Nine Fundamentals for Polished Concrete Floors

by Jason W. Barnes

All photos courtesy Green Umbrella

SPECIFYING A GROUND, HONED, AND POLISHED CONCRETE FLOOR CAN BE OVERWHELMING. THERE IS A SEEMINGLY NEVER-ENDING LIST OF DENSIFIERS, COLORANTS, EQUIPMENT, AND DIAMOND TOOLING, ALONG WITH COUNTLESS TRADESMEN AND SUBCONTRACTORS OF ASSORTED SKILL LEVELS. WITH ALL THESE VARIABLES, HOW IS IT POSSIBLE TO ACHIEVE A FLOOR THAT MEETS THE EXPECTATIONS OF THE OWNER, ARCHITECT, AND CONTRACTORS WHILE STILL KEEPING THE GOAL OF SUSTAINABILITY?[1]

Leaving a specification to read "polished concrete" is simply not enough. All too often, construction documentation is provided to a contractor and the floor still does not meet expectations. Efforts to standardize concrete polishing have been made by various groups, but suggesting a need for standards is different from implementing them. In other words, the current standards already in place can help create the needed specification for a successful floor—but only when followed.[2]

An architect may specify a gloss level based on a metal or resin bond grit level to yield that result, but if the abrasive is used on a floor burnisher instead of a concrete grinder, the desired sheen may actually vary substantially. Thus, specifying the gloss reading can make clear what the desired floor should be.

The systems approach

To further complicate matters, not all chemistry, equipment, and tooling work well together. For example, a specification for a high school project stated "use polish to a high gloss." However, there was no mention of edge-work. (The architect and owner naturally expected the floor to be polished from edge to edge.) The contractor used a grinder machine and left several inches of edge-work unpolished, claiming this was as

The equipment used to produce a ground, honed, and polished concrete floor should not only create a uniformly finished floor from wall edge to edge, but also promote high productivity, wet-cutting, and reduced environmental impact.

close as his machine would grind and that this was the rationale for edge painting. The general contractor (GC) and architect were compelled to paint the edges, which was not in the scope or budget and is not what the owner envisioned.

When it came to light there was equipment that could have done the job properly in the first place, the contractor simply pointed out he had followed the spec—therefore, the facility was charged for regrinding the entire floor. Additionally, dye did not penetrate the floor because a densifier that had a high alkalinity was used; the dye company's color chart did not match the floor.

To avoid these sorts of problems, continuity is needed. This sort of holistic systems approach would include:

- concrete hardeners or densifiers, colorants, and other treatments that belong to a 'family' of chemicals designed to work together;
- diamond tooling appropriate to the equipment being used to create an open surface for the introduction of chemistry and colorants; and
- certified contractors that are accountable to the manufacturer, not merely trained by the manufacturer or a polishing association.

Many specifications for polished concrete flooring are supplied by manufacturers. While there may be some advantages to this approach, an inherent problem is when not enough consideration has been given to whether a colorant selected is compatible with the concrete chemistries being specified, or whether the equipment and abrasives being used are able to open the concrete enough for the chemistry and color to properly penetrate.

It may be true equipment manufacturers would be less likely to show interest in creating a specification, but this type of contribution would result in a polished concrete floor that has just as much focus on the cut as on the floor. This is because the equipment used dictates the type of chemistry and colorant that should be employed.

A specification based on a complete concrete flooring system gives evidence of knowledge of the process from pour to polish; it includes clear communication to all parties to avoid or overcome issues arising during construction. Architects may be hesitant to specify means and methods in many building practices, but polished concrete should not be one of them.

Since the product is actually crafted onsite, instead of being installed, this author suggests specifying more of the ways and means greatly increases the likelihood of success for the desired floor finish. In the end, it also limits both negligence and liability.[3]

When properly implemented in a performance- or outcome-driven specification, there are nine fundaments resulting in a final product that meets expectations and schedules and promotes environmental responsibility.

One: Managing expectations

Clearly communicating the role the substrate plays in the final product helps all involved to have realistic expectations. For example, an existing slab might have visual defects or blemishes that may not be completely resolved by processing the floor, as opposed to new construction that has a substrate specifically designed with polished concrete in mind.

Before the project begins, expectations are set through a careful review of the condition of the substrate, the decision to take a system approach, and collaborative partnering with a manufacturer-certified contractor.

