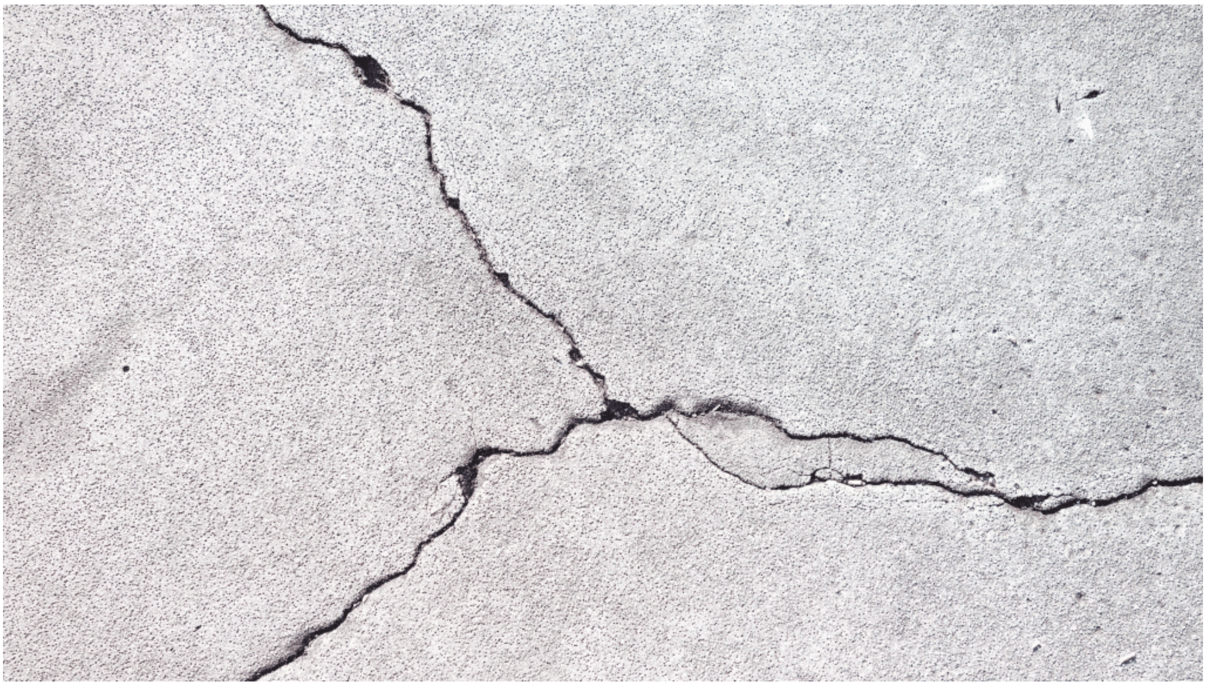
# Common Hardened Concrete Issues Pt 1: Cracks

Technical Bulletin #28 - April 2024



## Cracking in Concrete

We've all heard the time-honored phrase: "Concrete does two things.. it get's hard and it cracks!". While that is (mostly) true, we can get a lot more specific with categorizing types of unwanted concrete cracks and tracing them back to their root causes in order to prevent them from happening again. In this bulletin, we'll go through a list of common types or causes of cracks and what we can do about them.

## Plastic Shrinkage Cracks

Plastic shrinkage cracks are covered in detail in Tech Bulletin #6, but a quick recap: These cracks are formed from evaporation of water off the surface of the concrete while it is still plastic. They tend to be roughly parallel, do not continuously run to the end of the pavement or the next joint, and are not full depth. They typically are not a structural issue. Plastic shrinkage cracks can be prevented by monitoring the expected evaporation rate, and applying tactics such as use of an evaporation retarder, moistening the subgrade, setting up windbreaks, curing as soon as possible, and/or using microfiber.

## Drying Shrinkage Cracks

Drying shrinkage cracks are probably the most common from of cracks seen on concrete flatwork. They form because the volume of the concrete is less as it hardens, and if the concrete is restrained from moving by anything, such as the ground it is poured on or adjacent structures, the tensile stress on the concrete can exceed the tensile strength, and the concrete will crack. The easiest and most common way to mitigate this is to put joints in the concrete. This forms a weak spot where the concrete can crack as the tensile stress builds, but it is controlled into a predictable pattern that is structurally sound and aesthetically pleasing.  The key to jointing is ensuring joints are placed at the proper time, spacing, depth and pattern to be successful in controlling shrinkage cracks. Drying shrinkage can also be minimized by decreasing paste content, using larger aggregates, shrinkage reducing admixtures, external curing, and internal curing.

