BORAL

Building something great

Australian concrete guide

2023 | Edition 2.1

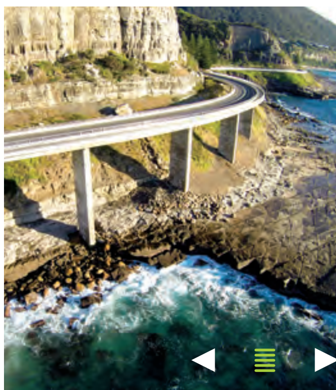


Table of contents

Kuripa Bridge, Brisbane, QLD

Preface

Concrete is an essential component in most construction projects, standing as the backbone to our built environment. Its significant presence is a testament to its ***versatility***, ***durability***, and ***resilience***, making it indispensable in shaping the world we live in. Understanding the intricacies of this crucial material is fundamental for those involved in supplying and placing concrete, be it the seasoned professional or the newly appointed apprentice.

Introducing *Boral's Australian Concrete Guide* – a comprehensive source of information about concrete, covering everything from its basic properties to those processes that equate to high quality outcomes. We hope to provide those who work with concrete the knowledge they need to excel in their craft.

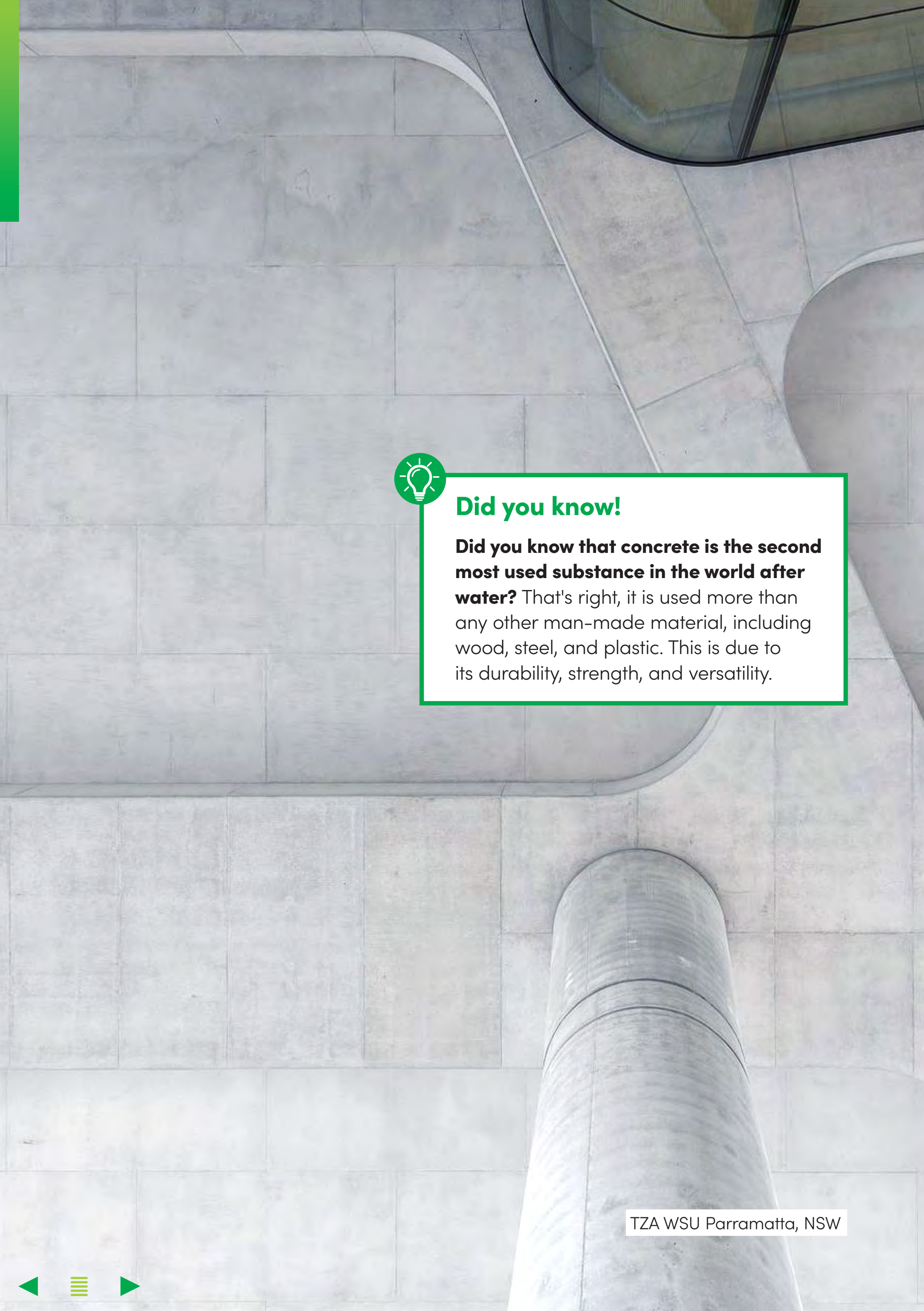
The guide begins with the fundamentals, explaining what concrete is, detailing its properties, and describing what makes up a good concrete mix. The subsequent sections delve into the specifics of testing concrete, conducting a slump test, and providing an overview of the techniques that ensure the right quality and consistency of a mixture.

Water, a critical component of any concrete mix, receives special attention in this guide. We explore the role of mixing water in concrete, the implications of its evaporation, and how this can be managed. This guide also provides valuable insights into curing and addresses the challenges posed by concreting in diverse weather conditions, equipping concreters with the knowledge to perform effectively in both hot and cold climates.

A noteworthy feature of this guide is its emphasis on safety, an aspect we hold paramount at Boral. We discuss the safe handling of concrete, providing guidance on best practices and precautions to mitigate any potential risks associated with its use.

To further support the practical application of these concepts, we detail Boral's range of products. A highlight is our lower carbon concrete range which are leading the way in sustainable practices within our industry.

As you navigate through this booklet, we hope it serves as a trusted guide on all things concrete. Concreting is complex and ever evolving, yet with the right resources, it is an art that can be mastered. Here's to your journey in mastering that art with Boral as your guide.



Did you know!

Did you know that concrete is the second most used substance in the world after water? That's right, it is used more than any other man-made material, including wood, steel, and plastic. This is due to its durability, strength, and versatility.

TZA WSU Parramatta, NSW

1 **What is** concrete?

Cement and concrete — *Are they the same?*

Many people think that cement and concrete are the same product. ***They are not.***

Cement is a dry powder that, when mixed with water, slowly reacts to form a hard, solid compound.

Concrete is a mixture of cement blended with water, various sizes of aggregates, and admixtures / additives. The cement and water form a paste that bonds the aggregates together when it hardens. Concrete, in its freshly mixed state, is a plastic, workable mixture that can be formed into almost any desired shape. It remains workable for long enough to be placed and finished and then it sets. It gains strength over time and if moisture continues to be present it will continue to gain strength for months.

Concrete has two components; aggregate and paste

Aggregates generally are of two sizes; fine and coarse. Fine aggregates are those with particle sizes smaller than about 5mm, commonly known as sand, which can be natural or manufactured. Coarse aggregates are those with particle sizes greater than about 5mm. Gravel and crushed stone are among commonly used coarse aggregates.

Paste is composed of cement, ground granulated blast furnace slag, fly ash, water and admixtures.

The cementing property of the paste results from a chemical reaction between the cement and water, called hydration. It is a reaction that requires time and favourable conditions of temperature and moisture. **'Curing'** is the provision of favourable temperature and moisture conditions over a period of time long enough to allow the hydration process to approach completion. With proper curing, hydration takes place very rapidly at first, and then decreases slowly for a long time. This allows the concrete to develop its strength and durability. Concrete needs continued moisture to develop its full potential. It should not dry out too quickly.

Strength of concrete

The compressive strength of concrete is measured by how much force is required to crush it, this is important in the design of structures. Samples of concrete are taken from the truck when the concrete is delivered to the site. The samples are stored in tanks of water at the laboratory for 28 days and then crushed to determine the compressive strength. The units of strength are megapascals (MPa). Each concrete mix is designed to achieve a certain 28 day strength which is known as the concrete grade. For example the grade of concrete required for a footpath might be 20 MPa whereas the grade required for a bridge might be 50 MPa. The grade would be specified by the relevant standard or by a project specification.

The principal factors affecting strength are the water-cement ratio and the extent to which hydration has progressed. The addition of too much water to concrete (beyond the intended mix design) will reduce strength and durability of the concrete.

Properties of fresh concrete

Before the concrete sets, it is said to be in a plastic state and after it has set, it is said be in a hardened state. Although freshly mixed concrete remains plastic for only a short time, its properties are important because they affect the quality and appearance of the hardened concrete.

Concrete with a suitable plastic consistency does not crumble as it is discharged, but flows without segregation of coarse aggregate from the sand. Mixtures of such consistency are suitable for most work. The ease or difficulty of placing and consolidating concrete is called workability. When concrete is placed it should not be so stiff that it doesn't flow or so wet that segregation occurs.

Another important property of plastic concrete is called 'bleeding'. Bleeding is the movement of water to the surface of freshly placed concrete. Excessive bleeding of water to the surface increases the water-cement ratio of the cement paste at the surface. This may result in a weak surface with poor durability, particularly if finishing operations take place while the excess water is present. However some bleed water is required as it prevents the surface from dying out prematurely. But the trowelling operation should not start until the bleed water has evaporated.

Concrete production (batching and supply)

Concrete is bought and sold by volume and the units are cubic metres or m^3.

Concrete is produced in batches and the size of the batch depends on the size of the concrete truck that will delivery it. The volume of concrete that each truck can carry varies but the volume is usually less than $8m^3$. For large pours multiple batches are produced and each batch is transported to site in a concrete truck.

What do you order?

The concrete company will need the following information when an order is placed.

- **a** The **volume** of the concrete required.
- **b** The **grade** (strength) of the concrete.
- **c** The **nominal slump** of the concrete.
- **d** The **time** between the concrete trucks.
- **e** Any **other specified characteristics** to meet engineering or architectural requirements.

