High-gloss Finishes

Creating new floors with polished concrete

Special Reprint
Construction the Specifier

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The walkway of this fitness center is polished concrete with single-dye color. It is a non-slip, 'high-traction' floor, a certification made by the National Floor Safety Institute (NFSI).

With advancements in concrete surface treatments, polishing equipment, and concrete coloring materials, the best features of classic terrazzo and other hard floor surface finishes can now be attained in contemporary polished concrete flooring.

Diamond polishing as a finish is a relatively recent concept for the construction industry. Just over a decade ago, diamond-grinding equipment was primarily used as a surface prep tool for concrete floors prior to the application of epoxy and urethane coatings. Versions of the same equipment were also used for polishing marble and other stone tile floors. With rapid advancements in abrasive diamond technology and the availability of more reliable and durable equipment, the final ingredient—a chemical hardener—was added to make the expense of diamond polishing a viable option in terms of service life and low maintenance costs. Almost immediately, creating an attractive, high-gloss surface

requiring a minimum of ongoing maintenance became the desire of many building owners.

Polishing is suitable for refurbishing old concrete flooring or producing new durable, low-maintenance, high-gloss installations. This process provides design professionals with a cost-effective flooring option that can accommodate tight budgets and creative design. As such, it can be found in schools, retail stores, public buildings, and malls, as well as high-traffic warehouses and industrial buildings. Polishing allows old concrete floors to be rejuvenated, adding years of useful life. (Floors subjected to foot traffic or forklift traffic perform equally well when polished.) Color options range from industrial gray or natural earth tones, to bold and eye-catching reds, blues, and greens.

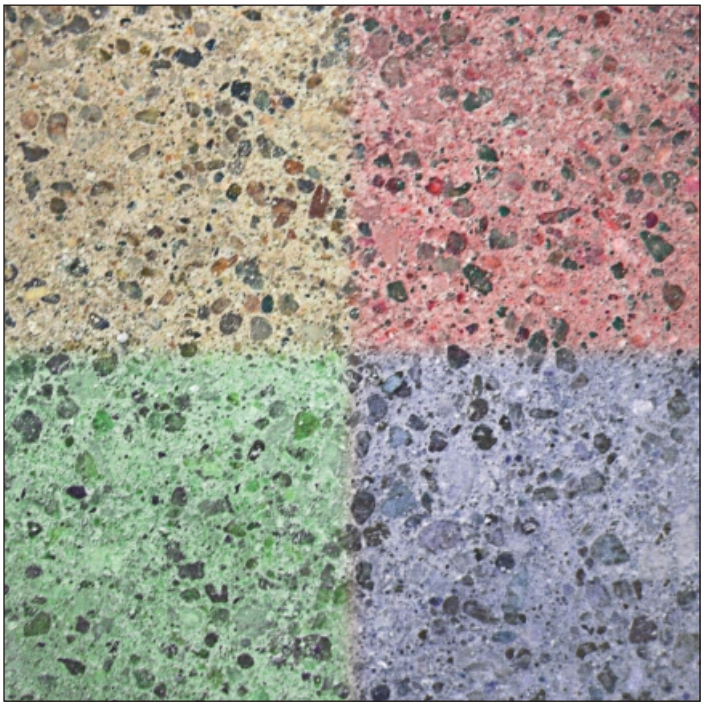
Polished concrete also has sustainable design features. In the case of existing buildings, this kind of surface greatly reduces the impact of construction by 'recycling' an old floor. Also, for new or old buildings, polishing concrete produces little pollution and uses non-toxic components (water-based, odorless chemical hardeners). These benefits contribute toward the accreditation of buildings under the U.S. Green Building Council's (USGBC's) Leadership in Energy and Environmental Design (LEED) rating system. Specifically, polished concrete floors can assist in obtaining one credit under Materials and Resources (MR), Credit 1, *Building Reuse.*

Preparing new and old concrete

When properly placed, new concrete is relatively smooth, flat, and sound, and generally requires less preparation than most existing concrete being considered for rehabilitation. Depending on the condition of existing concrete, costs may be affected by the need for additional coarse grinding steps or for patching and repairing of rough and/or deteriorated sections. The removal of old sealers, mastic residue, dirt, or other surface contaminants also adds time and cost to the overall process.

With both new and old concrete floors, a flat surface provides the most uniform polishing appearance. The mechanical action of the diamond grinding equipment tends to flatten uneven or warped floors, and in the process, the equipment removes some surface cement paste. The more paste removed, the more likely this may partially expose some of the larger aggregate in the concrete. Many

Polishing can be used on new concrete floors or to refurbish old or damaged surfaces. This process can be cost-effective and allows for creative design elements. Polished floors can be found in stores, public buildings, and shopping malls.



