When it Rains, it Can Pour…on Flatwork Projects

Being prepared lowers the risk of potential damage to fresh concrete

by George W. Seegebrecht

Even with the modern weather forecasting tools we have today, surprises happen. So you need to be prepared for rain if you're finishing concrete flatwork outdoors. An ounce of preparation along with an understanding of your mixture can mean the difference between success and failure.

As a concrete troubleshooting engineer, at least a couple of calls come in each year from contractors caught in the rain while placing a slab-on-ground, pavement, or bridge deck. Figure 1 shows the effects of a heavy rain on a freshly placed slab. This photo was taken shortly after the storm started—the damage can become much worse as a storm progresses.

Fig. 1: View of the effect of drops of rainwater on fresh concrete

Prepare to Protect

Being prepared lowers the risk of a hard rain damaging a fresh concrete placement. Simply deciding to proceed with a placement means you're ready to provide protection/countermeasures as needed to guard against showers. Preparation could be as simple as watching (and trusting) forecasts and changing placement dates, if the project schedule allows.

For mandatory placement dates that can't be changed because of weather, a protective enclosure might be the right countermeasure. This could be an easy option if your project is just about to come out of a winter protection mode; simply leaving the existing enclosure in place will be the safest action.

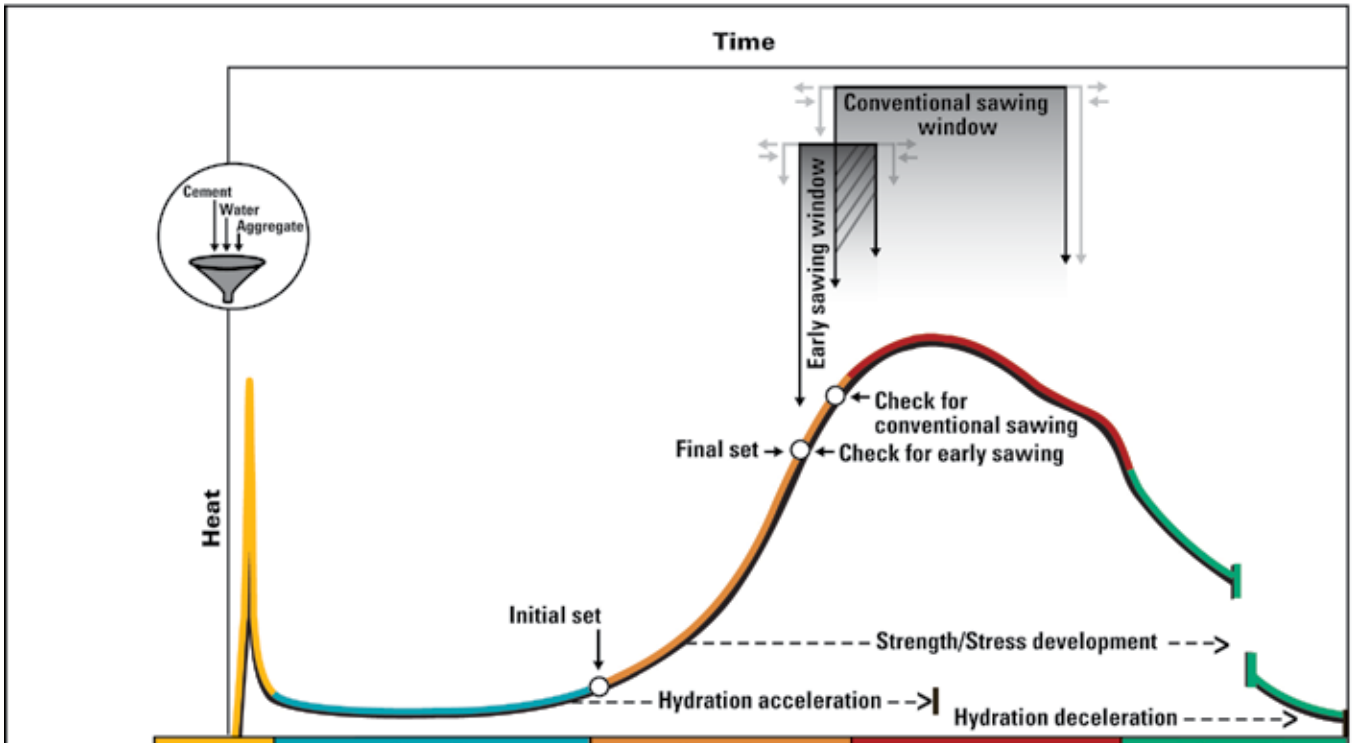
If temporary framework is erected and draped with plastic sheeting, it's important to ensure the frame provides the proper slope and that any sheeting joints are lapped and taped completely. Gaps in taping will result in a dripping leak, which will probably force you to pull a crew member from the placement to address the leak while the concrete is still plastic. In this case, poor planning not only pulls workers from the job but it can also result in a series of Rube Goldberg-type solutions—with secondary interior tenting or gutter systems to collect leaking water—that can obstruct the flow of work and interfere with finishing operations. So, take the time to button things up completely to save headaches during the placement.

