The true window of finishability

Do finishers have adequate guidelines for hitting the gap between premature and late finishing?

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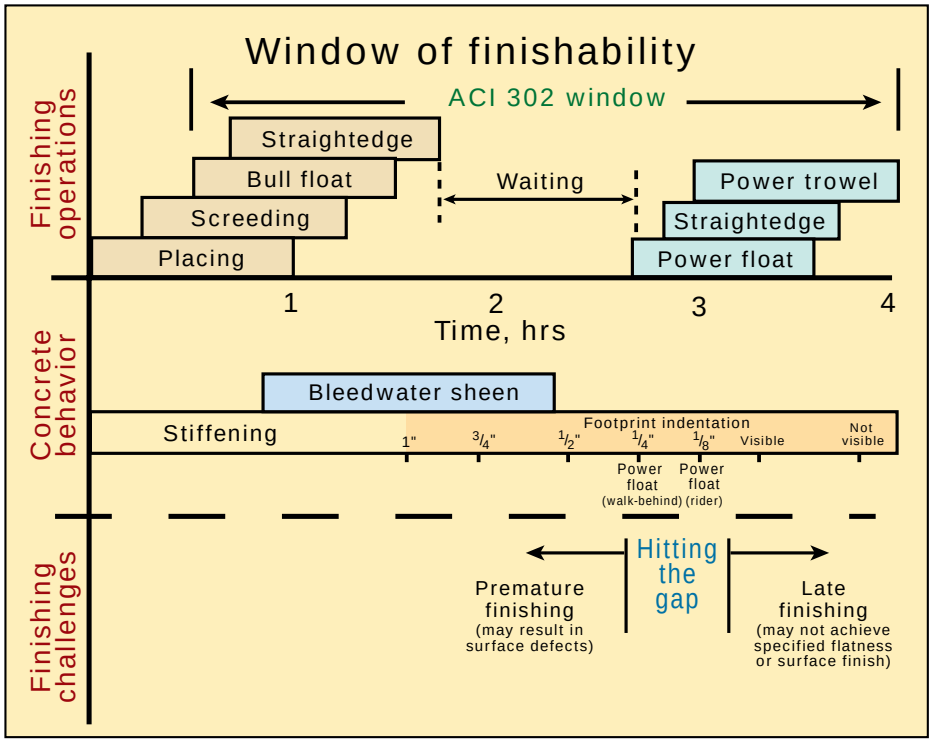
Petrographers' reports often cite premature finishing as a major cause for blistering and delamination, and numerous publications tell finishers to avoid floating slabs too soon. But what *is* premature finishing, and how precise are the methods finishers use to judge the proper time for finishing operations to begin?



While the window of finishability may span four hours, the period during which finishers must complete power floating, straightedging and power troweling is only a fraction of that time.

Defining the finishability window

ACI 302.1R-96, "Guide for Concrete Floor and Slab Construction" (Ref. 1), defines the window of finishability as the time period when various finishing procedures should be executed sequentially, neither too early nor too late in the concrete-hardening process. These procedures include "operations taking place after the concrete has been placed, consolidated and struck off." The drawing shows a time scale for the finishing operations included in ACI's definition.

As shown in the figure, the time gap between premature and late finishing can be a small part of the finishability window. Deciding when to start power floating operations may be the most crucial decision the finisher makes. Starting to power float too early can result in surface defects. Waiting too long can lead to unacceptable floor-flatness measurements or a poor surface finish.

Contractors have constructed millions of square feet of concrete slabs without any problems when using general guidelines that presumably allow finishers to start finishing at the correct time. But these guidelines aren't infallible and don't always prevent floor-surface defects.

Deciding when to start

For years finishers have used two general guidelines to decide when to start finishing operations (Refs. 1, 2):

- When no bleedwater is visible on the slab surface
- When a footprint no deeper than ⅛ to ¼ inch can be made in the slab

Bleeding. Finishers rely on the absence of a surface-water sheen to determine when bleeding has stopped. Depending on the concrete properties and ambient environment, however, bleeding may still be occurring when bleedwater isn't visible to the finisher because the water is evaporating. Because of this, at least one publication (Ref. 3) recommends delaying finishing "until the concrete has stopped bleeding throughout the slab thickness."

To see if bleeding is being masked by evaporation, some finishers poke the slab surface with their fingers or place garbage-can lids or clear plastic cups on the surface. These covers prevent evaporation as bleedwater rises to the surface, and finishers can look through the cup or lift the garbage-can lid to more precisely determine when the bleeding period has ended. Waiting for the absence of a bleedwater sheen in this case requires that the water reabsorb back into the concrete.

Although these crude methods may help to determine when bleeding has actually ceased, finishers may not be able to wait that long without the risk of losing the slab. Hot, windy weather may force finishers to get on the slab earlier, simply to achieve the desired surface finish. Fortunately, an early start may not cause problems.