Translucent dyes and various grind depths will bring interesting appearance alternatives to standard gray concrete floors.

owners find the random terrazzo look to be appealing, and actually desire it, while others prefer a more uniform appearance. As such, an on-site mock-up is always recommended to determine the acceptability of the final aesthetic and avoid having an unsatisfied client. Adhering to flatness specifications and proper hard-troweling steps will also greatly affect the floor's final appearance.

In the case of a new floor project, the polishing process can be completed with a minimum of interference with the ongoing operations of an existing facility or with other work trades. The chemical treatment applied after polishing is completely odorless and dries quickly, allowing treated floor sections to be opened as soon as they are completed.

The cost of polishing a new concrete surface is approximately the same as installing vinyl composition tile (VCT) or epoxy sealers, exclusive of the cost of ready-mixed concrete or coloring materials. Even so, it is considerably less costly than epoxy terrazzo floors and ceramic tile. Factors affecting the price include original condition of the concrete and size of the project. However, a limited budget does not restrict the creative possibilities of colored, polished concrete as a floor finish.

Specifying polished concrete

Specifications regarding concrete polishing are found in Division 03 of *MasterFormat 2004 (MF04),* specifically, 03 35 00–Concrete Finishes for new concrete, and 03 01 30.71–Rehabilitation of Cast-in-Place Concrete. For new concrete installations, specific mix design requirements help prepare the material and reduce extra costs in surface preparation. These authors recommend the following be included in the related cast-in-place concrete specification:

1. Section 03 30 00–Cast-in-place Concrete

Note to specifier:

i. This section must include the following:

1. Minimum concrete compressive strength of 23 MPa (3500 psi).

Shake-on colored hardeners, polishing, and decorative saw cuts can add dimension. Regular cleaning with mild, non-acidic, concrete cleaners and conditioners will help the floor hold its gloss longer. This surface does not require wax.

3. Non-air entrained.
4. Natural concrete slump of 114.3- to 127-mm (4.5- to 5-in.) admixtures may be used.
5. Admixtures may be used.
6. Flatness requirements: ASTM International E 1155, *Standard Test Method for Determining FF Floor Flatness and FL Floor Levelness Numbers.*
   a) Overall FF 40;
   b) Local FF 20;
   c) Overall FL not required;
   d) Local FL not required.
7. Tight hard-troweled (three passes) concrete. No burn marks. Reference American Concrete Institute (ACI) 302.1R, *Guide for Concrete Floor and Slab Construction*, class 5 or class 6 floor.
8. Curing: Options:
   a) ASTM International C 309, *Standard Specification for Liquid Membrane-forming Compounds for Curing Concrete.*
   i. No acrylic curing and sealing compounds.
   b) ASTM C 171, *Standard Specification for Sheet Materials for Curing Concrete.*
   c) Damp curing, seven-day cure.
   d) Curing sheets.

Like terrazzo placement, natural aggregates, sand, and cement are used when making cast-in-place concrete. If desired, specially colored aggregate (natural or manufactured), and sand can sometimes be integrated into the concrete mix design on new floors for unique colorations, which are exposed with polishing. New concrete may also be integrally colored with a coloring admixture, conforming to ASTM C 979, *Standard Specification for Pigments for Integrally Colored Concrete*. Numerous earth tone color admixtures can be blended with, or used to highlight, the aggregate and sand components of the mix design after the floor is polished. This coloring technique and others will be discussed later in the article.

To reduce unnecessary costly errors on new concrete placements, a pre-pour meeting between the general contractor, the concrete contractor, and the polishing installer contractor, should be written into the specification to discuss elevations, finishing, curing and slab protection. Mock-up panels employing all materials, tools, and techniques to be used on the job should also be constructed. Approved or certified polished concrete installers should be hired to ensure trained professionals and proper equipment are used.

Polishing to a glossy finish

The basic piece of equipment used in the polishing process is a walk-behind, diamond disc grinder for working large floor areas. The grinder drives diamond-impregnated abrasive discs, which progress in size from coarse- to fine-grit discs. The condition of the original concrete surface will dictate the grit coarseness of the initial grinding step. Once the floor is basically flat, the polishing process proceeds with a sequence of multiple steps of increasingly

Retailers often use different colors to identify unique product sections and create a visual impact. Various colored shake-on hardeners were used on this surface.

finer grit diamond pads until the desired finish is attained. The final grit level is generally referred to as either a medium, high, or very high gloss. These terms are relatively subjective and dependent on concrete properties. This process is similar to the fine sanding of wood.

