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Use Reinforcing to Stop Cracking

Even though rebar can cause shrinkage cracking, there is a way to employ reinforcing steel that prevents this phenomenon.

Continuous rebar in this 110x200-ft. 7- to 11-in. slab on grade will provide restraint against concrete expansion allowing the contractor to place a monolithic slab without any contraction joints, seams, or shrinkage cracks. The resulting slab will have greater durability and save the owner slab and joint maintenance cost.

A recent article by Allen Face, which appeared in the July 2011 issue of Concrete Construction, expertly explains how steel reinforcing in concrete cannot prevent concrete from going into tension and cracking. The cracking discussed in the article is inherent to the concrete itself and is classified as shrinkage cracking.

There are several things that can be done to minimize this cracking including uniform aggregate gradation, low w/cm ratio, and reinforcing sizing and placing. But none of these steps can eliminate the root cause of early stage cracking: restraint.

Restraint can come from several external sources such as subbase friction, adjacent foundation walls, and other abutting concrete structures. Design and construction techniques can minimize and often eliminate these external restraints. That leaves internal restraint in the form of reinforcing steel as the principle cause of early-age concrete cracking. In fact, steel reinforcing is the cause of approximately 80% to 85% of early-age shrinkage cracks.

Here note the lack of special rebar placement, joint doweling, or joint detail construction. Savings on these special construction items, along with the time savings of a monolithic placement, helped to bring this stage of the project in on time and below budget.

What’s going on inside

Concrete is a result of a chemical process—hydration—that transforms the basic components (stone, sand, cement, and water) into that amazing construction material called concrete. Water serves a dual purpose with a major percentage being consumed in the hydration process and the remainder being water of convenience added to make the concrete plastic and more workable during placement. Excess water of convenience dissipates from the concrete through settlement into the subbase, as bleed water, and through evaporation. Left behind are voids in the concrete that the concrete tries to fill by consolidation resulting in drying shrinkage. If there were no restraint, the concrete would shrink as it hardens into a consolidated form with no shrinkage cracks. If the hardening concrete is restrained, concrete shrinkage forces would still be present but the restraint would prevent physical movement of the concrete resulting in shrinkage cracking.

The finished slab provides a uniform surface without any shrinkage cracks or contraction joints. The slab was constructed by adding, a shrinkage-compensating component, to a standard concrete mix to create shrinkage-compensating concrete in accordance with ACI 223R10, “Guide for the Use of Shrinkage-Compensating Concrete.”

Using steel reinforcing the right way

Fortunately there is a way steel reinforcing can be used for structural and temperature purposes and at the same time prevent shrinkage cracking. These seemingly contradictory functions can be achieved economically and easily by adding a shrinkage-compensating component to a standard concrete mix.

The component is a cementitious mineral material that causes an expansion mechanism to form in the curing concrete. Formation of the expansion mechanism, if not restrained, would cause the concrete to expand and grow. If restraint is provided, steel reinforcing being the best method to provide restraint, the curing concrete will be restrained and won't expand.

The restraint will cause the expansion forces to be transformed into a compressive force in the concrete resulting in a densified concrete with lower permeability, greater wear resistance, and increased durability. After the concrete cures and hardens, then this compressive force dissipates, at about 28 days, and ideally leaves a small compressive stress in the concrete. At this time, the concrete has returned to its original as-cast volume and shape without any shrinkage. And because there is a small residual compressive stress in the concrete (and corresponding tension in the steel reinforcing) shrinkage cracks won't form. Reinforcing steel is used to restrain the expansion, thereby preventing the concrete from going into tension, which would result in shrinkage cracking in the concrete.

This is exactly the opposite phenomenon that occurs in conventional portland cement concrete where the rebar restraint is the cause of shrinkage cracking.

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