If there are any unusual concrete requirements such as the addition of oxides or fibres or any out of the ordinary performance requirements, the client should discuss these with the concrete supplier well before they need the concrete.

The Australian Standard; ***AS1379 — 'Specification and supply of concrete'*** may be referenced for additional detail on the criteria and differences between Normal and Special Class concrete.

What makes good concrete?

You do not need to be a concrete technologist. However, you should be aware that a **certain quality is built into each mix design** and you should be familiar with what constitutes good concrete:

1. **Cement and water combine chemically to bond the sand and coarse aggregate together.** Ground granulated blast furnace slag and fly ash may also be used as supplementary cementing materials, but always in combination with cement. The ratio of the volume of water to the weight of cement determines, to a large extent, how strong the hardened concrete will be. Providing the workability is adequate, reducing volume of water makes the batch stronger and the addition of water makes the batch weaker.
2. **Fine and coarse aggregate of a predetermined quality** is added to the cement-water paste in the batch to give bulk to the batch. They contribute significantly to the quality of the concrete. If all fine aggregate (sand) is used to make a one cubic metre batch, a large amount of cement-water paste is needed to coat and bond the particles. By using a combination of coarse aggregate and fine aggregate (sand) the amount of water and cement is reduced. This improves the quality of concrete as well as being more economical to produce.
3. **Admixtures and / or additives are used in concrete** (often in combination) to impart specific qualities to the fresh or hardened concrete. Admixtures can change the setting times, make the concrete flow further, increase the strength and improve the durability.

   The most common are water-reducing admixtures. They help produce a medium slump, workable concrete, requiring less mixing water. Set modifying admixtures, retarders and accelerators, are used in the summer and winter to counter the affect that hot or cold weather has on setting times. Superplasticisers or high range water reducers can greatly increase the slump without the need for additional water.

2 **The testing of** concrete

Technical service to the building and construction industries

Throughout Australia, Boral has established concrete testing laboratories staffed by qualified and experienced personnel to assist with the quality control of our product, and to act in a technical advisory capacity to the building and construction industry.

Each of our laboratories is accredited with the National Association of Testing Authorities Australia (NATA), and as such our test reports bear the NATA endorsement; 'Accredited for compliance with ISO / IEC 17025'.

This NATA accreditation represents a safeguard and provides conformation for the concrete purchaser, the architect and / or the engineer and the owner, that the testing procedures used have been in strict accordance with the relevant Australian Standards.

Field testing services

Concrete testing services has been established as an extension of these facilities. Upon request one of the company's field testing officers will go to the job site, measure the slump of the concrete and cast cylinders for compressive strength. Test specimens for other properties will be cast when requested.

The following day a Field Testing Officer will return to the site to collect the specimens and transport them to the laboratory for standard curing, testing and reporting.

Concrete research and development laboratory

Boral maintains a dedicated construction materials research and development facility. It was at this facility that special concrete mixes were developed for many major projects across Australia.

Major project case studies may be reviewed on our web site at **boral.com.au/projects**

> "Each of our laboratories is accredited with the National Association of Testing Authorities Australia (NATA)."

Determining the consistency of concrete (AS 1012, Part 3) — the slump test

The workability of concrete is assessed by from a slump test. Slump tests are carried out on samples of concrete taken from the truck on site.

If the slump test is to determine whether or not the concrete is to be accepted, the sample must be taken from the early part of the load, however the sample should not be taken from the first $0.2m^3$ of concrete out of the mixer.

If the test is to be representative of the entire load, samples should be taken from three well spaced parts of the load and remixing them on a non-absorbent surface.

Conducting a slump test

1 **Moisten the inside of the cone and place it on a flat, level and firm surface** – a piece of steel plate, concrete or stone slab, sheet or metal pan etc. This support should extend 50mm beyond the base of the cone to provide space for the concrete to spread when the cone is removed later. Hold the cone firmly in place when putting concrete in it by standing on the foot lugs.

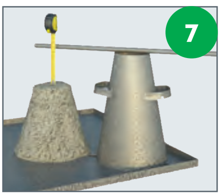
2 **Fill the cone with one-third of the volume** (approx. depth of 100mm) and rod the layer exactly 25 times with a round bullet-nosed steel tamping rod of 15mm diameter, 600mm long. Rod uniformly over the entire concrete surface.

3 **Fill the cone with the second layer until two-thirds full** (approx depth of 200mm) and rod this layer 25 times uniformly over the entire concrete surface just penetrating into the underlying layer.

4 **Fill the cone with the third layer until it slightly overflows** and then rod this top layer 25 times uniformly over the entire concrete surface, just penetrating into the underlying layer.

5 **Strike off the excess concrete from the top** with the tamping rod so that the cone is exactly filled. Remove spilled concrete from around the bottom of the cone.

6 **Lift cone straight up**, taking approximately three seconds to lift the cone. Never jar the concrete in any way until after the slump is measured in order to avoid possible incorrect results.



7 **Measure the slump as shown in the diagram.** If the top of the slump is irregular, do not measure the high point or the low point. Try to get the average. The slump shall be measured to the nearest 5mm for slumps 100mm and less, and to the nearest 10mm for slumps greater than 100mm.

Casting compression test specimen (AS 1012, Part 8)

The standard test specimen is a cylinder 100mm in diameter and 200mm long which are cast in calibrated moulds.

Before use, the inside surfaces of the mould should be thinly coated with a mineral oil to prevent adhesion of the concrete.

Filling and compacting

The moulds (100mm diameter x 200mm high) are filled in ‘two approximately equal layers’ and fully compacted usually by hand rodding for slumps of 40mm and above or by vibration for lower slumps down to 10mm.

1 **Compaction by rodding** – each layer shall be fully compacted using the standard tamping rod 15mm diameter, 600mm long. The tamping rod is inserted into the concrete 25 times for each layer. The bottom layer shall be rodded throughout its depth and for the upper layer; the first 10 strokes shall just penetrate into the underlying layer.

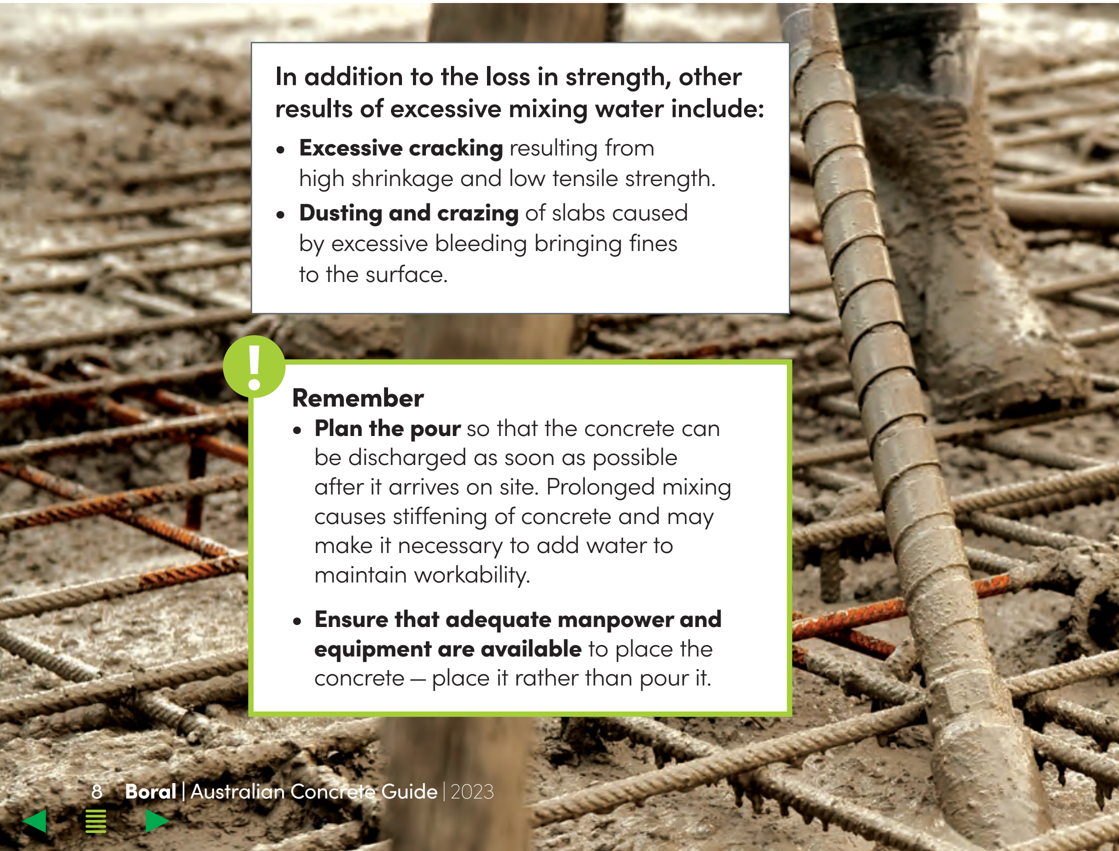
2 **Compaction by vibration** – for standard cylinders two approximately equal layers shall be used. All the concrete for each layer shall be placed in the mould before starting vibration of that layer. Vibration shall be continued only long enough to achieve full compaction of that layer. Over vibration should be avoided.

3 **Mixing water in** concrete

The use of too much mixing water in concrete is probably the most common abuse of concrete, and is often very costly.

In a correctly proportioned concrete mix, only about half of the mixing water is needed to hydrate the cement. The remainder acts as a lubricant to produce workability. When more water than is actually needed for workability is added, the concrete is diluted, its density, strength and durability is reduced.

In terms of basic concrete technology, the compressive strength is proportional to the strength of the cement paste which is in turn dependent upon the amount of water present in the mix for a given quantity of cement, or the water-cement ratio. For the same quantity of cement, the more water used to produce a higher slump, the higher this ratio becomes and the lower is the resultant compressive strength. The affect of adding, or reducing, the water has on the slump and strength of the concrete can be seen on **page 9**.



