CEMENT CONCRETE & AGGREGATES AUSTRALIA

A smooth, clean concrete floor or pavement is a thing of beauty - and like all 'masterpieces', it's the result of careful preparation and dedicated execution.

Cracks can occur for a variety of reasons. Some cracking is inevitable because concrete, like most other building materials, moves with changes in temperature and moisture content. Specifically, it shrinks as it loses moisture.

But the risk of cracking can be minimised by understanding what factors cause it and how to design and detail concrete work to address these issues.

Cracking in concrete falls into two basic categories:

- **prehardening cracks** that occur prior to setting of the concrete, and
- **cracks in hardened concrete** that occur after setting.

Pre-hardened cracks

The two most common forms of prehardening cracks that affect concrete work are **plastic shrinkage cracking and plastic settlement cracking.**

Plastic shrinkage cracking is caused by rapid drying of the concrete surface. It can occur at any time of the year, from cooler low-humidity weather conditions to, in particular, hot weather conditions involving any one or a combination of high temperature, low humidity and wind.

These types of cracks occur while the concrete is bleeding and during the finishing operation. Fresh concrete may be exposed to the elements for a considerable time during these stages, causing the concrete at the surface to dry and shrink before it has any strength to resist the shrinkage forces. (Concrete cracks in much the same way as clay soils.)

Polypropylene fibres can be added to the concrete mix to reduce the incidence of plastic shrinkage cracking. Fibres tend to bind the surface of the concrete together and provide some strength to the plastic concrete to resist the shrinkage forces.

Methods to reduce the risk of plastic shrinkage cracking include:

- erecting wind breaks to shield the surface from drying winds;
- if vapour barriers or damp-proofing membranes are not present, dampening the ground prior to placing concrete to reduce absorption;
- using a continuous fine mist spray to fog the surface of the concrete and prevent premature drying of the surface while bleed water is rising;
- spraying an evaporation retarder such as aliphatic alcohol over the freshly screeded concrete surface;
- using physical remedies such as revibrating the concrete, vigorous wood floating over cracks or extended use of power troweling to close up the full depth of the cracks;
- commencement of curing as soon as possible after finishing; and
- delaying placement if extreme weather conditions are predicted.

Plastic settlement cracking is caused when concrete settles under its own weight, often because of inadequate compaction. Once concrete is placed into the forms, the heavier particles (cement, sand, gravel) settle to the bottom and the lighter water is forced to the surface in a process known as bleeding.

Compaction of concrete ensures that the entrapped air is expelled and particles in the concrete are packed tightly together to minimise settlement. Deeper sections such as beams are always more prone to settlement cracking as more depth is available for settlement.

If settlement occurs after placement, any restraint to the settlement will typically result in the formation of a crack in the surface above the restraint and possibly leave a void beneath it.

Common restraints include reinforcement and service pipes within the concrete and even steps in formwork such as waffle rafts where the depth changes significantly.

Unlike plastic shrinkage cracks which can be randomly located over the surface, settlement cracks tend to be straight as they follow the line of the reinforcing or formwork.

Some methods to reduce the risk of plastic settlement cracking include:

- filling any deep beam sections to the level of the bottom of the slab before placing the concrete in the slab;
- always ensuring adequate compaction;
- revibrating the surface where there is more than a 300-mm depth of concrete below top bars; and
- ensuring all formwork can withstand expected working loads, and that the formwork stays in place to support the concrete until it is self-supporting.

Cracks caused by formwork movement

if there is movement of the formwork after the concrete has started to stiffen but before it has gained enough strength to support its own weight, cracks may form. This type of cracking has no set pattern.

To avoid cracking from formwork movement, formwork must be:

- sufficiently strong and rigid to support the weight of the concrete without excessive deflections; and
- left in place until the concrete has gained sufficient strength to support itself.

Cracks in hardened concrete

The two most common forms of cracking in hardened concrete are **crazing and drying shrinkage cracking.**

Crazing is best described as a network of very fine cobweb-like or alligator-skin cracks, which appear on the surface of concrete after it has been exposed to the atmosphere for some time.

It occurs in the surface cement mortar and is generally more common in surfaces with a highly steel-trowelled or burnished finish, as the additional time required for finishing leaves the surface exposed for a longer period prior to commencement of curing.

Crazing does not normally extend below the top 2 to 3 mm, nor does it lead to durability or other serious problems; it generally affects only the appearance.

To avoid crazing on trowelled surfaces:

- avoid very wet mixes and do not add excess water on site;
- do not use ‘driers’ such as cement, pigments or colour hardeners to soak up bleed water;

- do not work the bleed water into the surface but wait until the water sheen has gone. Excess bleed water can be dragged off the surface with a hose;
- do not overwork the concrete by unnecessary trowelling of the surface;
- avoid wetting and drying cycles and excessive 'wet wiping' of the surface where water is sprinkled onto the surface to aid with trowelling;
- protect surfaces from rapid drying during finishing; and
- commence curing promptly.

Drying shrinkage cracks are caused by moisture in the concrete drying out over time, leading to shrinkage of the concrete.

This is not a major problem if the concrete is free to move, but, if restrained, tensile stresses can develop in the concrete and, if these exceed the tensile strength of the concrete, cause it to crack.

The water content of the mix is the major factor influencing drying shrinkage. Other factors that may also affect the risk of cracking in hardened concrete include restraints, curing conditions, aggregate size and content, detailing geometry and construction practices.

To reduce the risk of cracking due to drying shrinkage:

- do not add excess water to the concrete on site;
- compact the concrete adequately to achieve the maximum density;
- provide adequate curing and commence promptly;
- place joints in correct locations, provide correct geometry (size/shape of slab panels) and ensure proper construction detailing to limit restraint of the concrete;
- use good construction practices when placing concrete; and
- provide adequate reinforcement and ensure correct placement.

As always, thorough preparation and understanding of the basic properties of the concrete in the prevailing conditions will go a long way to avoiding problems like cracking.

The information in this article is of a very general nature and does not replace professional advice specific to individual projects. More information on this subject can be found in CCAA's Guide to Concrete for Housing, which is available as a free download at www.ccaa.com.au