Grinding and polishing are generally done either wet or dry. If a wet process is used, a waste slurry is produced that may be difficult to control inside occupied buildings or on elevated slabs. Additionally, this slurry can get under racks and other hard-to-reach areas and requires proper disposal. Grinding slurry must be disposed of according to local hazardous waste requirements. With a dry process, a special high-performance vacuum system is used, which virtually eliminates all airborne dust and debris, simplifying disposal and keeping the area dust-free.

There is no reported concern regarding silicosis when using the proper equipment. Concrete dust residue is collected in bags and disposed of safely in a landfill. In almost all cases, dry grinding is appropriate and easiest to manage.

Even with its gloss, polished concrete is a safe walking surface. There are numerous ASTM tests used to indicate slip-resistant properties of floor sealers, waxes, and other floor finishes. However, none of these standards work well with polished concrete.

Proper testing will indicate the static coefficient of friction (SCOF) under both wet and dry conditions. Testing indicates finer grit levels and higher gloss actually provide a very safe floor for foot traffic, with SCOF readings increasing (*i.e.* becoming more slip-resistant) with higher gloss levels.

A walk-behind, diamond-impregnated disc grinder is used when working on large floor areas. The surface condition dictates the coarseness of the grinding steps. The disc options range from coarse-to fine-grit.

Application of a penetrating densifier is necessary to provide long term, low cost protection of the polished floor.

Polished concrete floors are becoming a popular design element in retail stores, corporate office buildings, schools and LEED certified buildings.

The National Floor Safety Institute (NFSI) is an independent tester of floors, including polished concrete. Its method, NFSI 101-A, *Standard for Evaluating High-traction Flooring Materials, Coatings, and Finishes*, tests treated surfaces twice:

- once, soon after a floor is polished and densified; and
- 30 days later to evaluate the effects of normal facility traffic on the original reading. Surfaces must register SCOF readings complying with the *Americans with Disabilities Act (ADA)* and Occupational Safety and Health Administration (OSHA) recommendations at both times under both wet and dry conditions. Qualifying products are then certified as 'High Traction.'

These authors recommend choosing a polishing system and products independently certified by NFSI as high traction. Floor cleaners and conditioners can also have a significant effect on ongoing non-slip properties of a polished floor. (They should also be tested to their standards and certified as high traction.) In polished concrete, densifiers penetrate into the 'near surface wear' zone. Therefore, since there is no surface coating, there is also no surface film to scratch, chip, peel, or discolor and, as a result, the natural, no-slip nature of concrete is retained.

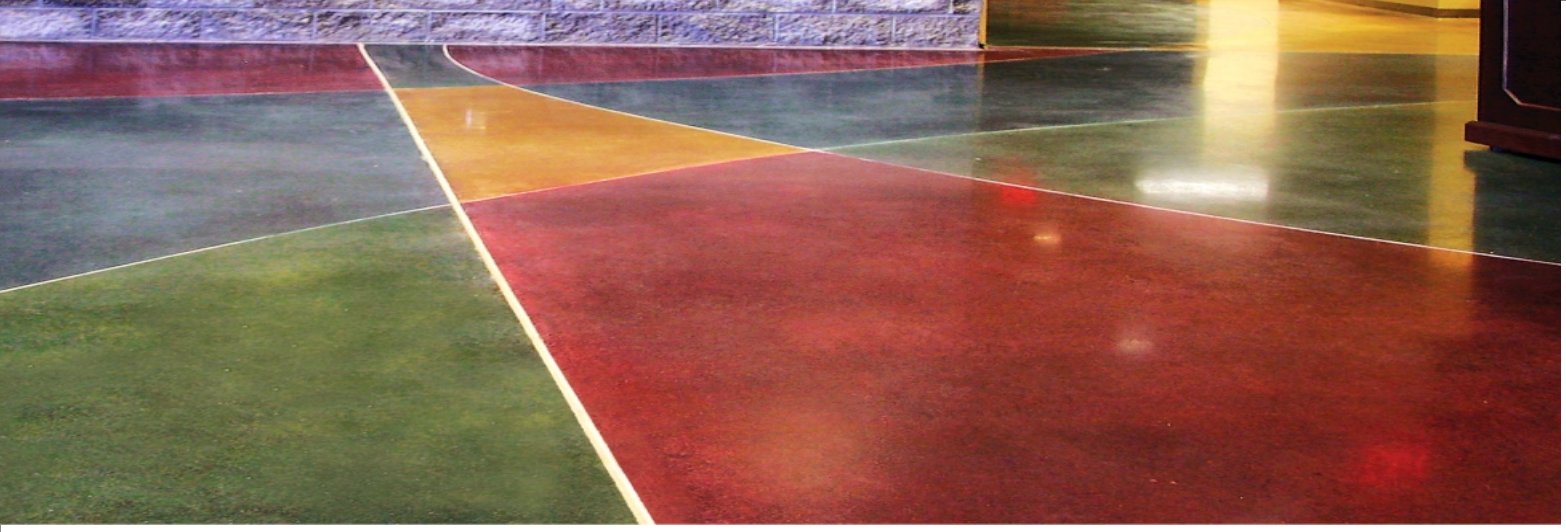
Coloring and protecting polished surfaces