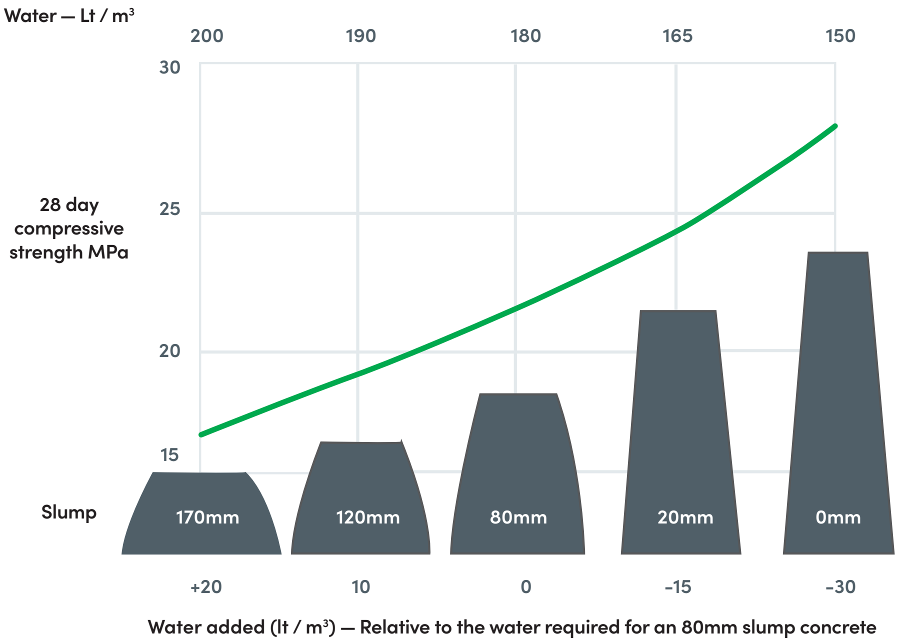
In addition to the loss in strength, other results of excessive mixing water include:

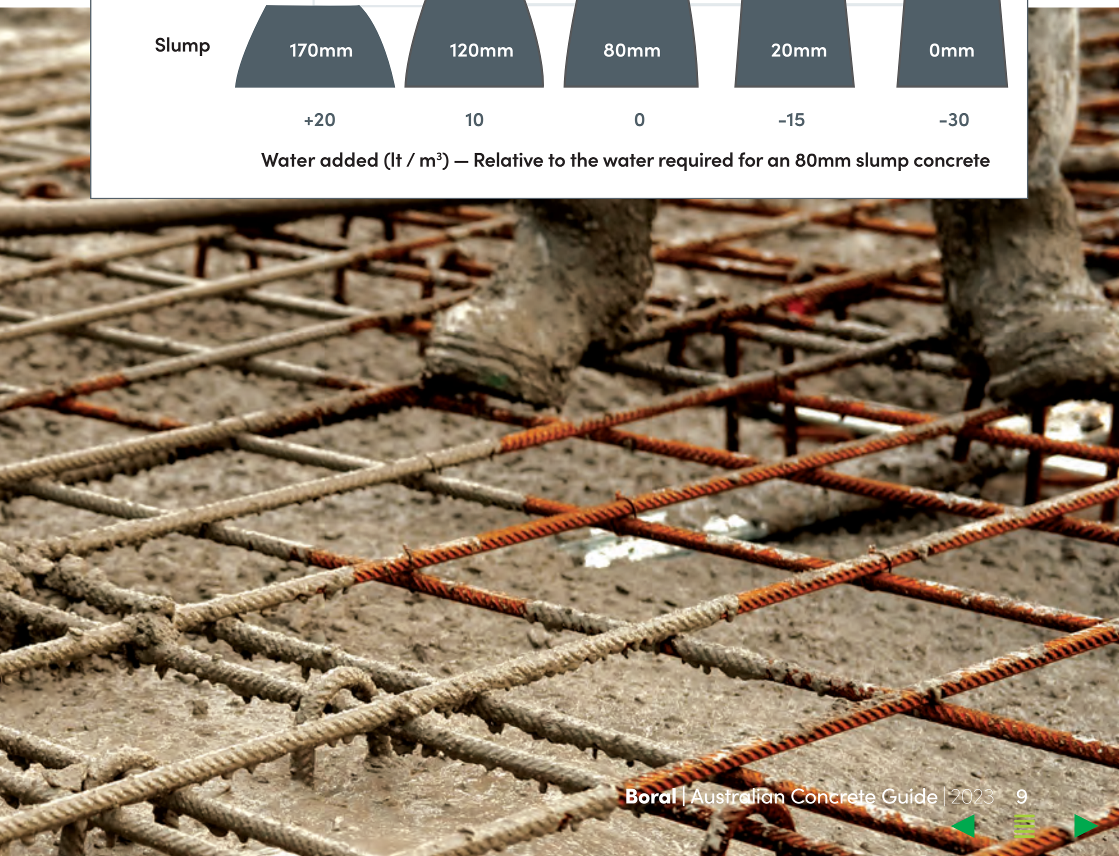
- **Excessive cracking** resulting from high shrinkage and low tensile strength.
- **Dusting and crazing** of slabs caused by excessive bleeding bringing fines to the surface.

Remember

- **Plan the pour** so that the concrete can be discharged as soon as possible after it arrives on site. Prolonged mixing causes stiffening of concrete and may make it necessary to add water to maintain workability.
- **Ensure that adequate manpower and equipment are available** to place the concrete – place it rather than pour it.

Effect of water content on strength and slump





"The vibrator should be inserted into the concrete at regular intervals. When pouring multiple layers the vibrator should penetrate about 50mm into the lower layer."

4 **Vibration of** concrete

Compaction removes entrapped air that would otherwise weaken the concrete. Compaction will also reduce the number and size of air pockets at the surface of off form finished walls and columns.

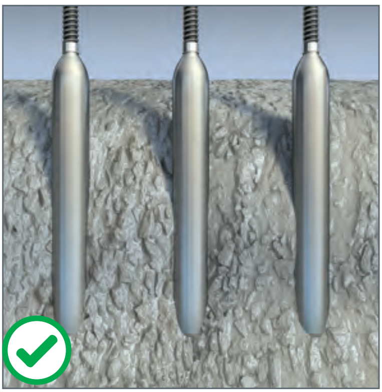
With the exception of self compacting concrete all concrete needs to be compacted by internal or external vibration. This is normally achieved by inserting poker vibrators into the concrete.

The concrete should be vibrated for 5 to 15 seconds and the amount of vibration needed in one spot can be gauged by:

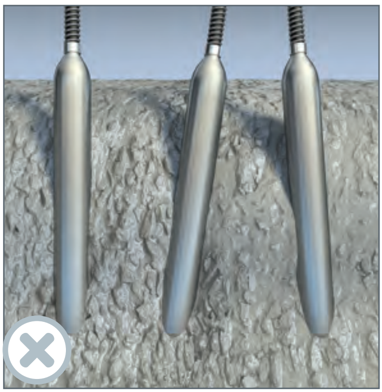
- the surface movement and texture of the concrete
- the change of the sound of the vibrator to a constant tone
- the **'feel'** of immersion vibrators in the operators' hands.

Hand-held poker vibrators should not be used to transport concrete along a horizontal surface or to re-mix concrete in forms, as some segregation will occur.

Systematic vibration of each layer is essential. The vibrator should be inserted into the concrete at regular intervals. When pouring multiple layers the vibrator should penetrate about 50mm into the lower layer while it is still plastic. Penetration at haphazard angles, spaces and depths does not result in a monolithic combination of the two layers.



Correct



Incorrect

Self Compacting Concrete (SCC)

Self compacted concrete does not require compaction from internal or external vibration. Self compacting concrete is only suitable for some applications.

5 Evaporation of bleed water from concrete

On warm, windy or low humidity days the bleed water may evaporate before the concrete sets. When this happens the surface of the concrete will shrink at the surface and as the strength of the concrete is low at this stage the concrete will crack. This form of cracking is known as plastic shrinkage cracking because it occurs while the concrete is in a plastic state.

Understanding the expected rate of the evaporation of the bleed water will give concreters the opportunity to take the correct preventive measures. The chart below shows the effects of air temperature, humidity, concrete temperature and wind velocity together on the rate of evaporation of water from freshly placed concrete.

The chart on **page 13** gives an indication of the evaporation rate of bleed water for different conditions.

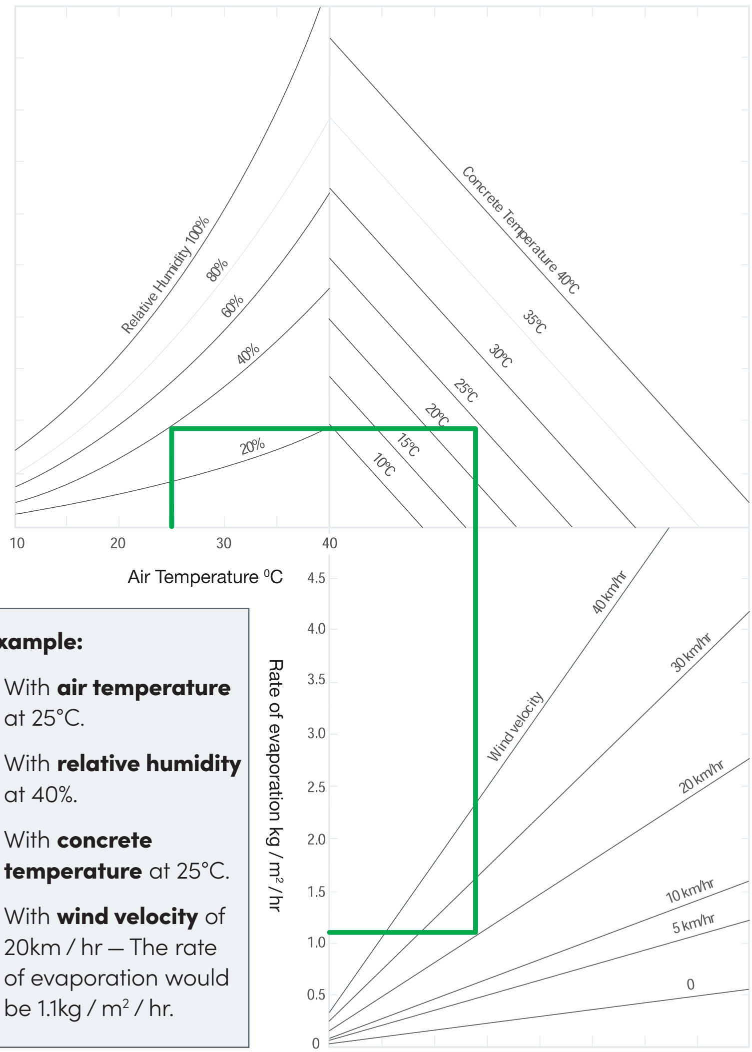
To determine the evaporation rate from the chart, start with the air temperature (in this example 25°C) and move vertically to intersect the curve for relative humidity (in this case 40%). From this point, move horizontally to the respective line for the concrete temperature (in this example 25°C). Move vertically down to the respective wind velocity curve (in this case 20km / hr), and then horizontally to the left to intersect the scale for the rate of evaporation (in this example it is 1.1kg / m^2 / hr).

