Specifying Polished Concrete Floors

Results and costs become more predictable as the industry matures

BY BOB HARRIS

During the past 10-plus years, diamond polishing has evolved as a viable alternative to conventional final finishes for new concrete floors, as well as an option for refurbishing floors that have previously been covered with materials having a shorter service life. Marketing for these floors has usually emphasized four major benefits when compared with other flooring options:

- Lower life-cycle costs based on costs for initial installation, annual maintenance, average service life, and replacement cost—usually based on the average life for the flooring option with longest average life span prior to replacement;
- Fewer moisture-related problems at the interface between conventional floor coverings and the concrete substrate. Such problems include delamination, blistering, staining, and mold growth;
- A variety of ways to produce multicolored and distinctive patterns (Fig. 1), including colored surfaces and embellishments such as score-cutting and staining; and
- Sustainable features such as the use of water-based, odorless chemical hardeners for either new or refurbished floors. Also, by refurbishing existing floors, instead of removing and replacing them, building owners reduce their waste output and carbon footprint.

The polishing contractor is often a separate subcontractor, similar to the floor-covering installer. Because new floor polishing products and procedures are still evolving, however, the roles of architects, engineers, general contractors, and concrete contractors in achieving successful polished floor results are also evolving. Typically, construction specifications define the roles of each party, but specifications for polished concrete have proliferated as rapidly as the products and procedures, creating confusion on the job site as to who is responsible for each step in the construction process. This confusion is increased when specifications for some steps are included in Division 3 for concrete and others in Division 9 for finishes. In this article, I'll assume that the polishing contractor is a separate subcontractor, discuss some of the requirements for polished floor finishes common to most specifications, and indicate the proper division in which to include these requirements.

Fig. 1: Polished concrete offers a variety of finishes, including plain gray, colored surfaces, and decorative embellishments

SPECIFICATION REQUIREMENTS

Specification requirements typically refer to hardened and plastic concrete properties, flatness of the finished floor prior to polishing, finishing methods, and curing options. In addition, requirements for aggregates, integral color, or other coloring options can also be included.

Hardened concrete properties

The ability to produce high-end polished concrete floors starts well before any of the polishing equipment even leaves the contractor's shop. Hardened concrete properties greatly affect the quality of the polishing subcontractor's finished project. Normalweight, nonair-entrained concrete is required, with a minimum compressive strength of 3500 psi (24 MPa) often being specified.

The specification should clearly state whether the required strength is a true minimum (no tests allowed to fall below 3500 psi [24 MPa]) or a design strength (average of any three consecutive tests equaling or exceeding 3500 psi [24 MPa], with no tests lower than 3000 psi [21 MPa]). As polishing started coming into wider use and was being accepted within the design community, some specifiers' logic was that stronger concrete is better. Wet-cured concrete was specified at strengths exceeding 6000 psi (41 MPa). The result was often a surface so dense that even aggressive 16 grit metal bond diamonds could not cut it (refer to the sidebar on "Why Polishing Costs Vary"). This required more aggressive—and expensive—means of profiling via shotblasting or scarifying to remove the surface paste.

Many of us in the industry have found that a well-proportioned mixture in the range of 3500 to 4000 psi (24 to 28 MPa) is more than sufficient, especially when polishing commences at least 28 days after placement.

Plastic concrete properties

Many specifications for plastic properties of concrete to be polished are ambiguous with respect to slump requirements. They commonly require a "natural concrete slump" of 4.5 to 5 in. (115 to 125 mm), but follow this with the statement that admixtures can be used. This apparently means that a 4.5 to 5 in. (115 to 125 mm) slump without admixtures is required, but that water-reducing admixtures can be used to increase the as-discharged slump beyond 5 in. (125 mm).

In line with the move to performance specifications, it seems beneficial to let the concrete producer and concrete contractor determine the needed slump based on weather conditions, size of placement, placing and finishing methods, and flatness requirements without being held to a very tight specified slump range set by the engineer or architect. The performance goal is concrete that's strong enough to produce the desired sheen.

Floor flatness prior to polishing

Common specification requirements for flatness prior to polishing are F_F 40 for the overall flatness and F_L 20 for the local flatness, as measured in accordance with ASTM E1155-96. Some advocate overall F_F values as high as 50 on the theory that flatter floors require less grinding.[1] Requiring an F_F 50 floor, however, may simply transfer cost from the polishing contractor to the concrete contractor and may not reduce the overall cost of the project. In addition, the many hard-trowel finishing passes needed to produce an F_F 50 floor may increase surface hardness, which in turn affects the degree of aggregate exposure that can be achieved, potentially increasing grinding costs. In some cases, however, requiring the flatter floor may be cost effective (refer to the sidebar on "Why Polishing Costs Vary").

