Causes of Cracking in Concrete

This Flooring Technical Note considers the main causes of non-structural cracks in concrete. It focuses on the reasons for cracking in concrete which are not due to poorly designed floor details or operational overloading problems.

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Introduction

Cracking in concrete is simply where the internal strength of the concrete is overcome by applied forces and stresses. These applied forces and stresses may be present for a number of reasons. It must be noted that as the concrete hydrates and cures, the internal strength of the concrete begins to develop until a maximum is achieved. Therefore the applied force and stress required to overcome the internal strength of the concrete at any point during the curing process increases as the concrete hardens.

The purpose of this technical note is to consider the mechanisms that occur which lead to cracking in concrete that are not due to poorly designed floor details or operational overloading problems.

Commentary

The following are deemed as the main groups of non-structural cracks in concrete:

1) Plastic Shrinkage Cracking (before concrete hardening)

The primary cause of plastic shrinkage cracking is the rapid drying out of concrete, which can cause the shrinkage strain of concrete to exceed its tensile strain capacity. The rate of evaporation of water from concrete can also be increased greatly by even the lightest of wind, at least doubling the chances of seeing shrinkage cracks develop; these can create a series of parallel shrinkage cracks, predominantly in one direction. For this reason, openings in building elevations should be avoided during the floor construction process.

Curing is obviously crucial to stop shrinkage cracking, and theoretically, should take place when bleed water has evaporated, but before further drying causes large plastic shrinkage. In reality, when large area casting techniques are used, this can be extremely difficult to achieve, and the rate of evaporation of bleed water is awkward to constantly review and manage on site. For this reason, the likelihood of some level of cracking should be expected and accepted by all parties.

The action of power floating effectively re-compacts concrete and closes plastic shrinkage cracks as they form. For this reason, floors which require only a basic concrete finish are more likely to exhibit shrinkage cracking.

However, cracks in non-powerfloated floors should not necessarily require heavy scrutiny, as the reason for opting for a skip-float finish in the first place may be down to a particular client preference (for example, retail stores may be covered with tiling). If this is the case, non-structural cracks may be deemed of little significance by the client due to the aesthetic limitations of non-powerfloated surfaces, unless the chances of cracking 'reflecting' through to the floor finishes is a genuine possible issue of concern.

2) Plastic Settlement Cracking (before concrete hardening)

Slabs with deep sections, or changes of depth, are mainly affected by plastic settlement cracking.

As *TR34 (4rd Edition)* stipulates that traditionally reinforced ground bearing floors should be detailed with a bottom mesh (nominal cover 50mm), the problems associated with plastic settlement cracks occurring directly over steel rebar locations is not covered in this document. However, settlement cracks are covered in *ACIFC Flooring Technical Note 02 – Cracks in Industrial Concrete Floors.*

3) Early Thermal Contraction Cracks (after hardening)

Thick slabs subject to excess temperature gradients, followed by rapid cooling, can exhibit early thermal contraction cracks after one day and up to several weeks.

4) Long Term Drying Shrinkage Cracks (after hardening)

Long term drying shrinkage cracks are particularly prevalent in thin slabs subject to high shrinkage and in slabs which have insufficient stress relief. Cracks of this type can occur up to several years after casting.

Summary

In summary, cracks will not form unless there is some type of restraint; however, cracks will form when the tensile stress exceeds the tensile strength of the concrete.

The hydration process of cement effectively turns the ‘wet’ in-situ material of concrete into a hardened material in a short period of time; however, the water content of the mix does not disappear during this time and subsequently water evaporates from the top surface for many months after the concrete is placed and finished.

The first few hours after casting are particularly important, as the rate of evaporation at this time is extremely rapid, and the water leaving the slab ideally needs to be limited. The process of curing helps to stop too much water loss at the time when the concrete’s strain capacity is at its minimum, therefore effective curing, usually by application of a spray-applied liquid compound to the newly finished surface, is extremely important. It should be noted, however, that curing compounds cannot seal plastic shrinkage cracks that have already occurred, so the timing of application is crucial.

Further Reading

The Concrete Society, *Non-Structural Cracks in Concrete,* Technical Report 22 (4th Edition, 2010)

The Concrete Society, *Concrete Industrial Ground Floors; A Guide to Design and Construction,* Technical Report 34 (4th Edition 2013)

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