The predicted ambient temperature, humidity and wind velocity can be obtained from the Bureaus of Meteorology. The concrete temperature can be predicted from the ambient temperature, as it is normally a few degrees above the ambient temperature.

Plastic shrinkage cracking may occur when the rate of evaporation exceeds be 0.5kg / m^2 / hr and precautionary measures should be considered. When the evaporation rate exceeds 1.0kg / m^2 / hr precautionary measures to prevent plastic shrinkage cracking, are required.

Precautionary measures could include changing the time of placement to avoid the unfavourable conditions, applying an evaporative retarder to the surface of the plastic concrete using wind breaks and starting the curing process as soon as the concrete sets.

Evaporation rate of bleed water for different conditions



Example:

- With **air temperature** at 25°C.
- With **relative humidity** at 40%.
- With **concrete temperature** at 25°C.
- With **wind velocity** of 20km / hr — The rate of evaporation would be 1.1kg / m² / hr.

Did you know!

Did you know that proper curing of concrete can improve its strength by up to 50%? Curing is a critical step in the concrete construction process that involves keeping the concrete moist and at a consistent temperature for a specified period. **If concrete is not properly cured it may not achieve it's design strength**, it will be less durable and will be more likely to crack.

6 **Curing of** concrete

Concrete must be adequately cured.

The following notes give some background to adequate curing.

What is hydration?

When cement is mixed with water it undergoes a chemical change that transforms it into 'rock'. When it hardens into a mass similar to rock, it is said to have hydrated. Therefore, hydration is nothing more than a chemical combination of cement and water. First, the outside of the cement particle hydrates and a cement gel (glue) is formed. As water continues to soak through this cement gel, further hydration takes place in the cement particle. This process goes on for many years just as long as moisture is present. The process of keeping the concrete damp is known as curing.

Curing, why and how

Aggregate mixed with the cement becomes part of the "rock" mass. The process of transformation is most rapid during the first 28 days. Nothing can stop the transformation except a lack of water or subnormal temperatures. If concrete is allowed to dry out in the initial stages, it will not achieve its potential strength.

Similarly, low ambient temperatures can adversely affect concrete strength, in particular it will reduce the early age strength of the concrete which will delay tensioning post tensioned slabs and stripping form work.

Surface strength

The strength or hardness of the surface of a concrete floor is particularly affected by the length of curing. Concrete floors that are cured for 28 days are significantly harder than floors that are only cured for a few days. Floors with a hard surface will have better resistance to abrasion caused by vehicles.

Permeability

Good curing will reduce the volume of pores in the concrete as more of the cement will hydrate to fill the pores. A reduction in the volume of pores will reduce the permeability of concrete and improve its watertightness.

Effects of curing

The longer concrete is cured the greater its strength.

If the concrete is to attain its potential strength and durability it must have:

- Sufficient water for hydration of the cement.
- A temperature conducive to maintaining the chemical reaction at a rapid, continuous rate.

Methods of curing

We have given some of the reasons why it is necessary to cure concrete. The table below lists some of the methods to cure concrete. All the methods have advantages and disadvantages.

Methods of curing

Methods	Advantage	Disadvantage
Sprinkling with water or covering with wet hessian	• Excellent results if constantly kept wet.	• The concrete will dry out if the concrete is not kept continually wet. • Difficult on vertical walls.
Curing compounds	• Easy to apply. • Inexpensive.	Sprayer needed – inadequate coverage allows drying out; film can be broken or tracked off before curing is completed.
Moist sand	• Cheap.	Can dry out, removal problem.
Plastic film	• Watertight. • Excellent protection. • Light and easy to handle.	Requires reasonable care and tears must be patched, must be weighed down to prevent blowing away.

To sum up the advantages of careful control of moisture concrete and temperature in curing

- The strength of concrete increases with age if curing conditions are favourable (the compressive strength of properly cured concrete is significantly greater than the strength of concrete which has not been cured at all).
- Properly cured concrete surfaces wear well.
- Drying shrinkage is greatly reduced.
- Greater watertightness of constructions.

Points to keep in mind when curing

- The mixing water needs to be retained in the concrete.
- If during the curing process the concrete is allowed to dry out – as may happen in hot weather – the chemical change stops right at the point where the concrete loses its moisture.
- Curing must be continuous to prevent the concrete from drying out.
- Apply an evaporative retarder when the evaporation rate of the bleed water is expected to exceed 0.5kg / m^2 / hr.
- Start the curing operation as soon as the concrete has set.
- Cure concrete for at least seven days.

Riverside Walk, Brisbane, QLD

7

Hot and cold weather concreting

Hot weather concreting

When a high evaporation rate is expected the following actions will increase the likelihood of a successful outcome.

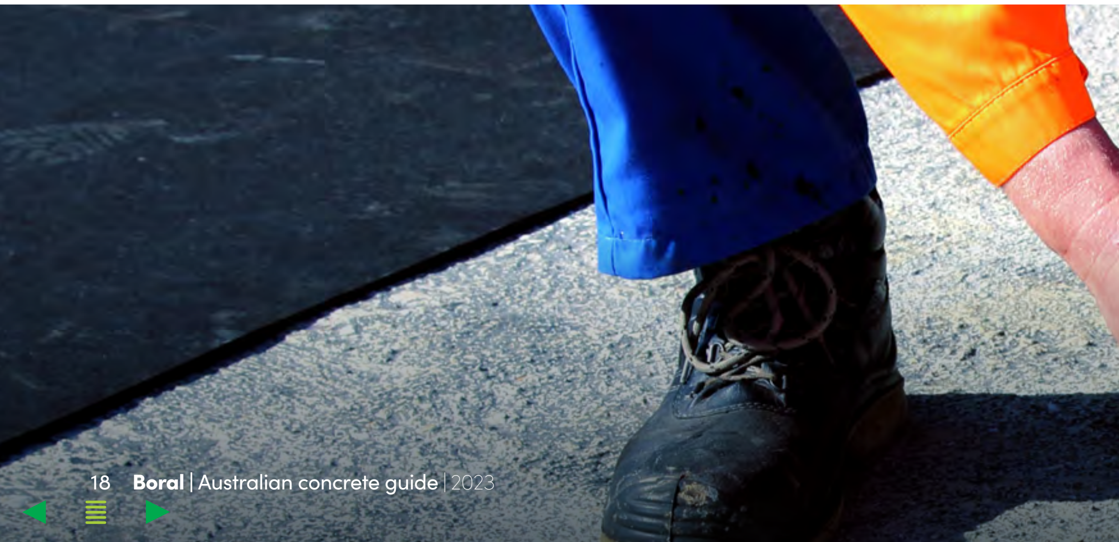
- Consider placing the concrete at a time when the ambient conditions are more favourable for placing concrete.
- Thoroughly moisten the subgrade, reinforcing steel and formwork before placing the concrete.
- Discharge concrete from waiting trucks as soon as possible. Heat builds up in mixer drums if this is not done.
- Avoid delay in placing the concrete. Have sufficient labour and equipment on hand to place the concrete quickly.
- Try to shade the concrete from direct sunlight during placement.
- Apply an evaporative retarder as frequently as required to prevent the surface from drying out.
- Start curing the concrete using one of the methods described on page 16 as soon as it has set.

If these problems are not anticipated, and appropriate action is not taken, there may be:

- Strength reduction.
- Shrinkage cracks.
- Crazing or cracking.
- Finishing difficulties.

!

Remember!
Check the weather forecast to estimate the evaporation rate of the bleed water.
Plan work in advance and have adequate labour available so that concrete can be handled rapidly.



Cold weather concreting

Few areas in Australia experience temperatures low enough to warrant elaborate and expensive protection of freshly placed concrete. But frosts, abrupt drops in ambient temperature and / or prolonged periods of cold weather, are common in our winter seasons. Harmful effects of these conditions on new concrete can be avoided by relatively simple measures in ordering, placing and curing.

Placed concrete undergoes a **'gel'** formation that hardens over a period of weeks. Generally, the lower the ambient (surrounding) temperature, the slower the rate of hardening.

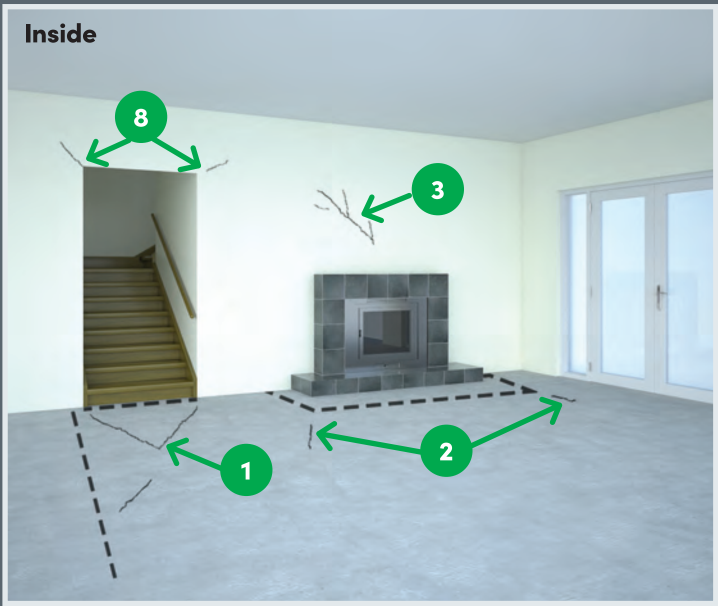
At an ambient temperature just above 0°C the development of strength in unprotected freshly placed concrete is very slow. If the ambient temperature drops to or below 0°C some of the water in the concrete may freeze, setting will virtually stop until it thaws and this interruption of hydration reduces final strength and durability.

