Waterproof Concrete With Site Supervision Ltd

Because concrete isn't waterproof without experienced, close supervision.

Shrinkage in Concrete Through Drying.

See also our other pages on cracks due to settlement and thermal cracking.

There are three time periods of note:

1. The first 5 hours or so before the concrete has gained any strength.
2. The next 12 hours during which time the concrete is curing rapidly.
3. All the time after that.

And there are two distinct situations:

1. Drying Shrinkage.
   Drying of water from the concrete's surface. The concrete loses water.
2. Autogenous Shrinkage.
   Unseen drying within the concrete as the cement grains adsorb more and more water to form gel as a part of the curing process. The concrete does not lose any water.

<u>Drying Shrinkage.</u>

In the short-term shrinkage through drying is of very limited structural concern but of major concern where appearance and surface durability are important:

1. Crazing. Where the concrete on a surface dries out and shrinks.
   (E.g. Slabs).

   This is made worse by bleeding and stirring up laitance (water and cement slurry) by floating excessively or too much water.

   It is very limited to the very near surface. It can be very bad for surface appearance, surface permeability and surface durability however there is little or no structural concern.

2. Crazing. Where formwork is used.
   (E.g. Walls and columns).

   Walls cast with permeable plywood formwork seem less inclined to suffer crazing than walls cast with steel or plastic formwork.

3. Curling. Noticeable at joints in slabs.

   A concrete member cast against damp ground could dry over the top surface and curl as the top shrinks and the bottom remains the same length.

Long-term shrinkage is more of a structural concern.

In dry, windy conditions it could take months for drying cracks to appear in hardened concrete. In normal conditions it can take years.

Water in concrete unused in the hydration process, that in excess of about 50% the weight of cement powder, remains as billions of inter-connected water-filled pores that remain in place as the concrete hardens.

If any exposed concrete dries and if there was enough excess water to push cement grains apart then the moisture loss reduces the volume of the concrete. Shrinkage. Drying starts at the surface of the concrete and the surface will want to shrink. For some time the concrete beneath will hold the surface in place but as the drying goes deeper, when the tensile strain is too great the surface will crack.

These cracks will be shallow in good, structural concrete but potentially deep enough for chemicals to get in to attack steel and discolour the surface.

<u>Autogenous Shrinkage.</u>

Concrete is a matrix of crystals formed from a gel which in turn is created from cement grains and water combining. Quite simply, as cement and water combine the gel produced is a larger volume than the original cement and water from which it forms but when crystals form the resultant volumes are less than they were originally. This internal shrinkage not involving any loss of water from the concrete is called Autogenous Shrinkage.

It has been found that if there is sufficient water present to replace the lost volume then no Autogenous Shrinkage takes place.

It has further been found that if there is only 35% water to cement by mass (theoretically enough water to fully hydrate cement) not only is the concrete unworkable but as the first molecules of cement grain form gel with water, new water cannot get through to the next cement molecule.

Unless there is an excess of water in the concrete mix then the cement cannot fully hydrate. There is no pressure present to push water through new gel to the next layer of cement molecules. On the other hand there is significant capillary pressure to hold water back in the pores between cement grains and any gel produced.

Therefore drying can take place at the surface of the cement yet to hydrate even if there is water held within the pores.

The hydration of cement causes shrinkage which can cause cracking.

By experimentation it has been found that there is no Autogenous shrinkage where the water:cement ratio is at least 0.48, though there is often no significant shrinkage with a water:cement ratio of 0.42.

Further experimentation has shown that where concrete is allowed to dry out at the surface then water is pulled from the internal pores until capillary pressures are equalised and reduced water in the pores will pull water from gel yet to cure as crystals. This explains why surface drying prevents concrete gaining full strength, especially near its surface.

Poor concrete might re-wet from rain and pure cement might re-commence curing, but PFA and GGBs cannot re-start curing once stopped by drying.

Good quality concrete can be too watertight to re-wet and re-start cement curing beyond the first mm or so at the surface.

Experiments have revealed that with a water:cement ratio of 0.4 there is no Drying shrinkage but there is Autogenous shrinkage.

At 50% drying shrinkage is measurable but there is no Autogenous shrinkage in placed concrete.

At a water content of 60% Drying shrinkage over time is considerable and highly damaging.

Readymix concrete is typically 55% with WRA and 60% without and so highly susceptible to shrinkage through long-term drying.

Using a Super-Plasticiser, like the one we supply, can reduce the water cement ratio to 48% easily. There will be no Autogenous shrinkage and damage from Drying shrinkage can be avoided with a good mix design and careful curing.

Control Joints.

The problem with controlling cracking with reinforcing steel is that the concrete has to crack before the steel takes up the tensile strain and restricts the crack width. This still allows ingress of chemicals that might corrode or discolour and over time the joints will craze and break away at the surface.

Modern thinking for industrial floors - where cracks are possibly of greatest nuisance - is to avoid all cracks and therefore control joints. By reducing the extent of all 3 types of cracking it is considered possible not to have any control cracking and to pour up to 4,000m^3 in a day. (source: Advanced Concrete Technolgy. Processes.)

This shows how all concreting can benefit from quality and care.