WHY POLISHING COSTS VARY

The sequence of polishing and the types of available diamond tooling have changed through the years. Traditionally, the normal polishing sequence in the industry consisted of first grinding with coarse diamonds bonded in metal-matrix segments and typically decreasing the grit size with each grinding pass. Starting with 40 grit metal-matrix segments, the contractor would proceed through 80 and 150 grit grinding, while applying a hardening silicate after either the 80 or 150 grit pass. The final honing would be done with progressively finer resin-matrix diamond pads—100, 200, 400, 800, 1500, and 3000 grit—with the 1500 and 3000 grit pads producing the highest sheen. The critical step in the normal sequence was the switch from metal- to resin-matrix diamond systems, as any deep scratches left by the metal-matrix segments were difficult to remove with resin-matrix pads.

In current practice—especially when the concrete contractor produces a floor with an F_F of 50 or greater—it's possible to polish the floor using only resin-matrix diamond pads. Using only resin-matrix pads from start to finish speeds the grinding process and lowers the cost. As mentioned in the text, however, there is a cost associated with producing F_F 50 floors. When the concrete contractor is unable to produce floors this flat at a cost equal to or less than the savings produced by using only resin-matrix pads, normal grinding methods using metal-matrix segments may still be needed.

Budget-conscious clients have found that eliminating several of the steps during the polishing process makes a polished concrete floor affordable on a larger scale. A typical sequence would include using 80 and 150 grit metal-matrix segments followed by application of the hardening silicate. Then polishing using 100 or 200 grit resin-matrix pads would be followed by polishing using 400 grit resin-matrix pads.

For any polishing project, the final step should include the application of a topical guard that's burnished at high speed with a diamond-impregnated pad. A topical guard includes a hardener and a copolymer to provide a stain-resisting film, so this step provides a finish that maximizes light reflectance and eliminates the need for conventional coatings.

Many specifications require three troweling passes to produce an ACI 302.1R-04 Class 5 floor,[2] yet they also prohibit burn marks. Floor Classes 4, 5, and 6 for single-course floors all require a steel trowel finish, but specifying a set number of troweling passes is a "means and methods" specification as opposed to a performance specification. The concrete contractor is in the best position to know how many troweling passes are needed to achieve the specified flatness. The limitation on burn marks is a performance specification, but a requirement for no burn marks may be unachievable. The use of more flexible reinforced plastic trowel blades can be helpful in reducing the possibility of burn marks.

Curing options

Most specifications allow several options for curing the concrete. These include:

- Membrane-forming curing compounds (ASTM C309). Acrylic curing and sealing compounds are not recommended;
- Sheet-membrane curing (ASTM C171); and
- Damp curing for 7 days.

When polished floors will also be colored, the choice of curing method may be dictated by the coloring method to be used. For instance, although shake-on color hardeners can produce more vibrant hues than integral coloring admixtures, liquid-applied curing compounds should not be used with the colored hardeners because they will have to be removed prior to grinding.

Because all of these specification provisions relate primarily to the concrete contractor, they should be included in Division 3 specifications.

OTHER DECORATIVE EFFECTS THAT CAN BE SPECIFIED

A few other factors related to the concrete can affect the ultimate look of the polished surface. The type of coarse and fine aggregate can have an effect cosmetically, especially if the desired look includes exposed aggregate. For a light exposure of fine aggregate only, the fine aggregate color affects the final color of the polished floor for either plain gray or colored concretes. Similarly, producing a terrazzo look by exposing coarse aggregate results in different color effects, depending on the coarse aggregate color. If cost is a primary concern, polishing contractors are limited to using the concrete producer's indigenous aggregate source and making the owner aware of the probable finished surface. A mockup is suggested. Although it could be cost prohibitive, importing more colorful decorative aggregate and top seeding is always an option.