While gray concrete is the norm, color can add significant dimension to a polished floor. With new installations, integral color can be added to the fresh concrete mix, or for a more intense effect, installed by the concrete contractor as a shake-on color hardener.

The floor of this car dealership is polished concrete with a natural appearance and decorative saw cuts.

Color can also be applied to hardened concrete in the form of a reactive stain or penetrating dye after the polishing process. Whether the concrete is plain gray or integrally colored, the application of a reactive chemical stain will create translucent and variegated colorations. (For more information, see “Coloring Polished Concrete Floors” on page 7.) Color options range from industrial gray to reds, blues, and greens.

Once the floor has achieved the desired polish and color, it is still comparatively soft. Two factors come into play at this time. The first factor influencing the softness of the surface is the fact



Colored admixtures, shake-on color hardeners, penetrating chemical stains and dyes add interest and beauty to polished concrete floors.

part of the concrete's hard-troweled surface is removed during the polishing steps. Microscopic inspection reveals an open-pore structure and cement matrix now more vulnerable to wear. Second, because such a high gloss can be obtained by polishing concrete, a common misconception is to believe the process has closed up the floor when the exact opposite has occurred.

After polishing, it is imperative the finish always be protected with an odorless, non-toxic chemical hardener and densifier. In simple terms, proper chemical treatment restores strength to the abraded 'near surface wear' zone of the concrete (*i.e.* the top 1.6 to 3.2 mm [1/16 to 1/8 in.] of the floor). Chemical treatment also makes the concrete surface harder, denser, and more abrasion- and contaminant-resistant. There are several formulations of liquid hardeners on the market. In the authors' opinion, a densifier is best applied after polishing, as opposed to during the process. However, this depends on original floor condition and manufacturer recommendations.

Maintaining a polished surface

Adherence to a recommended cleaning schedule also helps the floor hold its mechanically polished gloss longer and greatly reduces the absorption of spilled liquids (except for strongly acidic or alkaline materials), without the application of maintenance sealers or waxes. Floor wax or topical sealers are never needed on a polished concrete floor. Maintenance costs stay low, usually in the range of $0.25 to $0.50 per square foot per year. This cost estimate is less than half the estimated annual cost to maintain a simple floor wax. Installing a polished concrete floor can add up to hundreds of thousands of dollars in savings over the life of the building on an area measuring 929 m^2 (10,000 sf). The treated concrete floor is easily maintained by regular cleaning with periodic dry and wet mopping. Mild, non-acidic, concrete cleaners and conditioners are recommended for everyday care.

For a successful project, the authors recommend the design team consider the following:

1. There are national programs using certified and trained applicators and it is wise to insist on employing only approved installers, equipment, and products.
2. Color and color types to be used (*e.g.* shake-on hardener, integral color, reactive stain, penetrating dye) should be clearly specified.
3. A minimum five-step process for a base bid is recommended, with incremental steps bid as an addendum once the final finish is determined by the project conditions and owner's representative.
4. A compatible chemical hardener and densifier must be applied at the end of the process. It should be certified as non-slip, and if possible, carry the NFSI designation for high traction.
5. Mock-ups are recommended, and should be installed using available materials and equipment, demonstrating aggregate exposure, shine, and color options.
6. Polished concrete work should be protected after installation until the owner takes possession.

Additional Information:

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Abstract

Polishing concrete can be used to refurbish old or damaged floors or add dimension to new ones. The process to attain glossy surfaces is discussed, along with safety standards, maintenance, and chemical treatments to protect floors. This discussion also includes an overview of materials use to color concrete surfaces to add a further decorative element.

Coloring Polished Concrete Floors

The successful installation of polished concrete floors requires an understanding of how various tools and processes affect a surface. Introducing color to a polished floor is not just a matter of making a color choice. It requires a good understanding of the different coloring products available and how they impact the installation of polished concrete. There are basically four products or methods for coloring gray concrete. Each has its own distinct color palette and method of application.

