in step 4 by dividing its batch yield by the volume of concrete specified in each of the three batches (gives yield in m^3/m^3 for each batch);
6. Provided the yield for each batch exceeds 98% then the correct volume has been delivered.

The aim of correct mix design is to achieve a yield of 100% on average but the reality is that batching accuracy and material changes may produce minor variations in apparent yield from batch to batch that is taken account of by allowing up to 2% in variation.

3.2 CONTROL OF ADDITIONS DURING DELIVERY

The most common addition to a concrete batch during delivery is water which is used to adjust the concrete slump where it is less than that specified. The addition of water to a mix specified by a characteristic strength or a maximum water/cement ratio needs to be carefully controlled to avoid non-conformances. While some specifiers rule out the addition of water to a batch after it leaves the concrete plant, AS 1379 does recognise the need for a limited ability to control the concrete batch slump on site. Common causes of this need can include higher ambient temperatures, delays in delivery due to traffic conditions, delays on site due to unforeseen site issues.

AS 1379 allows for various tolerances for each specified target slump as already discussed in Part VIII, Section 25 of this Guide. This Standard also allows the addition of water to a batch of concrete to maintain its slump within specified limits subject to a number of conditions that in summary ensure that:

- The addition of water does not cause the specified W/C ratio to be exceeded when applicable;
- Any water addition is recorded on the supplier's and customer's copy of the identification certificate;
- After any water addition the concrete will be fully mixed according to the Standard method;
- Where the batch is being tested for properties other than slump then the sample for these tests are taken after the addition of water.

AS 1379 also allows for additions of admixtures and additives on site provided these additions are approved by, and under the management of, the concrete supplier and dosed in accordance with the additive supplier's recommendations. In this case the same conditions apply to such additions and their impact on the concrete batch slump (as applies to addition of water to correct slump for other reasons) as noted above.

Examples of additives and admixtures that may be added on site are:

- High Range Water Reducing admixtures with shorter slump retention periods;
- Some types of fibre reinforcement;
- Colouring additives.

3.3 CONTROL OF CONCRETE TEMPERATURE

As noted in sub-section 2.2, the ambient and concrete temperature can have a significant impact on concrete slump control and thus on mix water control.

The concrete supplier obviously can't control the ambient temperature during production and delivery but certainly can manage the concrete temperature during delivery using some of the methods discussed in Part V, Section 18 of this Guide.

AS 1379 provides guidance on the maximum and minimum concrete temperatures allowable during concrete supply. These are a minimum concrete temperature of 5ºC and a maximum concrete temperature of 35ºC. The Standard also notes that special care is required to manage the concrete when the ambient temperature is under 10ºC or above 30ºC.

Some specifiers link the concrete temperature to maximum allowable time for concrete delivery (time from starting mixing of the concrete to being placed in forms) in an effort to better control slump loss. Concrete delivery time is discussed in sub-section 3.4.

3.4 CONTROL OF THE DELIVERY TIME OF CONCRETE

AS 1379 sets a limit of 90 minutes for time from commencement of mixing until the discharge of all concrete into forms. There is provision for the 90-minute limit to be varied by agreement, provided it can be shown that the concrete will retain the workability qualities on discharge (without the addition of excess water) and provide adequate time for placing, compaction and finishing.

The potential for a batch of concrete to be in workable condition after 90 minutes is dependent on the temperature of the concrete, the W/C ratio of the mix and the types of admixtures used. With higher concrete temperature and lower W/C ratio it is less likely that it will be possible to exceed 90 minutes of workable condition.

3.5 IDENTIFICATION OF DELIVERY

AS 1379 defines the Identification Certificate as being the equivalent of a delivery docket. It is required to provide a unique means of identifying the details of a batch of concrete. The certificate is required to contain the following information:

- Name of supplier, and place of manufacture;
- Serial number of certificate;
- Date of supply;
- Name of customer;
- Project name and location;
- Delivery vehicle identification, if applicable;
- Quantity of concrete covered by the certificate;
- Specified class and strength grade, or other mix identification;
- Specified slump, if applicable;
- Maximum nominal size of aggregate;
- Time of commencement of mixing;
- 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 water added after commencement of discharge;

- Any other detail that may be agreed between the customer and the supplier.