Some polished concrete contractors are not aware that the sands used in the concrete mixture can influence the final appearance. One of the concrete producers my company used in Georgia batched two types of sand in

Fig. 2: Scoring and staining can add special decorative effects to polished floors

their concrete. They used a mixture of manufactured and natural sand, with a much higher proportion of the less costly manufactured sand. Because the manufactured sand is very coarse and angular—unlike the rounded natural sand—small pieces of the sand were being dislodged during coarse grinding the floor in preparation for polishing, leaving tiny holes in the surface that detracted from the final appearance. Our remedy for this was to skim coat the entire surface with a cement-based slurry (which dramatically increased the labor costs), then continue polishing. On future jobs, we changed to a different producer that used fine aggregate composed predominately of natural sands. This significantly improved the quality of our polished concrete.

When special decorative effects such as staining are specified (Fig. 2), they should be included in Division 9. The desired gloss level—medium, high, or very high—can also be included in Division 9. These terms are subjective, and it might be preferable to test a property such as static coefficient of friction under wet and dry conditions and then relate the tests results to the gloss level. It is counterintuitive, but testing has indicated that higher static coefficient of friction readings correspond with higher gloss levels.[3] Although performance specifications for polished concrete may be included in Division 9, it is not appropriate for the engineer or architect to specify the steps to be used in grinding and polishing floors. The polishing contractor is most knowledgeable about the means and methods needed to produce a desired result.

MAINTENANCE IS CRITICAL

In marketing polished floors, claims have been made that maintenance costs are zero. This is not true. Although waxing and sealing are not needed, floors that are not properly maintained will eventually lose their shine. Polished floors are still porous and prone to staining when subjected to reactive and penetrating spills. Reactive spills include acidic materials such as salsa, pickle juice, or battery acid. These can etch the polished surface if not quickly removed. Penetrating spills such as motor oil are absorbed into the polished surface, changing the color. These spills should also be quickly removed.

Polishing a floor that had previously been covered with vinyl composition tile produced this unexpected ghosting of the former location of tile seams. The color variations may have resulted from differences in the degree of concrete hydration at the seams and beneath the tiles, or they may have developed as cleaning products penetrated the seams to the concrete

REFURBISHING FLOORS

Refurbishing existing floors can increase the polishing costs. It's understood that the cost of removing sealers, oil stains, and ground-in dirt from uncovered floors must be balanced against the time and cost of replacing the concrete. The same applies to removal of covering materials and mastics from covered floors. Apart from this, several other conditions must be dealt with.

Older floors may be much stronger than the 3500 to 4000 psi (24 to 28 MPa) compressive strength that's optimal for polishing new floors. This can increase the costs because more aggressive surface preparation methods are required.

Older floors are also less likely to be as flat as desired. This results in longer grinding times and nonuniform exposure of the aggregate (the size of the visible aggregate will increase with depth). If the floors have curled, greater exposure of coarse aggregate is likely at the curled parts of the slab.

Finally, some hard-to-predict effects can occur on previously covered floors. The photo shows the results of polishing a floor that had previously been covered with vinyl composition tile. Ghosting between the removed tiles is believed to be caused by differences in the concrete's degree of hydration at the seams and beneath the tiles.

Routine maintenance for polished floors should consist of daily dust mopping. Dirt and grime can dull a polished floor quickly by abrading the surface. Frequent mopping is also needed. Although only clean water is often used, it's not a bad idea to use a specially designed neutral cleaner or conditioner that suspends the dirt particles so they can be more easily removed with squeegee vacuums. Using only clean water leaves much of the dirt on the floor where it will eventually abrade and discolor the surface. Avoid cleaners that are highly alkaline or acidic as these will quickly dull a polished floor. The exact maintenance routine, particularly the frequency of cleaning, is dictated by the service environment of the floor. High traffic areas, for instance, require more frequent cleaning.

We have had excellent results preserving our floors by regularly scrubbing them with diamond impregnated pads mounted on an automatic scrubber. If the shine starts to dull, we occasionally use these pads at high speeds to reburnish the floor.

An essential part of the final walk-through for a polished floor job should be providing the owner with written instructions for maintenance.

References

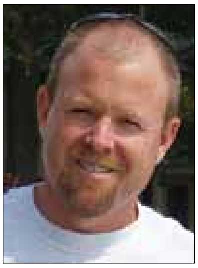
1. Nasvik, J., "Perfect Polishing," *Concrete Construction*, Oct. 2007, pp. 37-42.

2. ACI Committee 302, "Guide for Concrete Floor and Slab Construction (ACI 302.1R-04)," American Concrete Institute, Farmington Hills, MI, 2004, 77 pp.

3. Jancy, H., and Schwietz, G., "High-Gloss Finishes," *The Construction Specifier*, Dec. 2006, pp. 42-50.

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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