

Limits on Pour Sizes — Balancing Cost, Schedule and Quality

From an engineer seeking advice about a contractor request:

A basin slab is approximately 14,000 square feet and the contractor wants to place this 2 ft thick mat in 1 pour. It is approximately 1000 cy of concrete. The mat is reinforced with 2 layers of #6 reinforcing bars at 6 inches on-center each way. The design calls for construction joints about 30 feet on center. I have seen larger pours than this for a mat but never for a water retaining structure. I am very concerned about the structure cracking (then leaking) due to shrinkage. Has anyone done a mat this size in one day for water retaining structures? Any advice on it?

From another engineer giving advice:

What are you getting for this reduction in quality? Make them follow the specifications: (1) Thirty feet between joints, (2) Pour slab in a checkerboard pattern and (3) Wait 14 days between adjacent pours. If it leaks, the contractor will never admit his changes created the leaks.

How the ASCC Hot Line would have responded:

We recommend that the basin slab-on-ground be placed in one pour without construction joints to balance the cost, schedule and quality provided to the owner. First, cost and schedule. As opposed to placing the mat all in one day, placing it in 30 ft squares in a checkerboard pattern with a 14 day wait is likely to increase the cost by 50 to 100% and increase the schedule by 2 to 3 weeks. You are hoping that the trade-off to this increased cost and schedule is less cracking and leaking.

The leaking that occurs in water-retaining structures, in order of magnitude, is from (1) construction joints, (2) cracks and (3) through the concrete. The 30 ft construction joint requirement creates about 700 lineal feet of interior construction joint. In our experience, the construction joint is an expensive item and typically leaks from about 10 to 50% of the joint length. It is also more difficult to repair than cracks.

Based on ACI 350 “Code Requirements for Environmental Engineering Concrete Structures” the #6 at 6 inches on-center each way is adequate for slabs with construction joints at 30 ft. This Code does allow slab placement beyond 40 ft if the appropriate temperature and shrinkage steel is provided. To allow for a single pour, the top steel should be increased to #8 at 6 inches on-center each-way. This increase in reinforcing steel provides the same crack control for the one pour as the #6 at 6 inches on-center does for the 30 ft construction joint requirement. The slight increase in steel cost is more than offset by the reduced cost of placing in one pour.

As for checkerboard placement, ACI 302 “Guide for Concrete Floor and Slab Construction” since 1980 and again in the 1989, 1996 and 2004 editions, recommends *against* using the checkerboard method as “experience has shown, however, that shrinkage of the earlier placement occurs too slowly for this method to be effective”. Thus the checkerboard approach increases cost but does not provide any benefits.

ACI 350 requires the elapsed time between casting adjoining units to be at least 48 hours and states that if the elapsed time between adjoining placements is very short, there will not be adequate dissipation of shrinkage and heat of hydration effects in the first placement. The 2 ft thick mat is not thick enough to be considered mass concrete and heat of hydration effects should be minimal. As for dissipation of shrinkage, curing is expected for at least 7 days, therefore, there will be minimal moisture loss and without moisture loss, minimal shrinkage. In addition, a 2 ft thick mat exposed only at the top surface will not lose moisture very fast.

ACI 209R-92 “Prediction of Creep, Shrinkage, and Temperature” provides information on how much shrinkage can occur in a time period for a given slab thickness. If the concrete surface is cured for 7 days and then dried for 7 days, the 7 days of drying allows 15% of the shrinkage to occur for a 6-inch thick slab. ACI 209R-92 provides correction factors for other size members, and for a 2 ft thick slab drying from only the top surface for 7 days results in a predicted drying shrinkage of 1%. We don’t believe that waiting 14 days to achieve a 1% reduction in shrinkage provides the owner with benefits that offset the increase in cost and schedule.

The ultimate indicator of quality will be the leak test. We assume that a leak test has been specified in accordance with ACI 350.1-10 "Specification for Tightness Testing of Environmental Engineering Concrete Containment Structures." The cost of crack repair is expected to be minor to meet the leak test requirement. We believe the best value and quality for the owner is place the slab in one pour, increase the top steel, and have the contractor repair the necessary cracks to meet the leak test.