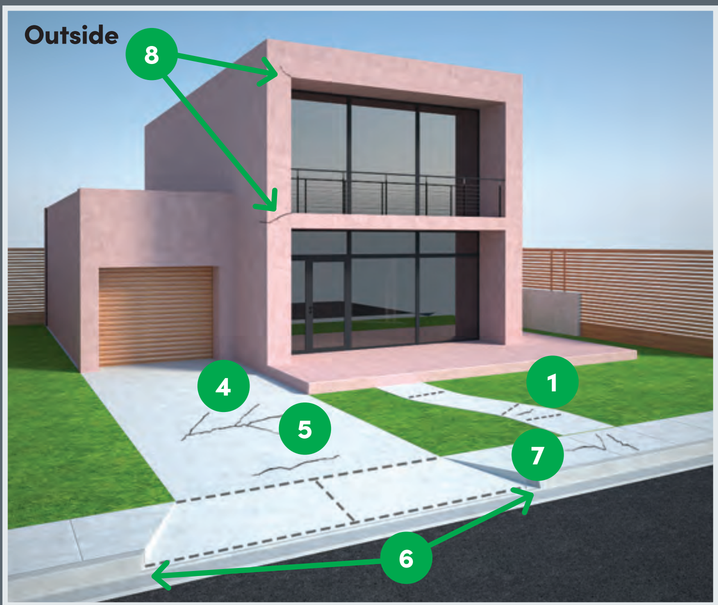
Because some heat is generated during the hydration process, ordinary concrete has a minor inherent resistance to the freezing of its water content after placing. But when the temperature of the concrete surface itself falls below freezing point, the water near the surface will freeze, increasing its volume by about 10 percent. The expansion occurs while the concrete strength is very low and will result in scaling or spalling. The damage will become more severe if several freezing / thawing cycles occur.

Air-entrained concrete mixes have excellent resistance to surface scaling after freezing because, as ice crystals begin to form, residual water under pressure moves into the millions of small air cells in the concrete, thus relieving stress.

8 **Cracks in** concrete

Types of cracks





Types of cracks

Most cracks in concrete can be classified as one of the following. The typical location of these cracks can be seen in the images on page 20.

1 **Shrinkage cracks** — avoid by cutting contraction joints along dotted lines.

2 **Shrinkage cracks caused by stress** concentration at corners — prevent by placing expansion joint along dotted line, or by using reinforcing trimmer bars.

3 **Settlement crack** caused by movement of subgrade or footings.

4 **Cracks due to heaving under slab** through poor drainage of subgrade.

5 **Expansion cracks** — prevent by placing expansion joints at dotted lines.

6 **Shrinkage cracks in feathered sections.** Narrow feathered sections should be avoided.

7 **Plastic shrinkage cracks**, due to quick loss of water to subgrade or the atmosphere.

8 **Shrinkage cracks at door or window corners** — avoid by using reinforced steel.

Of the different causes of cracks mentioned above two require more detailed attention, ***'plastic shrinkage and drying shrinkage'***.

Plastic shrinkage cracks

When wind, low humidity, high air temperature, or a combination of all three, cause water to evaporate from a concrete surface faster than it can be replaced by water bleeding (rising) to the surface. The rapid evaporation that causes this can be minimised by wind breaks, shading and applying an evaporative retarder.

Drying shrinkage

Concrete, when placed contains more water than is required for hydration of the cement it contains. When the concrete hardens and starts to lose the excess water, it starts to shrink, which is referred to as drying shrinkage. Unrestrained concrete should not experience cracking due to drying shrinkage, however, all concrete structures have some restraint.

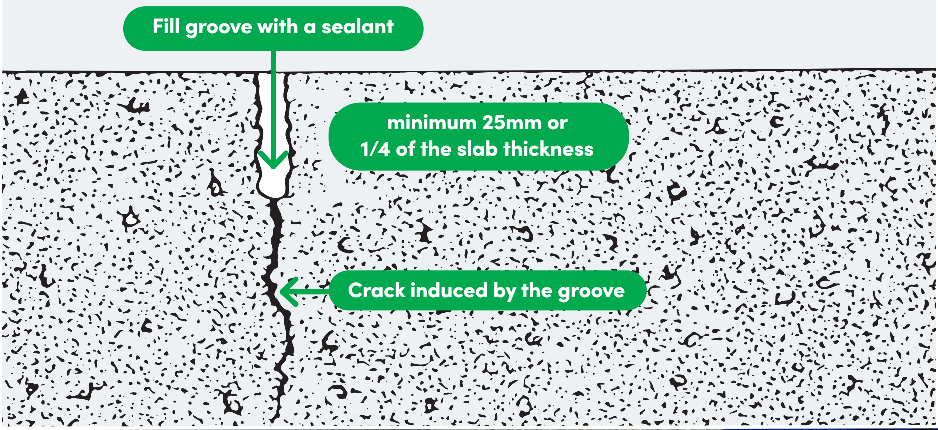
The cracking phenomenon is complex and depends upon a number of things — rate and amount of drying, tensile strength, tensile strain, creep, elasticity, degree of restraint and other factors. In the laboratory, drying shrinkage tests are the most easily and most frequently performed tests in relation to shrinkage / cracking problems. However, there is sometimes too much emphasis on the drying shrinkage of hardened concrete as the criterion of susceptibility to cracking.

Controlled cracking – grooves and joints

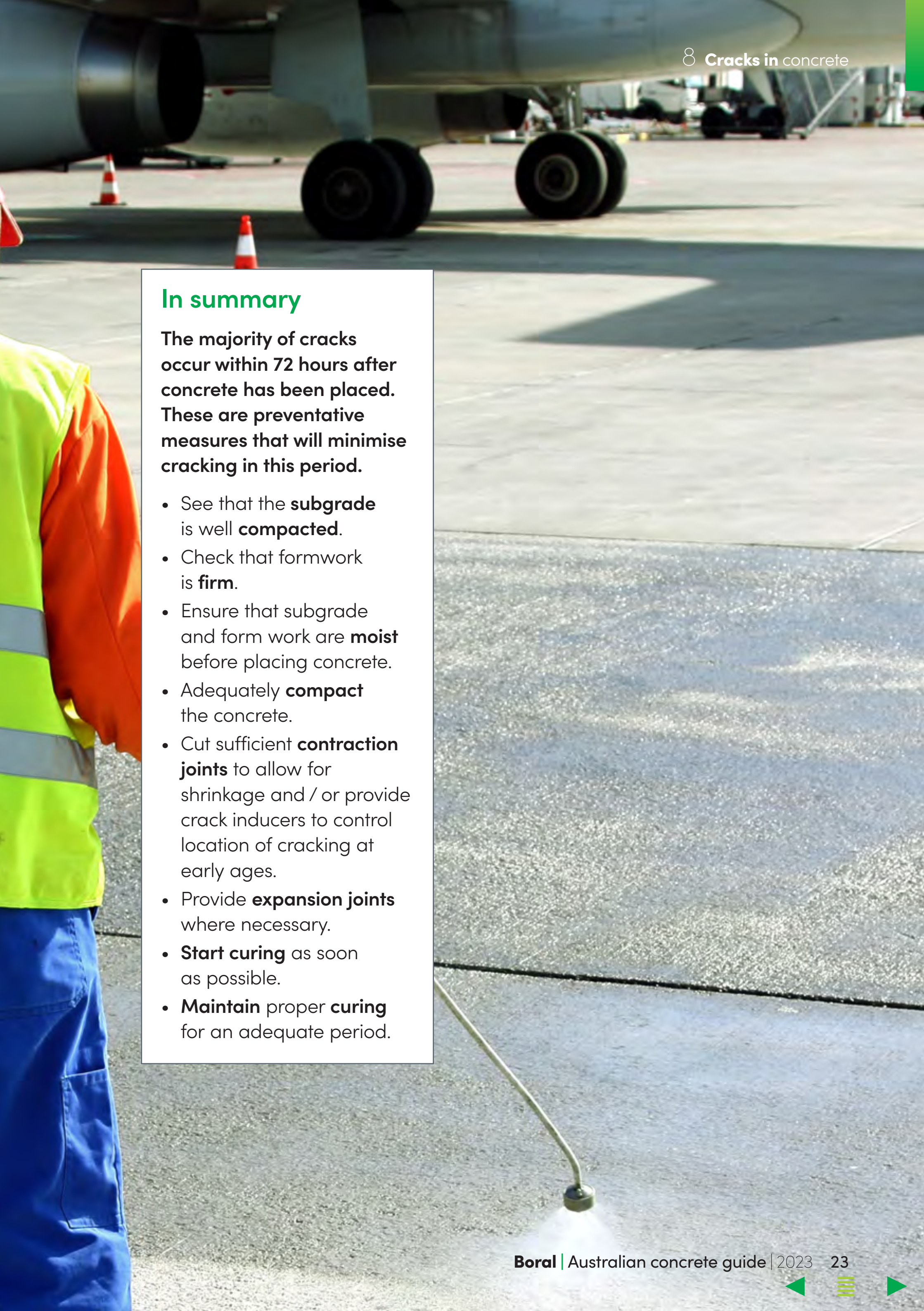
Shrinkage cracks cannot always be prevented, but they can be controlled by making planes of weakness to establish the direction of cracking when contraction occurs. These planned cracks are called control joints and can be produced by one of the following methods:

- **For small slabs**, a hand held grooving tool can be used before the concrete sets. The groove should be one quarter the depth of the slab or 25mm which ever is larger.
- **Proprietary crack inducers** can be placed where the cracks are required. Some crack inducers are placed on the substrate prior to placing the concrete and some are inserted into the concrete before it sets.
- **The concrete can be cut with a concrete saw** as soon as it is strong enough to resist damage from the saw. The cut should be one quarter the depth of the slab or 25mm which ever is larger.