Admixtures

Integral coloring admixtures are available as either powder or liquid colorants, which are added to ready-mixed concrete at the batch plant. Generally used with a gray portland cement mix design, the products result in subtly muted earth tones. The integrally colored concrete can be placed full-depth or as a 50-mm (2-in.) topping over the structural slab. The latter method allows the various trades to work over the gray concrete structural slab without worrying about damaging or soiling the finished floor.

Once the interior work is completed, the concrete contractor can then install the topping. This can minimize the cost of protecting the surface while the floor is curing, and the cost of cleaning prior to grinding and polishing the concrete. It is important to remember not to use a membrane-forming curing or sealing compound on new concrete, as this can interfere with the polishing process. The use of wet curing or curing sheets is more appropriate.

Shake-on color hardeners

Another material that can be used to color new concrete is a shake-on color hardener. A prepackaged blend of silica quartz sand, cement, and color, this material is topically applied and finished into uncured concrete, forming a very durable layer of color. Compared to a coloring admixture, shake-on products offer a greater range of lighter and more vibrant hues, as well as select greens and blues. Geometric patterns or unique and natural variations can also be created with individual colors or by combining colors.

A significant benefit of using a shake-on color hardener is that it creates a very dense and wear-resistant surface. When combined with the densifying effect of the liquid hardener after polishing, the floor is well-suited for use in areas with high foot and vehicular traffic (e.g. industrial facilities or 'big-box' stores.)

Shake-on color hardener is broadcast onto gray concrete when the floor is being installed. It cannot be effectively or correctly applied to existing cured concrete. Color hardener is usually broadcast manually. However, for large installations such as industrial floors, a mechanical hopper may be used to quickly apply the product. After broadcasting, the product is finished by hand and machine, and allowed to cure before polishing. The finishing process tools and timing are the same as for gray concrete. It is important to not use liquid-applied curing or sealing compounds over the color-hardened surface since it will have to be removed prior to polishing, adding time and cost to the installation.

Penetrating chemical stains

A reactive penetrating chemical stain can be used when coloring an existing or older concrete floor. This material can be applied to gray concrete or a surface colored via an admixture or shake-on color hardener. Penetrating chemical stains are liquid materials that react with the cement component of concrete, creating translucent and mottled colors.

Since results can vary with concrete age and mix design, these authors recommend doing a mock-up. While there are a limited number of earth tones, stain colors can be combined and manipulated during application for eye-catching results. Multiple applications of the stain can be done for deeper colors. However, once the reactive ingredient in the concrete is depleted, additional applications may prove ineffective. This is particularly true with old concrete and should be verified during the mock-up process. If the coloration reaction is less than desired, the use of a dye combined with a reactive stain should be evaluated.

This chemical process leaves a residue after reacting with the concrete, and the floor will require thorough scrubbing, neutralizing, rinsing, and drying time before it can be opened to traffic. The surface can be neutralized by applying a solution of 0.5 kg (1 lb) of baking soda mixed into 19 L (5 gal) of clean water. The solution is then manually scrubbed with stiff-bristled brushes, rotary floor-scrubbing machines, or powered, walk-behind washing/scrubbing machinery. After scrubbing, the wet residue should be wet-vacuumed off the surface. It should not come into contact with plain gray concrete or alternately colored surfaces as the residue may discolor those areas. It is also possible to create shapes and patterns with shallow saw cuts followed by staining with one or more colors.

Dyes

Dyes can also be used to alter existing interior gray or colored concrete. However, they are not ultraviolet (UV)-stable and can potentially fade when used outside. As previously mentioned, dyes are a good companion coloring product when working with reactive chemical stains. Composed of micronized organic pigments in a solvent carrier, these materials are spray-applied and then penetrate into a concrete surface, creating natural and translucent colors. Single and multiple applications are possible. (Applying dyes more than once makes for richer colors.) However, after three or four applications, the concrete surface usually rejects additional material and the color will not change. This should also be verified with a mock-up. Unlike reactive chemical stains, there are more colors available and the effect can be less mottled.

Dyes are usually applied at the grit level just prior to the final polishing step. They dry in minutes, allowing the final polishing and liquid hardener application to continue with minimal downtime once the dye residue is removed. This can be achieved without the use of water or any cleaning agent—simply running over the floor surface with a white buffing pad is sufficient. This easy removal is advantageous in occupied areas or elevated floors where the use and control of water can be difficult. Shapes and patterns may also be introduced with shallow saw cuts.

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