## Autogenous and Chemical Shrinkage Cracks

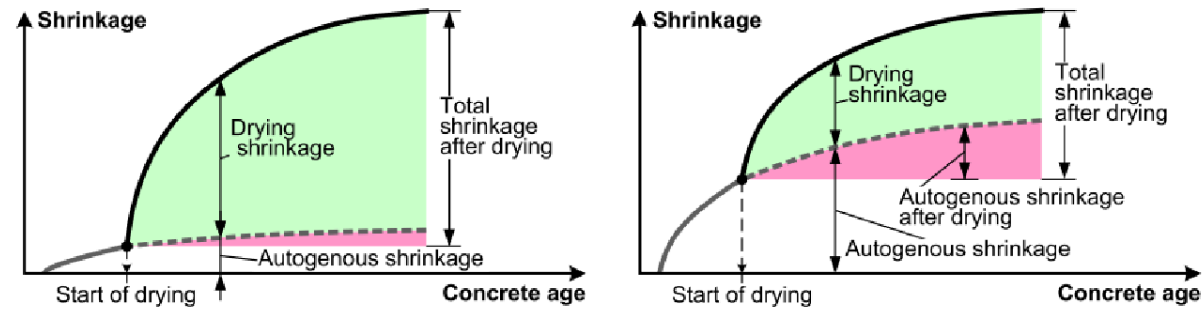



*Figure 3. Shrinkage strain components in normal (left) and high-strength (right) concrete [8].*

Similar to drying shrinkage, these complicated forces are a result of the hydration process of cement and are minimal in most normal concretes. They can be a significant driver of shrinkage in high strength and high paste content mixes. SCC mixes, high-early patch mixes, and other high cementitious mixes are at a high risk of extra shrinkage forces from these actions. Cracks from these phenomena represent the same as drying shrinkage insofar that they need restraint to form.

## Reinforcement-Related Cracking

Rebar is often used to control concrete cracks, and it is effective in providing tensile strength to concrete. However, rebar itself can cause concrete to crack through a number of different mechanisms.

1) Rebar settlement cracking or plastic settlement cracking (above).  This happens when excessively-bleeding or improperly consolidated concrete settles down around rebar, leaving a crack above the rebar. Properly consolidating and using measures to control bleeding are an effective way to prevent this.

2) Cracking from rebar corrosion. We'll cover this in a future Tech Bulletin, but rebar can expand as it corrodes and break the concrete from the inside, causing cracks and delaminations.

3) Rebar restraint cracks. Sometimes rebar internally restrains concrete where it wants to move and can cause a crack to form from the rebar.

4) Rebar pull-out cracks. If tensile forces on rebar are so intense that they can break the bond with concrete, they will often cause cracking from where the bond has been broken. This is often an engineering failure if it happens in the field.

## Thermal Cracks

Thermal cracks are typically associated with mass concrete (See Tech Bulletin #18), but can happen on any kind of concrete exposed to extreme temperature change. How this works is that cooler concrete takes up less volume than warmer concrete. If a concrete member isn't uniform in temperature, cracks will form where the warm concrete meets the relatively cooler concrete. This easily happens in mass concrete where the structure is generating it's own heat, but it can happen in concrete with embedded heating tubes, or newly poured concrete that is not protected from winter conditions.

## Settlement Cracking

Not to be confused with plastic settlement cracking, this form of cracking happens when the base material no longer supports the weight of the concrete or the loads that may be applied to the concrete. Often we see this on driveways, where runoff from the yard washes away the sub-base and leaves voids under the concrete. This can be addressed by filling in the void with foam and resetting the elevation of the concrete, although the crack will remain.

### Crazing Cracking

Crazing, or map cracking, is the development of micro-fissures in the surface paste layer of concrete.  This is often a result of over-finishing, finishing in excessive bleed water, and/or inadequate curing. The good news is, crazing is rarely anything but a aesthetic concern.

## Strength-related cracking

Cracking that forms from a load being applied to concrete with inadequate strength to hold that load often ends up looking like the above. The concrete will have a bit of a "shattered glass" look. This could be due to the concrete not achieving the specified strength or a load was applied that was much higher than the specified strength.  The most common place to see this kind of cracking is on trash compactor pads where higher strength concrete was not used. The load from the front wheels of the garbage truck can exceed the compressive strength of the concrete.

## D-Cracking

So called because of the "D" shape of the cracks near a joint intersection, D-cracking is a result of freeze-thaw deterioration of the coarse aggregate in the concrete. This tends to happen at joint intersections because this area is most easily saturated with water and has the strongest freeze thaw damage potential. Aggregates prone to D-cracking should not be used in concrete in areas where they might be subject to freeze thaw. Sometimes, this pattern of cracking can represent from extreme saturation and freeze thaw damage to the paste, so further investigation is needed if D-cracking is suspected.

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