Example of a control joint formed by a hand held grooving tool.



22



In summary

The majority of cracks occur within 72 hours after concrete has been placed. These are preventative measures that will minimise cracking in this period.

- See that the **subgrade** is well **compacted**.
- Check that formwork is **firm**.
- Ensure that subgrade and form work are **moist** before placing concrete.
- Adequately **compact** the concrete.
- Cut sufficient **contraction joints** to allow for shrinkage and / or provide crack inducers to control location of cracking at early ages.
- Provide **expansion joints** where necessary.
- **Start curing** as soon as possible.
- **Maintain** proper **curing** for an adequate period.


DAVCRON
1300 552 555
890
SLOW
BE 96 QD
BORAL
BORAL

9 Concrete **delivery requirements**

At Boral we regard the safety and welfare of our people as our most important responsibility. We are committed to operating our businesses in a manner which ensures that our employees, contractors, visitors and the communities in which we operate are free from harm.

In seeking to meet our zero harm goal, Boral is committed to ensuring the safe delivery of our products and would like to formally draw your attention to our specific concrete delivery requirements set out below

Traffic management

Our Drivers	Our requirements — for Customer Planning
Must be **satisfied that they have a safe and legal area** for the truck to park and discharge the load.	**Authorised traffic control is to be in place if** **1** The truck has to **face oncoming traffic** while discharging. **2** The driver has to discharge the load on **a main road** or is in a **hazardous position** (e.g. bend or over the crest of a hill). In this case, barriers and traffic cones are required.
	Safe and legal access for pedestrians **3** The customer must ensure that when the footpath is crossed or blocked by the trucks discharging that there is **safe and legal access for pedestrians**.
	A spotter available at all times to guide the truck into position for discharge **4** Customers will need to ensure that the **spotter is wearing Hi-Vis clothing**, is at a safe distance from the truck and is visible to the driver at all times.

ZERO HARM TODAY

Environmental

Our Drivers	Our requirements — for Customer Planning
***Have the right* to refuse to enter any site** if they believe that the truck will illegally drag contaminates off-site onto a public road upon their departure.	**Cleaning facilities** **5** Customers to **provide a wheel wash, pressure washer** or other means of cleaning wheels and a area to clean any contaminates from the truck before the truck leaves the site.
***Are not* to wash onto street** where contaminates could enter storm water drains.	**Wash down of chutes** **6** Customer to provide a **skip or alternative**.

Power lines

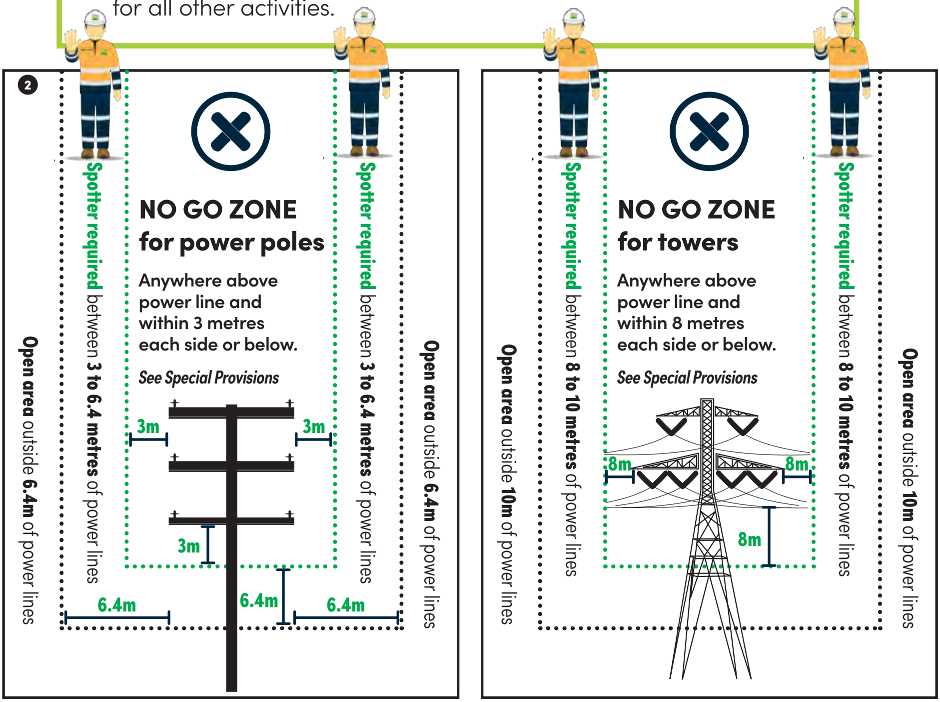
Approach distances for work performed by ordinary persons

Phase to phase AC voltage (volts)	Approach distance (metres)
Up to 33,000 volts*	0.9
33,000 to 132,000	3.0
132,000 to 330,000	6.0
Above 333,000	8.0

*Note: the 0.9 separation distance relates to the following activities:

Remember!

- **No vehicles** driving under power lines.
- **No trucks** discharging while parked under power lines.
- **No vehicles and personnel** under power lines that connect a domestic house to the power lines.
- The separation distance increases to a **minimum three metres** for all other activities.



Source 1 WorkCover New South Wales, *Work Near Overhead Power Lines Code of Practice* 2006.
2 Safe Work Australia, *General Guide For Working In The Vicinity Of Overhead and Underground Electric Lines*, Page 8-9, July 2014. https://www.safeworkaustralia.gov.au/system/files/documents/1703/overhead-underground-electric-lines-general-guide.pdf

Cranes, kibbles and booms

Approach distances for work performed by ordinary persons

Our Drivers	Our requirements — for Customer Planning
***Must comply* to all PPE requirements** and ensure that kibble is not overfilled.	**Dogman or spotter** Our **drivers must not be used** as a dogman or spotter.
***Are not* to wash onto street** where contaminates could enter storm water drains.	**Loading kibble** **1** Customer to ensure **truck driver is directed into position** for discharging loads. **2** The loading area **must be clearly defined and kept free** of obstructions and trip hazards.
	Slewing kibbles Slewing of mobile cranes or booms **cannot pass over truck** — kibble is to be raised **above Agitator height and slewed away** from personnel.

Open trenches and ramps

Our requirements — for customer planning

The minimum width for access road should be three metres clear of any building materials or debris:

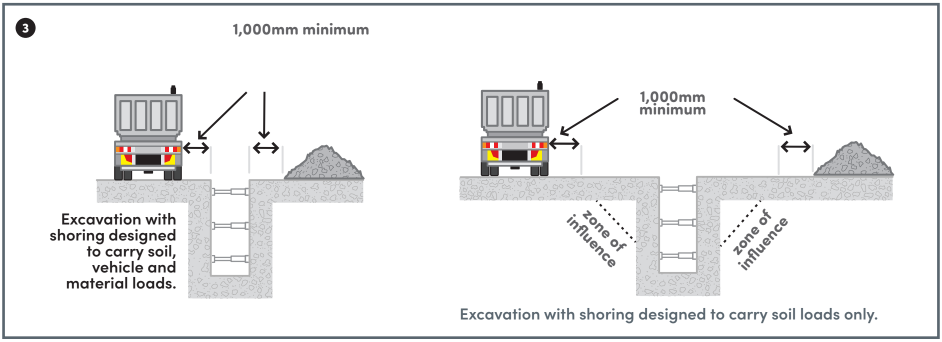
1 The customer should consider extra width if there are any turns on the access road. The minimum distance any part of our truck must stay away from an open trench is the depth of the trench plus one metre.

This means for example:

1 If the **trench depth is 500mm** deep the truck must stay 1,500mm away.

2 If the **trench depth is one metre** deep the truck must stay two metres away.

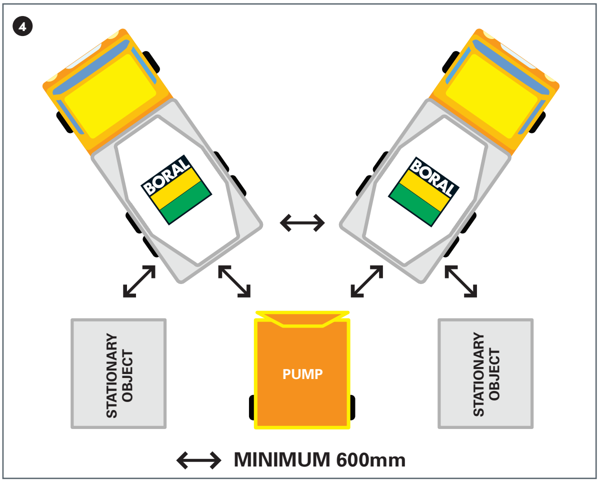
3 If the **trench depth is 1.5 metres** deep the truck must stay 2.5 metres away.



Source
3 Safework Australia publication July 2012 – *Excavation Work Code of Practice*.

Pumping

Our Drivers	Our requirements — for Customer Planning
***Must stand* well clear of pump lines and couplings** where practicable.	**The concrete pumping area should be:** **1 Reasonably level, solid and free of obstructions**, with careful attention paid to positioning of the pumping equipment and any stabilising devices. **2** Clear of **excavations, trenches or holes** in the ground. **3** Clear of **inadequately compacted** or soft ground. **4** Clear of **cellars, basements, pits or back-filled ground**, to allow for the safe discharge of the concrete delivery trucks.
***Must wear* all required Personal Protective Equipment (PPE):** **1** Safety Helmet **2** Safety glasses **3** Ear plug / muffs **4** Hi-Visibility vest or shirt **5** Work gloves **6. Steel capped boots**	The emergency stop should be **visible to the driver** and operational crew. We also require there to be a **600mm clearance between two trucks** simultaneously feeding into pump hopper as demonstrated in the diagram below.



