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Concrete Cracking

By Roy H. Reiterman, P.E.

Here is what some well-respected people in this great industry of ours have said about concrete cracking:

Expect the best but compromise on the results!

There are no guarantees!

There are too many variables present!

All concrete cracks!

Steel Reinforcement adds a factor of safety for added strength and will give better crack width results!

Having said that – I believe we have better reinforced concrete today than ever before. "Why" you ask? Because we specify and check the mix design more readily (water/cement ratios and proper selection of large and small aggregates, just to mention a couple). We have a vast list of admixtures to specify today for more enhanced mixes. There are improved batching facilities and operations. There are better placing methods and equipment. Certainly, improved curing methods. More higher strength concrete is being specified then ever before.

In our welded wire reinforcement (WWR) business, we encourage the use of more high strength steel and more sheet reinforcement, especially for flatwork. More WWR is being designed with larger spacings (12" and more). Larger spaces increase the rigidity with the use of larger wire sizes, which helps to keep the WWR where it will do the most good in slabs and paving. Engineers are now designing and specifying areas or ratios of steel that will refine the design and help keep intermediate cracking tight.

Speaking of tight cracks – Many are still not aware that we must always expect some intermediate cracking. You ask what is intermediate cracking. Those are cracks that appear sometimes months after placement and occur between saw cut joints that are cut soon after placing the concrete. That is the real reason why we encourage the use of steel reinforcing in concrete – for lack of better words, an insurance policy to protect against wide cracks and to help prevent displacement and curling.

PCA says joints should be cut within 8-12 hours or whenever the concrete can be walked on without leaving an impression. Too many people say they can cut concrete a day or two after placement – but they are taking the chance that the concrete may have already cracked and may not be able to detect cracks for some time later on. I heard an engineer say recently – of an industrial slab of considerable size without one intermediate crack in it after 6 months, that he will wait to see what the slab looks like in a year or more. He expects that there will be some noticeable cracking. A prominent researcher in the admixture industry, said recently "when steel reinforcement is used, depending on the area or ratio specified, the cracks will remain tight over the life of the structure compared to plain or unreinforced concrete. Some may hardly be noticeable."

Speaking of crack widths, I would like to suggest some current texts for reference. The authors have many years of experience which will leave you with excellent guidelines for your future designs. I prefer the work by Ringo and Anderson*. They consider an applied loading and resulting moment capacity. They consider solving for a combination of the resisting moment (referred to as cracking or critical moment) of the concrete plus a factor of safety of 1 - 10% of the resisting moment for steel reinforcing. The factor of safety is a variable because it depends on the use of the concrete slab, concrete thickness and the loading that will be satisfied with a determined area of steel reinforcing. What results, is a quality reinforced concrete slab or paving that is structurally designed to support the applied loading and will offer the proper ratio of reinforcement to resist wide cracks. After actual experience with a variety of designs, one can determine a ratio of reinforcing that satisfies a variety of applications.

Concrete Cracking continued

Here are those references by experienced authors:

*Designing Floor Slabs on Grade, Boyd C. Ringo and Robert B. Anderson, ACI'S, Practitioner's Guide, PP-4. Contained in the Practitioners Guide are: A PCA publication, Concrete Floors on Ground, Second Edition, EB075.02D and A WRI publication, Innovative Ways to Reinforce Slabs-On-Ground, TF 705 by Robert B. Anderson

Mr. Anderson points out that the Equivalent Strength procedure, one of five procedures he describes in the text, titled "Innovative Ways to Reinforce Slabs-on-Ground," TF 705, will significantly reduce the frequency of cracks in the 40 mill (0.04" or 1mm) range. His example in the reference shows the Equivalent Strength procedure produces a steel ratio of 0.32%.

The 0.32% ratio of steel reinforcement equates to 0.23 square inches per each 12" width x 6" thick concrete cross-section. The steel area converts to a welded wire style of WWR 12xl2-D23xD23 with a minimum yield strength of 60ksi. With 80ksi reinforcement, the style of WWR is 12xl2- D17.5xDI7.5. It should be pointed out that the above example slab would carry a heavy static or moving loading and produce a very high quality slab with minimal intermediate cracking and very narrow or tight cracks. A consulting engineer will advise on particular needs for specific loads and final designs.

A final question can be pondered – What crack width and how much displacement or curling and what maintenance costs would occur if the steel reinforcing were not present?