Use of chemistry that is pH-neutral and does not require rinsing, coupled with equipment that is environmentally responsible, yields a polished concrete floor created with lower downtime.

Both surfaces can be processed using the same system, equipment, and chemicals, and then still yield different results.

Before the project begins, expectations are set through a review of the condition of the substrate, taking a system approach, and partnering with a manufacturer-certified contractor. Good, solid communication and reasonable goals, established through an awareness of each slab's possibilities and limitations, may prevent dissatisfaction with the finished product.

The specification should outline a process that involves mechanically polishing floors using bonded abrasives. A specification that identifies the finished product's polish as "high-gloss sheen" will result in a floor able to keep its finish longer than a substrate opened by various means and then coated with an acrylic or resinous polymer sealer. Especially for public works or projects with limited budgets, the more detailed the spec, the better result one can expect. It greatly reduces the likelihood of added costs to the project later because what was envisioned was not properly specified.

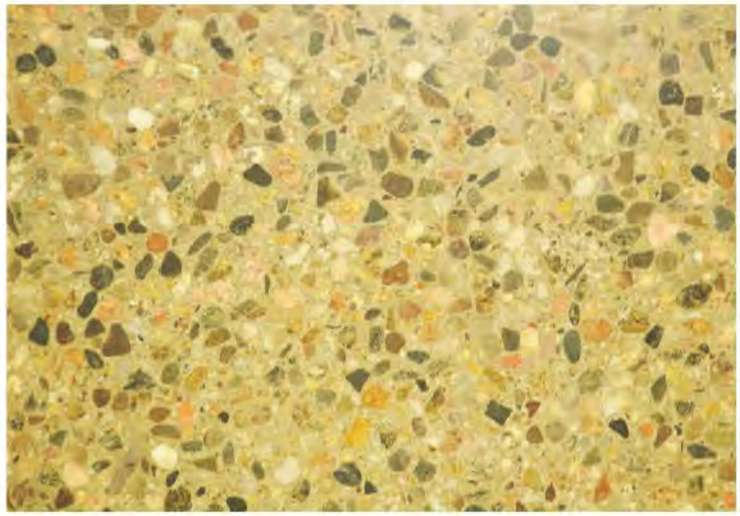
Many general contractors view the floors as the last step in the construction process. To save considerable time and money, the GC should plan timelines with a manufacturer or product consultant that has experience with similar projects. This means less downtime for other trades and promotes a schedule that will proceed in the most efficient manner (*e.g.* grinding floors either before or just after walls go up).

When construction continues after the floors are complete, they will be exposed to possibly the most damaging traffic they ever will experience. The manufacturer may recommend a specific method for protecting the floors. The GC plays an important role in onsite accountability, ensuring the specification is followed. For instance, acid-etching masonry walls after the floor has already been polished will also etch the concrete.

When selecting a floor processor or subcontractor, the GC would want to compare the price quoted to the costs that may actually be incurred. Some have discovered that grinding equipment used for floor processing can have hidden electrical expenses, increasing the actual cost of the floor to more than what was bid. Better success is seen when those trained and certified by the equipment and chemical manufacturers are contracted to process polished concrete floors. When selecting a contractor, there should also be reasonable profit margins expected, even in a down economy.

It is beneficial for the owner, architect, contractor, and floor processor to be educated as to what the specification outlines. Owners should understand polished concrete is different from other types of flooring to which they may be accustomed, but still requires maintenance. The architect and GC's expectations of the concrete polishing contractor will greatly be based on the equipment, unless specified. A person who uses janitorial equipment, and another who employs devices designed for concrete processing, will produce different results.

Accountability and quality assurance can be monitored by having a product representative onsite during the concrete polishing process. This person, in coordination with the contractor, would ensure certified contractors are producing the desired floor, the specification is being followed, and the final product will meet expectations.



Making use of local aggregates or seeding in objects to be revealed during the grind can be an aesthetic way to add uniqueness to the floor.

For residential and hospitality spaces, polished concrete can be a hypoallergenic flooring solution that is versatile, economical, bright, and easy-to-clean.

Two: Green polishing specification

The importance of the polished concrete specification cannot be understated. The final results of new construction are significantly improved when the slab is poured to the proper mix design, floor flatness, and levelness. When planning, it is important to view this part of the design as a total flooring system that includes mix design, finishing and curing methods, control joint placement, colorants, and polishing process.