If the placement occurs in the middle of an open field, erecting a protective cover may not be plausible. So, before getting caught in a rainstorm, make sure your crew knows they should avoid working rainwater into a freshly placed surface or broadcasting dry cement on the wet surface in an attempt to soak up water. Throwing dry cement into pools of surface water will almost guarantee a soft surface with little abrasion resistance and a tendency for dusting. It may be counterintuitive (and almost painful) to do "nothing,"

but it's better to wait, let the rain pass, and pull or push the surface water off the edge of the slab prior to completing finishing. A highway straightedge or a 1-1/2 in. (38 mm) diameter garden hose can be directed across the surface to herd water off the slab edge.

A Matter of Timing

Hydration, a chemical reaction, begins as soon as mixing water comes into contact with cementitious materials, but shortly thereafter, the concrete enters a dormant period of about 2 to 4 hours (Stage 2 in Fig. 2). During this period, fresh concrete is plastic (malleable) and can be transported, placed, consolidated, and finished. If a rain event occurs when the concrete is in this stage, the concrete surface should be protected. If, however, the finishing process has just been completed, rainwater may not cause any damage to the surface as long as surface manipulation is avoided. Any finishing of the surface will work surface water into



	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
	Mixing	Dormancy	Hardening	Cooling	Densification
	Lasts about 15 minutes	Lasts about 2–4 hours	Lasts about 2–4 hours		Continues for years
Characteristics of concrete mixture	High heat is generated immediately, followed by rapid cooling.	Mixture is plastic, workable, and not generating significant heat.	• Hydration generates significant heat. • Mixture sets, begins to harden, and gains strength. • Stress begins developing in the concrete.	Stress development will exceed strength development if stress is not relieved.	Slab continues to become stronger and less permeable.
What engineers, supervisors, and workers must do to ensure durable pavement	Ensure adequate mixing.	Transport, place, and finish the concrete while plastic and workable.	• Begin curing as soon as possible. • Thoroughly apply curing compound.	Saw joints to relieve stress and control cracking.	• Insulate the slab if the air temperature is expected to cool rapidly and significantly. • Protect curing compound as long as possible.

Fig. 2: Concrete characteristics and stages of hydration. As the concrete passes beyond initial set (within Stage 3 - Hardening), the slab becomes less vulnerable to damage by rain impingement *(Figure from Reference 1, courtesy of the National Concrete Pavement Technology Center at Iowa State University's Institute for Transportation)*

Fig. 3: Workers broom a slab-on-ground. Vulnerability to rain damage depends on when the rain event occurs relative to the setting time as well as the intensity of the downpour. Workers should avoid finishing additional water into the slab

the concrete (Fig. 3), resulting in an elevated water-cement ratio (*w/c*) and loss of surface durability.

Warmer temperatures accelerate the hydration reaction, so the concrete stiffens sooner. Colder temperatures slow the reaction, retarding the setting and leaving the concrete plastic for a relatively longer period of time. Storms often are accompanied by drops in temperature. On one hand, a temperature drop could leave the unprotected surface vulnerable to rain damage for a longer period of time. On the other hand, once the rain finally does pass, lower temperatures could give workers time to remove surface water and finish the slab to correct defects before the concrete sets.

If the concrete has stiffened to the point that it's ready for scheduled grooving or grinding, then it's at or past Stage 3 (Fig. 2). Damage due to rain is no longer a concern. In fact, a warm rain at this time could help with curing.