The certificate can perform an important part of both the concrete supplier's and the customer's quality management system. The serial number of the certificate also appears on testing certificates and is required to provide an audit trail to enable analysis of non-conforming concrete.

4. SPECIAL PROJECT DELIVERY REQUIREMENTS

4.1 SPECIALISED DELIVERY METHODS

Where very large volumes of concrete need to be placed on a single project, the method of transporting concrete to the construction site often needs to be reviewed. Managing traffic with large numbers of trucks moving on a site or coping with the problems of already congested public road access can lead to some innovative methods of increasing the reliability and volume rate of concrete supply. A few of these are discussed below.

Aircraft Pavement Supply

The construction of very large aircraft pavements has benefitted from the use of suitably designed 'slip-form' paving machines over many years (**Figure 10.2**). At optimum speed of placement, the paving machine may demand over 300 m^3 per hour. In order to achieve this it has been found that a central mixer plant delivering full loads of concrete into tipper trucks provides the best speed of unloading and turnaround in front of the paving machine. This method provides significant challenges for the concrete producer to ensure they maintain the required consistency control for the concrete as well as meet the production and mixing capacity requirements.

This method of placing concrete road pavements has also become more common in recent years for the same reasons (refer to Part VI, Section 19 '*Slip-formed concrete*' for more information).

Figure 10.2 – Concrete Paving using a 'Slip-form' machine[10.1]

Gravity Dam Concrete Supply

Concrete dam walls have been constructed from concrete for over a century. As the size of dams being constructed has increased with increasing pressure to shorten construction times, various innovative technologies have been developed. One of these is the use of 'Roller Compacted Concrete' (RCC) as the main volume of the dam wall structure.

Delivering large volumes of very low consistency concrete (usually zero slump concrete) into the construction zone can be achieved using 40-tonne dump trucks if accessibility is provided but also by mobile conveyor systems directly from the batch plant.

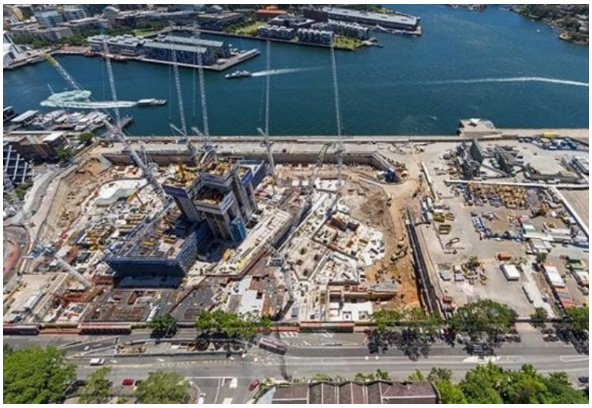
Pump to Site Concrete Supply

With the impacts of traffic congestion in large cities and the demand for large quantities of concrete to be supplied to major construction sites at all times of the day, the usage of a normal truck and transit mixer delivery system can become problematic.

One solution used over the years has been to set up an on-site concrete plant using truck and transit mixer to move concrete around the site. This can work where the access roadways and parking areas for trucks can be provided but this is often not possible.

An innovative solution that has been used in Australia has been using staged pumps through the site to pump the concrete directly from the on-site concrete plant to the various locations on site where concrete is required (**Figure 10.3**).

(a)



(b)

Figure 10.3 – 'Pumped to Site' Concrete Plant Setup and Overview of Site at Barangaroo South in Sydney, NSW[10.2]

5. REFERENCES

1) AS 1379 – *Specification and supply of concrete* (R2017)
2) AS 3600 – *Concrete structures* (2018)
3) AS 1012 – *Methods of testing concrete*

End Notes

10.1 Photo adopted from *'WIRTGEN Slipform Paver, SP 1600'*, by Natalia Brandt, licensed under the Creative Commons Attribution-Share Alike 4.0 International license, https://commons.wikimedia.org/wiki/File:WIRTGEN_Slipform_Paver,_SP_1600.jpg

10.2 Photos Courtesy of Boral Limited

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