Source

4. Cement Concrete & Aggregates Australia, *Concrete Pump Delivery Industry Guidelines, 2014,* Page 15. https://www.ccaa.com.au/common/Uploaded%20files/CCAA/Industry%20Guidelines/CCAA_Concrete_Pump_Delivery.pdf?ss360SearchTerm=concrete%20pump%20industry%20guidelines

Pumping

Our Drivers	Our requirements — for Customer Planning
Must never **reverse without a spotter** in place.	A spotter to assist **reversing trucks** must be provided by the contractor or pump operator.
	We require the provision of a **safe location** for the spotter, pump operator and truck drivers to prevent them from being caught between the reversing truck and the pump hopper, other trucks or stationary objects.
Must never **stand on the pump truck or straddle** between the concrete truck and the pump truck.	Our customer must ensure they have a **competent person** reversing trucks onto the receiving hopper at all times.
	The **primary chute** on concrete trucks should only be moved when the truck is stationary. It is preferable for the truck driver to perform this task. If another worker performs this task then the permission of the driver should be obtained.
	The **concrete receiving hopper** should be at a height that allows a gravity flow of concrete into the hopper.
	The pump must be fitted with a **secure hopper grate** constructed of parallel bars. A grill must be provided to prevent access to dangerous moving parts such as feed or agitator mechanisms and valve gear.

Remember!
No one should ever be allowed or able to stand between a reversing truck and the pump or other nearby stationary object.

Blowback — Importance advice notification

- **Blowback into a concrete truck can only occur if:**
  1 A risk based process has been **documented**, and
  2 **Approval** has been given by Boral.
- Allowing concrete to be blown back into the agitator barrel is an inherently **dangerous procedure** unless it is carefully controlled. Air pressure can cause anything inside the pipeline to act as a high velocity projectile.
- Blowback must occur via a **well secured fixed line** to prevent 'whipping'. The steel pipe must extend 600mm inwards beyond the barrel drip ring.
- Appropriate **work platforms** must be provided to fit the blowback line.
- The **pump operator** is responsible for fitting the line.
- The **driver** is to be positioned forward of the pump truck cabin.

Road surfaces and gradients

- **Forward road gradients** are not to exceed one metre high for every 10 metres in length (1:10)
- **Cross slopes** are not to exceed one metre high for every 10 metres in width (1:10)
- The **road surface** are to be compacted (or able) to sustain:
  — 23 tonnes (6 wheeler concrete truck)
  — 28 tonnes (8 wheeler concrete truck)
  — 32 tonnes (10 wheeler concrete truck)
- **Self draining** (free from pooled water)
- **One way roads** are to be 1.5 times the width of the concrete truck with passing bays (a minimum of 16 metre in length and four metres wide)
- **Two way roads** are to be 2.5 times the width of the concrete truck.

Barangaroo, Sydney, NSW

10 **Safe handling of** concrete

Concrete is a very alkaline material and if not handled properly, and with the appropriate personal protective equipment (PPE), caustic burns may be experienced.

Boral's Concrete Safety Data Sheet (SDS) can be viewed at:
https://www.boral.com.au/sds-sheets?product_category=86

The page '1 of 7' of the referenced SDS is included below:

BORAL

Building something great

1. IDENTIFICATION OF THE MATERIAL AND SUPPLIER

1.1 Product identifier

Product name	**BORAL PRE-MIXED CONCRETE**
Synonyms	ASPIRE (R) • BORAL COLORI® • BORAL EXPOSE® • BORALSTONE® • ENFLO • ENVIROCRETE (R) • ENVISIA® • GROUT • LUMINESQUE (R) • READY-MIXED CONCRETE • WET-MIX CONCRETE • WINTERSLAB (R)

1.2 Uses and uses advised against

Uses	CONCRETE • WET MIX CONCRETE Boral Pre-mixed Concrete is used for a wide variety of applications in building and civil engineering.

1.3 Details of the supplier of the product

Supplier name	**BORAL AUSTRALIA**
Address	Triniti T2, Level 3, 39 Delhi Road, North Ryde, NSW, 2113, AUSTRALIA
Telephone	(02) 9220 6300
Website	http://www.boral.com.au

1.4 Emergency telephone numbers

Emergency	13 11 26 (Poisons Information Centre)

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

CLASSIFIED AS HAZARDOUS ACCORDING TO SAFE WORK AUSTRALIA CRITERIA

Physical Hazards
Not classified as a Physical Hazard

Health Hazards
Skin Corrosion/Irritation: Category 2
Serious Eye Damage / Eye Irritation: Category 1

Environmental Hazards
Not classified as an Environmental Hazard

2.2 GHS Label elements

Signal word **DANGER**

Pictograms

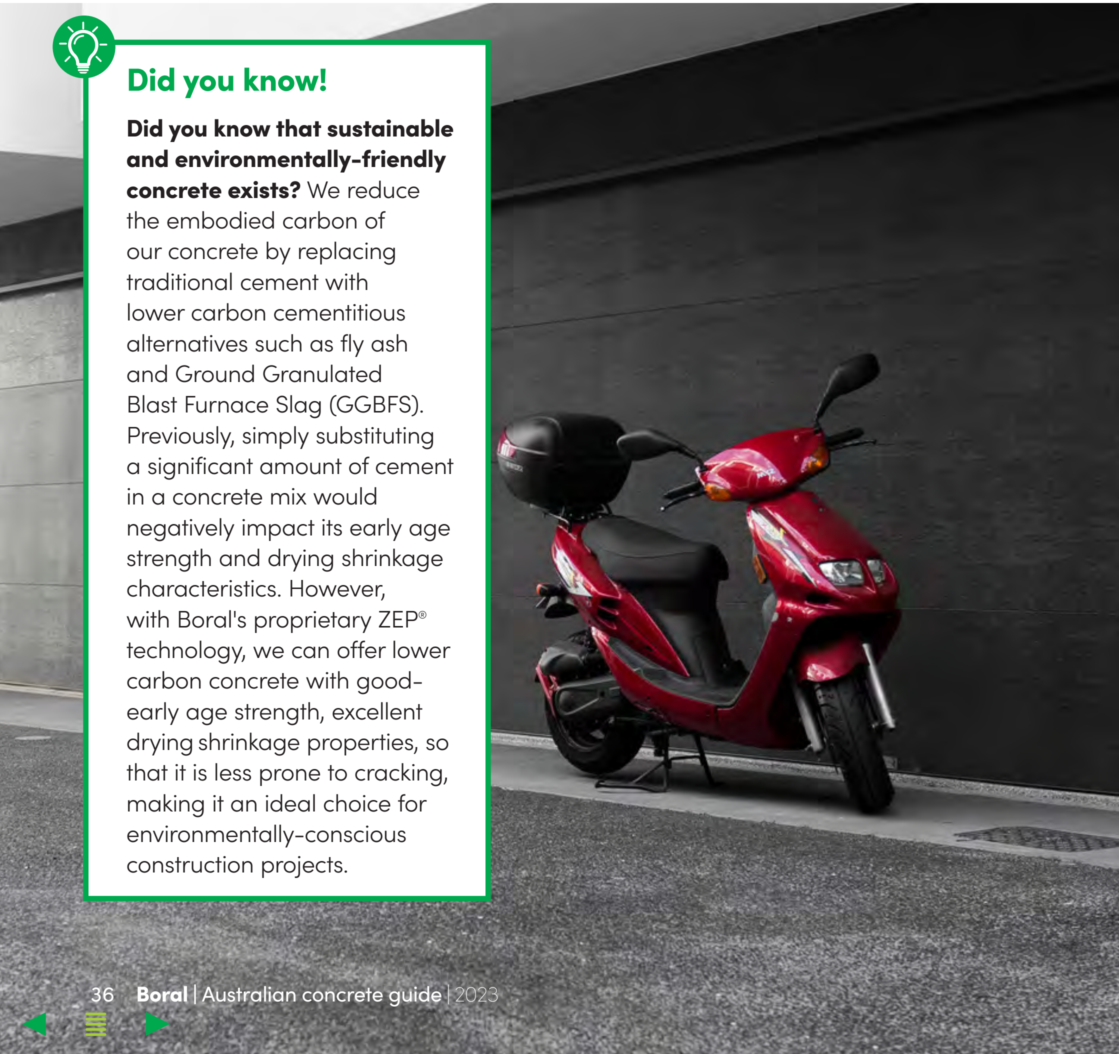
Hazard statements

H315	Causes skin irritation.
H318	Causes serious eye damage.

Prevention statements

P280	Wear protective gloves/protective clothing/eye protection/face protection/hearing protection.

ChemAlert. Page 1 of 7 SDS Date: 27 Jun 2022 Revision No: 3.1



Did you know!

Did you know that sustainable and environmentally-friendly concrete exists? We reduce the embodied carbon of our concrete by replacing traditional cement with lower carbon cementitious alternatives such as fly ash and Ground Granulated Blast Furnace Slag (GGBFS). Previously, simply substituting a significant amount of cement in a concrete mix would negatively impact its early age strength and drying shrinkage characteristics. However, with Boral's proprietary ZEP® technology, we can offer lower carbon concrete with good-early age strength, excellent drying shrinkage properties, so that it is less prone to cracking, making it an ideal choice for environmentally-conscious construction projects.

11 Products

General purpose concrete

Boral provides a range of concrete products that are designed for general purpose applications such as slabs on ground, footpaths, foundations and general paving, and are suitable to for every day applications.

Special purpose concrete

With more than 75 years in concrete manufacturing, Boral's team of technical specialists have formulated a wide range of concrete products for special purpose applications to help you achieve your engineering, architectural and sustainability goals.

These products include, but are not limited to:

- high durability
- post-tensioned
- high pumpability
- pool mix
- piling concrete
- no-fines (permeable concrete).

Decorative concrete

Boral's Decorative Concrete category consists of:

- boralstone®
- exposé®
- colori®
- luminesque® – the ingredient brand (glow in the dark aggregate) which can be sold as a complementary product.

All category ranges incorporate the functionality and strength with design flair and aesthetic appeal.