The groundwork is laid by the architect specifying a polished concrete floor that will meet expectations, and then holding to that specification. While many architects cite a need for "equal to" products or for multiple bids, of primary concern should be the products and the contractor's ability to perform the process specified.

These floor systems involve more than simply opening up the concrete and applying a topical sealer. Consequently, the architect should employ a system approach when writing a specification. It should outline:

- an appropriate mix design;
- methods used during flatwork finishing;
- the process for grinding, honing, and polishing floors using a wet system;
- that bonded abrasives be used;
- use of sustainable, high-productivity open slab and edge grinders, densifier, color, and impregnating microfilm (the product first bonding with the substrate); and
- floor protection during construction.

One appeal of polished concrete as a flooring option is the lower maintenance costs. However, since the lowest bids are often taken for public projects, a completed floor may not be processed using mechanical means, unless specified.

For example, a subcontractor may grind the floor and then apply an acrylic or resinous polymer sealer, which would have a high-gloss sheen at first, but need to be reapplied every few months for upkeep. The floor would also be susceptible to

There is a need to specify a processed floor to the wall edge, as opposed to adding change orders that do not meet client expectations.

staining and etching. For a facility to benefit from the lower maintenance costs associated with polished concrete floors, the specification needs to follow a systems approach.

Three: The engineered substrate

Much like a painter starts with a canvas, the polished concrete floor starts with a substrate. It is important to engineer this concrete with preference to shrinkage compensation concrete or another mix design favorable for the reveal expected by both architect and owner. The components should be in place for a substrate that leads to a successful exposing of the surface. In addition to establishing the actual mix for slab-on-grade concrete, it is wise to consider using a vapor retarder. (Even in arid parts of the country, this helps control moisture within the slab, which can affect color and staining.)

Mix designs vary, but preference may be given to material conforming to American Concrete Institute (ACI) 223R-10, *Guide for the Use of Shrinkage-compensating Concrete*. Other standards to note include:

- ASTM C 33, *Standard Specification for Concrete Aggregates*, for aggregate conformity;
- ASTM C 150, *Standard Specification for Portland Cement*, depending on soil conditions; and
- ACI 302.R-89, *Guide for Concrete Floor and Slab Construction*.

It is best to avoid air-entrained concrete because porosity causes several issues. The pores will have to be filled to render proper sheen and clarity on the floor—this entails more chemicals and could affect bonding. Additionally, excessive use of fly ash (*i.e.* greater than 15) should be avoided as there will be less calcium hydroxide for the hardeners to react with.

Specifying a mix design has much to do with the exposure of rock desired. Attention should also be given to ensure proper slab finishing—that is, it is cured for 14 days, using a water base seven- to 10-day natural dissipating-type curing compound, if necessary.

This photo shows two common pitfalls: color misapplication and slab curl with the resulting uneven joints, elevated by Type G concrete.

This prevents putting a product on that would inhibit the color or hardeners penetrating or causing unnecessary grinding of the substrate. If fine aggregate concrete mix is specified, the concrete must be thoroughly floated and tamped.

Established guidelines for overall value of F_F 50 and F_L 30 should be in place using rational numbers for each to have a starting canvas that leads to a more even reveal, using ASTM E 1155, *Standard Test Method for Determining Floor Flatness (F_F) and Floor Levelness (F_L) Numbers*, for reference.

Wet cures work well and the concrete may be machine-trowelled, but not burned black. Burning the surface inhibits the introduction of concrete chemistry and color, and can add unnecessary grinding steps to the process in efforts to cut through a hard, burned surface. Onsite management by knowledgeable manufacture consultants often take pressure off architects and GCs that may not have the experience to know what to look for during these crucial construction steps.

Four: The equipment

Traditional (or 'European-style') grinding equipment uses high-voltage three-phase or 220 electric power. It is not designed for wet processing (discussed later in this article) and can add a substantial cost in electricity that may not have been considered when the project went out to bid. These costs are often passed on to the owner or GC, and also contribute to a considerably larger carbon footprint when compared to alternative fuel-powered equipment.

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The grinding and honing process should be done wet using reactive, non-water-soluble, pH-neutral chemistry to minimize silica dust contamination.

Electric-powered grinding equipment may contribute to increased downtime and labor costs for the duration of the project since it takes time to set up cords and for an electrician to set up special wiring for the units.

