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SCP Tech Brief: Concrete Cracking

An unfortunate truth in concrete construction is that concrete cracks. There is no magic technology that solves all forms of concrete cracking. This tech brief can provide guidance to distinguish between different types of common cracks.

Cracking is caused by many different reasons, but all cracks in concrete are caused by movement of the concrete in a way that exceeds the concrete's ability to resist the forces generated. Concrete is strong in compression, but relatively weak in tension, flexure, and torsion. Some cracking mechanisms cause the concrete to move differently from the top to the bottom, for instance, generating stress at the interface between the two movement planes. In general, concrete cracks due to external loading, thermal gradients, moisture gradients, or in response to a chemical reaction (internal or external).

Cracking Due to External Loading

When loads exceed concrete's ability to resist the forces applied cracks may occur. An example is negative-moment cracks above beams in an elevated deck caused by flexural forces between the beams moving in a downward direction. The concrete remains stationary above the beams while the concrete between the beams moves, sometimes resulting in cracking. Another example is cracking in a slab on grade that is exposed to traffic loads along an edge, breaking the concrete in a half-moon shape. Proper design to resist forces applied, including the strength of concrete and reinforcement sizing and positioning are the keys to limiting cracking due to external loading.

Plastic Shrinkage Cracking

Sometimes the surface of a freshly placed concrete slab dries out before the remainder, forming a "crust" that tends to crack. These types of cracks are typically shallow, run parallel to each other, and do not intersect the edges of the slab. The cracking typically appears in the time period just before finishing operations begin up to final troweling. These cracks are known as plastic shrinkage cracks because they happen when the concrete is still relatively plastic – it has not yet reached final set.

Plastic shrinkage cracks can occur when weather conditions cause rapid evaporation of bleed water before it can be replaced naturally by the subsurface concrete. Low relative humidity, high winds, and high concrete temperature can all contribute to plastic shrinkage cracking.

Figure 1: Plastic Shrinkage Cracks (image from ForConstructionPros.com)

The good news is that plastic shrinkage cracks are not usually structural problems. The bad news is that they are cosmetically unappealing in instances where the concrete is exposed. Weather conditions conducive to plastic shrinkage cracking of concrete can be readily predicted by using several weather-related websites and/or commercially available instruments. There are several recommendations that help prevent plastic shrinkage cracks from ACI, NRMCA, and other sources, including erecting wind breaks, misting or fogging the slab with water, placing concrete in the early morning hours, lowering concrete temperatures, and using micro fibers.

Plastic Settlement Cracking

Also known as subsidence cracking, plastic settlement cracks appear over embedded items such as reinforcing steel as concrete settles or subsides. Plastic settlement cracking is caused by insufficient consolidation, high slumps (overly wet concrete where aggregate segregation is occurring), or lack of adequate cover over embedded items. These types of cracks are recognizable by their resemblance in number and spacing to the reinforcing steel pattern below in the slab. Plastic settlement occurs due to the lack of proper consolidation, high slumps, or inadequate cover over rebar. Plastic settlement can be of particular concern on deep (> 12”) reinforced concrete slabs.

Figure 2: Plastic Settlement Cracks (SCP file photo)

Crazing

Crazing is the development of a network of fine random cracks on the surface of concrete caused by differential shrinkage of the surface layer. These cracks are rarely more than 1/8 in. (3 mm) deep and are more noticeable on steel-troweled surfaces and when concrete is wet. Crazing is most often caused by a higher water to cement ratio at the surface of the concrete as a result of over-troweling, sprinkling water on the surface of the concrete during finishing operations, or finishing concrete while bleed water is still present.

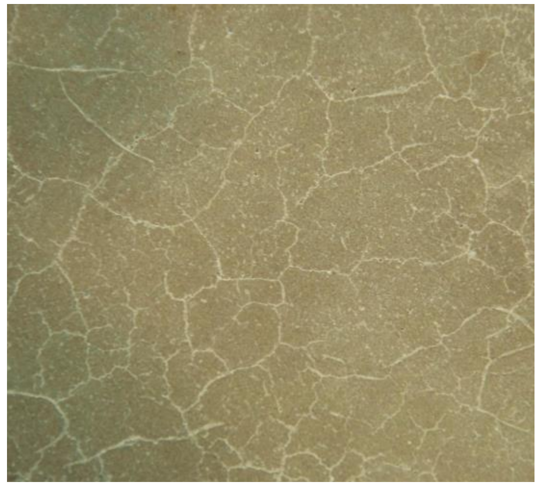

Figure 3: Crazing (image from ConcreteConstruction.net)

Settlement Cracking

Figure 4: Settlement Cracking (SCP file photo)

Settlement cracking is caused by the loss of base or subgrade support of the slab. Concrete is strong in compression, but relatively weak in tension or flexure. When support is lost, concrete may "settle" along with the base or subgrade material. These cracks often indicate a significant structural issue that should be addressed and are recognizable by the vertical displacement from one side of the crack to the other. Settlement cracking occurs due to loss of support beneath the slab.

Drying Shrinkage Cracking

Drying shrinkage cracks are caused by the change in volume of concrete associated with the loss of some of the water in the concrete due to evaporation. When concrete is first placed, it is typically at its greatest volume. Only a fraction of the water used in concrete is consumed by the cement hydration process. Much of the remaining water leaves the concrete, causing the concrete to shrink. When concrete is restrained by the ground, embeds, re-entrant corners, etc., tensile forces develop that can exceed the concrete's ability to withstand them, and cracks form. Contraction joints are generally utilized in concrete to provide vertical planes of weakness that allow the concrete to form cracks in predetermined straight lines.

Figure 5: Drying Shrinkage Crack (SCP file photo)

Drying shrinkage cracks are most likely to form at or near sources of restraint such as turn-down footings, depth changes, plumbing, and other penetrations.

Conclusion

Please note that there are many other types of concrete cracks that may occur. The preceding descriptions are the most commonly encountered early-age cracks in concrete construction. While proper slab design and installation methods can help reduce the chances for random cracking, ACI states that cracking can still be expected in at least 2% of all concrete panels, even where all work is executed properly.

For further information, many sources exist on concrete cracking and the mechanisms involved. SCP recommends information from ACI, PCA, and NRMCA as sources for further reading.