Sustainable concrete

Boral has a range of sustainable concrete products which create less greenhouse gas emissions during manufacture. These include:

- **ENVIROCRETE®** – Lower carbon concrete
- **ENVIROCRETE PLUS®** – Lower carbon concrete with enhanced engineering properties
- **ENVISIA®** – Lower carbon concrete with superior engineering properties.

Boral's advanced concrete range

Developed with the assistance of Boral's highly respected concrete research and development laboratory, Boral's high performance concretes have been used in many highly technical and demanding projects around Australia.

Cycle Path, Tempe, NSW

12 **Glossary** of terms

Term	Definition
Admixture	A material compliant with AS 1478.1 added to concrete in small quantities to improve its plastic or hardened properties.
Accelerator	A chemical which, when added to concrete shortens the time of set, or increases the rate of hardening or strength development.
Aggregate	Granular material such as sand, gravel, and crushed stone when bound together by cement paste forms concrete.
Aggregate — Heavyweight	A heavier than normal aggregate such as barite, magnetite, limonite, ilemenite, iron or steel used to produce extra heavy concrete.
Aggregate — Lightweight	A lighter than normal aggregate made from basic materials such as clay, slate, fly ash, vermiculite, pumice or scoria used to produce lightweight concrete.
Air entraining agent	An admixture for concrete which causes air to be incorporated in the form of minute bubbles in the concrete during mixing, usually to increase its workability and frost resistance. Normally expressed as AEA.
Amorphous silica	A very fine pozzolanic material composed mostly of non-crystalline silica; commonly referred to as 'silica fume'.
Batch plant	An installation of equipment that weighs and batches raw materials to produce concrete. Mixing either occurs in a mixer which remains at the batching plant or in concrete mixing trucks which deliver the concrete to the site.
Bonding agent	A substance applied to an existing surface to create a bond between it and a succeeding layer as between a sub-surface and a terrazzo topping.
Broom finish	The surface texture obtained by stroking a broom over freshly placed concrete.
Bush hammer finish	A finish on concrete obtained by chipping off the surface mortar
Cement content	Quantity of cement, fly ash and ground granulated blast furnace slag contained in a cubic metre of concrete.
Cement — Expansive	A special cement, which when mixed with water, forms a paste that tends to increase in volume at an early age used to compensate for volume decreases due to drying shrinkage.
Cement — High early strength	Cement characterised by producing earlier strength in concrete than regular cement.

Term	Definition
Cement — Hydraulic	A cement that is capable of setting and hardening under water, such as normal General Purpose (type GP) cement.
Cement — Portland	Ground portland cement clinker and gypsum which is the basis of General Purpose cement.
Central mixed concrete	Concrete that is completely mixed in a stationary mixer before it is transported to the job. It can be transported in mixer trucks, agitators or dump trucks.
Chute	A rounded trough or tube for sliding concrete from a higher to a lower point.
Compressive strength	The measured maximum resistance of a concrete specimen to compressive loading expressed in megapascals (MPa).
Concrete	A composite material which consists mainly of aggregate, cement and water, normally weighing 2,200-2,500kg per cubic metre.
Concrete — Foamed	Concrete made very light and cellular by the addition of prepared foam or by generation of gas within the unhardened mixture.
Concrete — Lightweight	Concrete made with lightweight aggregate; the unit weight of the resulting concrete is in the range of 800 to 2,100kg per cubic metre.
Concrete pump	An apparatus that pumps concrete to the placing position through a pipeline or hose.
Concrete — Reinforced	Concrete construction that contains mesh or steel bars embedded in it.
Construction joint	A normally keyed joint formed by a bulkhead between successive placements of concrete.
Contraction joint (control joint)	A joint or deep groove separating concrete in a structure or pavement designed to prevent formation of cracks elsewhere in concrete.
Conveyor	A device for moving materials; usually a continuous belt, system of buckets, a confined screw or pipe through which material is moved by air or water.
Core test	Compression test on a concrete sample cut from hardened concrete by means of a core drill.
Craze cracks	Fine, random cracks or fissures caused by shrinkage that may appear in a concrete surface within a few days of placement.

Term	Definition
Curing	Maintenance of moisture and temperature of freshly placed concrete during some definite period following placing, casting or finishing to provide enough moisture and the proper temperature level to promote continued hydration within the hardened concrete.
Drum speed (RPM)	The various rates of rotation of the drum of the mixer when used for charging, mixing, agitating or discharging. These various drum speeds are usually outlined on the mixer rating plate.
Drying shrinkage	Contraction caused by moisture loss from hardened concrete sometimes resulting in cracks in the concrete occurring days, weeks, or months after placement.
Dusting	A defect in a slab surface; the powdering of the surface under foot or vehicle traffic. Usually caused by over trowelling wet concrete.
Efflorescence	A deposit of salts, usually white, formed on a surface, the substance having emerged from below carried by water vapour.
Entrained air	Microscopic small air bubbles intentionally incorporated in concrete during mixing to improve durability and workability.
Entrapped air	Large air voids in concrete that are not purposely entrained; generally larger than 1mm and are usually due to incomplete consolidation.
Expansion joint	A separation in the concrete filled with compressible material to allow room for the expansion of the concrete in hot weather or movement due to other causes.
False set	Premature stiffening of freshly mixed portland cement concrete. Plasticity can usually be regained by further mixing with no additional water.
Flash set	The rapid development of rigidity in freshly mixed portland cement concrete, usually building up considerable heat. Rigidity cannot be dispelled nor can the plasticity be regained by further mixing without addition of water.
Flexural strength	The ability of concrete to withstand bending measured by breaking a test beam.
Float	A tool, usually of wood, aluminum or magnesium, used in finishing operations to impart an even texture to a fresh concrete surface immediately after placement.

Term	Definition
Fly ash	The fine ash resulting from the burning of powdered coal in electric power plants, sometime used as a mineral admixture.
Ground granulated blast furnace slag (GGBFS)	A glassy granular cementitious material resulting from the rapid chilling of molten iron blast-furnace slag.
Groover (jointing tool)	A tool used to form grooves or weakened joints in a concrete slab before hardening to control crack location.
Gross vehicle load	The weight of a vehicle plus the weight of a load.
Grout	A mixture of cement and water with perhaps some fine material used to fill cracks and voids in concrete or to prime concrete pumps.
Hardener	A chemical applied to concrete floors to reduce wearing and dusting
Hairline cracking (crazing)	Small cracks of random pattern in a concrete surface caused by too rapid surface drying.
High early strength concrete	Concrete that, through the use of high-early-strength cement or admixture, is capable of attaining specified strength at an earlier age than normal concrete.
Mixer capacity	The volume of concrete permitted to be mixed or carried in a particular mixer or agitator.
Mortar	Usually consisting of cement, water, sand and admixtures; no coarse aggregate.
Plastic shrinkage cracks	Cracks that appear in fresh concrete during or just after finishing. They are caused by premature drying of the surface.
Pile	A long slender timber, concrete or steel structural element driven, jetted or otherwise embedded on end in the ground for the purpose of supporting a load or of compacting the soil.
Reinforcement corrosion	Corrosion of steel reinforcement which may cause cracks in the concrete and a reduction in structural capacity.
Retarder	An admixture which delays the time of set of concrete.
Schmidt Hammer	(Trade Name), Swiss Hammer, or Rebound Hammer — a device used to estimate the compressive strength of hardened concrete by measuring surface hardness.
Screed	A tool for striking off the concrete surface.

Term	Definition
Segregation	a) separation of the coarse aggregate from the mortar portion of the concrete, or b) improper balance of the aggregate sizes from stockpiles or bins resulting in stony or sandy mix.
Self-compacting concrete	Concrete that is able to consolidate under its own weight, without the need of vibration.
Slump	A measure of the workability (flow characteristics) of freshly mixed concrete. It also is an indication of the relative water content of the concrete and may be used to determine whether a load of concrete will be accepted or rejected on site.
Slurry	A wet mixture of water and portland cement (and pozzolans); usually containing no aggregate.
Spalling	A chipping or peeling off of concrete surface or corners.
Superplasticizer	A high range water-reducing admixture used to achieve very high slumps / spread of plastic concrete.
Swirl finish	A non-skid curving texture imparted to a concrete surface during final finishing.
Topping	**a** A layer of high-quality concrete placed to form a floor surface on a concrete base, or **b** a dry shake application of a special material to produce particular surface characteristics.
Truck-mixed concrete	Concrete, achieved by mixing in a truck mixer.
Vibrated concrete	Concrete compacted by vibration during and after placing.
Water reducing admixture	A material that either increases workability of freshly mixed concrete without increasing water content or maintains slump with a reduced amount of water.

ZERO HARM
TODAY

Boral is the largest integrated construction materials company in Australia, with a leading position underpinned by strategically located quarry reserves and an extensive network of operating sites. We also manufacture and supply a range of building products.

Boral Concrete has over 200 pre-mix concrete plants around Australia producing a wide range of concrete mixes in metropolitan and country areas.

We are playing a key part in creating a sustainable future for our industry.

In Boral we strive to deliver Zero Harm wherever we operate. Employees, contractors and everyone involved in Boral's operations should ***expect to go home at the end of their working day*** in the same condition in which they started work.

Discover more Concrete at Boral

Scan QR Code

Boral Products	**boral.com.au**
Boral Specific concrete	**boral.com.au/products/concrete**
Boral Concrete plants	**boral.com.au/community/concrete-plants/boral-concrete**

BORAL

Building something great

Boral, the Boral logo, boral.com.au and Build something great are trade marks or registered trade marks of Boral Limited in Australia, other countries, or both. If these and other Boral trade marked terms are marked on their first occurrence in this information with a trade mark symbol (® or ™), these symbols indicate Australian registered or common law trade marks owned by Boral at the time this information was published. Such trade marks may also be registered or common law trade marks in other countries. Other product, company or service names may be trade marks or service marks of others. Boral is a registered trademark of Boral Limited or one of its subsidiaries. Particular projects may require the use of specific products or construction techniques. Boral recommends obtaining technical advice prior to construction.

17704 06/23