The Skies Have Cleared

If you get caught in a storm, visually survey the entire slab area after the rain event. If parties disagree about the quality of the slab surface after a rainstorm, try to scratch the surface at the end of the curing period. Use a flathead screwdriver or pointed geologist's hammer and compare the relative surface scratch hardness of the slab in question to slab sections known to be of good quality. While this is simply a rough qualitative check of a concrete surface, it can help to clear up misperceptions. Keep in mind, however, that the slab you're using for comparison will probably be significantly more mature and therefore somewhat harder than the slab you're evaluating.

Some have used a Schmidt hammer (ASTM C805/C805M, "Standard Test Method for Rebound Number of Hardened Concrete") to evaluate surface quality after a rain event, but it must be noted that results can vary greatly especially when slabs are not the same age. Also, note that if the rebound hammer is used as directed in the standard, grinding the test area with an abrasive stone may actually eliminate the surface being accessed.

A more scientific approach would be to extract representative cores from the slab and examine them according to ASTM C856, "Standard Practice for Petrographic Examination of Hardened Concrete." Examinations will yield descriptions of the surface quality, including the depth of any rain-affected zone. Since the focus of the examination is the surface, it should be possible to avoid coring the full slab thickness. Experienced contractors

Quick Quiz

Materials and the weather vary from project to project, but here's a quick quiz that might help to avoid a headache on a future job:

1. As soon as it starts raining, finish the surface in the rain and keep touching up any damage so that there is nothing to do once the rain stops.
   ____True ____False
2. If rainwater has ponded onto a finished, yet plastic surface, applying dry cement will soak up the water and remove any blemishes caused by rain.
   ____True ___False
3. What actions are best once a downpour starts on a still plastic (workable) surface?
   a. Protect the surface with an overhead covering of canvas or plastic sheeting pitched to drain water quickly. Overlay and tape edges of the covering to prevent leaks over the slab area.
   b. Use a garden hose to skim ponded surface water from the slab if further finishing will be attempted.
   c. Refrain from finishing the rainwater into the surface.
   d. All of the above as needed.
4. Rain on a freshly placed slab means the surface is ruined and the slab must be replaced.
   a. Yes. The surface is damaged and will soften over time.
   b. Not necessarily. The amount of damage depends on whether or not the concrete had set and if surface water was finished into the slab surface.
   c. No. You should have an engineer examine the slab surface, get a core examined microscopically, and use this information to assess the need for further action if necessary.
   d. b and c.

(Answers: 1. False; 2. False; 3. d; and 4. d.)

may be familiar with interpreting petrographic reports. If not, results can be reviewed with an experienced concrete engineer or petrographer.

Remedies

If it's found that the surface quality has been compromised, remedies must address the extent and severity of damage caused by the rain. For example, if a slab surface has been rendered soft to a depth of about 1/8 in. (3 mm), this amount could be removed by shot-blasting, grinding, or hydro-blasting down to the underlying sound concrete. Proper surface preparation will yield a clean, sound, roughened surface suitable for application of a repair material. If a polished floor surface is desired, you should follow standard surface preparation steps while grinding and polishing the floor.

If only small areas of a thin slab are damaged, it might be most economical to remove the damaged sections and replace them with a full-depth repair. This may provide cost savings by avoiding the time required to select an experienced repair contractor, prepare the surface, and bond a layer of repair material.

Conversely, thick slabs with large areas of damage may be most economically repaired using a surface treatment. An experienced repair contractor will be able to make a proper repair that will restore the surface to the intended durability requirements. Some repairs may even improve on the intended appearance with a colored or decorative finish. While this will likely incur additional costs, making repairs at limited or isolated locations will require careful attention to match the color or shade of the repair materials with the parent concrete.

Isolated repairs of rain-damaged concrete, especially when steady streams of rain have bored into plastic concrete, can be quickly repaired with concrete used for the slab placement itself. This requires that an extra wheelbarrow of concrete is held in reserve at the beginning of the storm—just another example of being prepared for the surprises a concrete job can bring.

References

1. *Integrated Materials and Construction Practices for Concrete Pavement: A State-of-the-Practice Manual*, FHWA Publication No. HIF-07-004, P.C. Taylor, S.H. Kosmatka, and G.F. Voigt, eds., Center for Transportation Research and Education, Ames, IA, Oct. 2007, p. 74.

Note: Additional information on the ASTM standards discussed in this article can be found at www.astm.org.

Selected for reader interest by the editors.

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