For air-entrained concrete, Klieger (Ref. 4) showed that scale resistance wasn't affected for concrete finished when only 50% of the bleeding had occurred. For non-air-entrained concrete, Bimel (Ref. 5) reported that for one test slab, power floating began while bleedwater was still visible on the surface. Chain-drag tests conducted the next day and a month later revealed that this instance of premature finishing didn't result in delamination.

Stiffening. The footprint-indentation criterion has changed over the years as new finishing equipment has been introduced. In 1970, a maximum footprint indentation of ½ inch was cited as the time for the first pass with a hand float (Ref. 6). With the advent of the first walk-behind and riding power trowels, the footprint indentation was changed to about ¼ inch. For today's heavier riders with high blade rpm, some finishers use a ⅛-inch footprint indentation as the appropriate guide for the start of floating.

Regardless of the value used, the accuracy and precision of the footprint-indentation test are questionable (see box). Some finishers walk the slab, basing their starting-time decision on additional factors such as sponginess, but this method is even less precise.

Penalties for late finishing

ACI 302.1R-96 says that to meet higher flatness tolerances, floating of slabs must start as soon as possible to generate sufficient mortar to assist in restraightening. The guide recommends a footprint indentation of about ¼ inch. Waiting too long, with the concrete stiffening, can make it difficult for finishers to meet the flatness tolerances, although restraightening the surface with a wide bull float after initial strike-off can limit problems related to late finishing.

Many specifications that demand high flatness numbers apply pay penalties if the flatness specs aren't met. To avoid such penalties, finishers may begin power floating earlier to generate enough mortar and leave enough time for further restraightening operations.

Delaying power floating also delays power troweling, which may make it difficult for finishers to achieve an acceptable surface finish. Many owners want polished or burned surfaces, which require extra finishing time to close the concrete surface. If the concrete surface has stiffened too much, power troweling will fail to provide the smooth surface finish that owners desire.

Who's responsible when finishers don't hit the gap?

To hit the gap between premature and late finishing, finishers must balance the effects of concrete property variations, the ambient environment (wind, sun, relative humidity and rain), crew size and equipment availability while relying on crude bleeding and setting guidelines. Most of the time, they're successful. When they aren't, however, and de-

Measuring footprint indentation

IMPLIED ACCURACY AND PRECISION

- Determine number of footprint indentations needed, and select finisher of appropriate weight.
- Instruct finisher to maintain same pressure for each footprint.
- Measure footprint indentations using an ASTM-certified and calibrated straightedge and ruler.
- Report measured footprint indentations to nearest 0.01 inch.
- Calculate an average footprint indentation.
- Start floating when average footprint indentation is equal to 0.25 inch.

ACTUAL ACCURACY AND PRECISION

- Find nearest finisher.
- Have finisher step on slab.
- Have finisher step off slab.
- Close bad eye; use good eye to look at footprint.
- Estimate footprint indentation.
- If indentation is about ¼ inch, start floating.

fects such as blisters or delaminations occur, investigators usually assume the defects were caused by premature finishing. This makes concrete contractors responsible for the failure. But depending on the contract documents under which the work was performed, responsibility may not be that clear.

ACI 301-96, "Standard Specifications for Structural Concrete," section 5.3.4.2.b, tells contractors: "Place, consolidate, strike off and level concrete, eliminating high spots and low spots. Do not work concrete further until it's ready for floating. Begin floating with a hand float, a bladed power float equipped with float shoes or a powered disk float when the bleed water sheen has disappeared and the surface has stiffened sufficiently to permit the operation."

However, if finishers follow these directions, and a surface defect occurs, who is responsible? Based on the ACI guidelines for beginning floating, a prudent contractor should document, with construction photos or videos, that no bleedwater sheen was on the surface and finishers weren't leaving deep footprints in the slab when power floating began.

References

1. ACI 302.1R-96, "Guide for Concrete Floor and Slab Construction," American Concrete Institute, Farmington Hills, Mich., 1996.

2. Steven Kosmatka and William Panarese, *Design and Control of Concrete Mixtures,* 13th ed., Portland Cement Association, Skokie, Ill., 1994.

3. NRMCA *Technical Information Letter No. 470,* National Ready Mixed Concrete Association, Silver Spring, Md., June 21, 1989, p. 2.

4. Paul Klieger, "Effect of Atmospheric Conditions During the Bleeding Period and Time of Finishing on the Scale Resistance of Concrete," *Journal of the American Concrete Institute,* Vol. 27, No. 3, ACI, November 1955.

5. Carl Bimel, "Is Delamination Really a Mystery?" *Concrete International,* ACI, January 1998, p. 33.

6. Carl O. Peterson, "Concrete Surface Blistering—Causes and Cures," *Concrete Construction,* September 1970, p. 317.

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