Equipment powered by fuels like propane, on the other hand, allow for safe wet grinding. Eliminating the need for electricity means being able to process floors before other trades are onsite, making the schedule more efficient. This type of equipment can also have higher productivity, with some processing 465 to 930 m^2 (5000 to 10,000 sf) per hour per cut. Edgers, used to process floors from wall to wall edge, can also greatly reduce labor.

Propane-powered concrete grinders and polishers can meet U.S. Environmental Protection Agency (EPA) and California Air Resources Board (CARB) requirements with an emissions shut down system (ESDS) and catalytic converter. They can also meet Indoor Environmental Quality (EQ) Credit 3.7, *Green Cleaning: Sustainable Cleaning Equipment*, for the U.S. Green Building Council's (USGBC's) Leadership in Energy and Environmental Design for Existing Buildings Operations and Maintenance (LEED EBOM) program.

Five: The wet grind and wet hone process

Making use of a wet process eliminates potential airborne contamination. It also controls ambient indoor air quality (IAQ) by ensuring that silica dust neither contaminates existing surfaces and HVAC ventilation systems, nor affects construction workers or future inhabitants.

Wet processing has not been popular in the past because the densifiers driving the market did not work well within this method. A sodium-based densifier would have a tendency to efflorescence when applied to a wet ground floor. More common chemistry now on the market is 100 percent reactive, non-resinous, water-soluble, and pH-neutral chemicals can be used with a wet process (and are not considered 'hazardous waste'). Much of the chemistry products now available can be applied without further labor investment, while at the same time reducing environmental impact.

Specialty concrete treatments with cutting agents work with a wet process to soften the substrate. The frothy slurry created by the process is ground into the floor to help seal pores, producing a denser surface. This is because the cutting agents help with a more aggressive cut, allowing a reduction in bonded abrasive steps and labor requirements. A slurry recovery system may be used to reuse water. Further, the wet concrete process holds open the product to be recycled.

Six: The chemistry

Environmental conscientious chemistry is more than just content low in volatile organic compounds (VOCs). Chemistry should fit into the system approach for an overall green process. Many impregnators and coatings on the market are solvent-based and do not lend themselves to environmentally conscious construction. Additionally, chemistry that contributes to alkali silica reaction (ASR) can exponentially accelerate natural damage to the concrete.

One should avoid specifying a topical product that is no more than a 'wax,' as it would be wasting time to open the concrete. It is also important to remember many facility maintenance personnel apply an ultra-high-speed burnisher coating, negating all the effort that was put into a sustainable floor.

If a microfilm or other sub-topical treatment needs to be applied, it should have a low-VOC content and be a non-resinous polymer to avoid having a topical treatment that requires maintenance such as for vinyl composite tile (VCT) floors.

Many are still using chemicals that are caustic (*i.e.* pH above 11.0) and produce hazardous waste water that is expensive to dispose of properly. Dumping caustic water is a serious concern in many states. The application of pH-neutral (or higher) chemistry product that has no rinsing requirements is preferred when specifying a concrete treatment. Alkaline- and pH-balancing chemicals are available for use on difficult substrates.

Hardeners and densifiers should meet:

- ASTM C 779, *Standard Test Method for Abrasion Resistance of Horizontal Concrete Surfaces*;
- ASTM C 672, *Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to De-icing Chemicals*; and
- ASTM D 1308, *Standard Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes.*

They should also pass the National Cooperative Highway Research Program (NCHRP) 244, *Chloride Ingress Testing.*

Processing a floor 'wet' can improve ambient air quality; using heavy-duty grinding equipment allows for the floor to be procesed throughout—from grind and hone to final polish.

Seven: The color system

For successful integration of color, the use of colorants must fit within the 'family' of chemistry employed on the floor. The introduction of color should be preceded by the placement of a concrete slab with proper moisture content and a balanced pH level. Testing should be specified such as ASTM F 2170-09, *Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using In-situ Probes*, and ASTM F 710, *Standard Test Method for pH.*[4] Preference should be given to the colorant that will provide for the best sustainability with the least environmental impact.

Products may be applied as matte-finish color hardeners on open concrete, or applied during the concrete polishing process for a deeper penetrating, higher gloss, and richer color. Use of colorants should be coupled with hardeners and microfilms that enable depth of penetration and lasting wear. There are three common options for this:

- integral—included as part of the mix design, integral colorants are available in a wide range of hues and intensities; they create a consistent color throughout the concrete substrate and are usually ultraviolet (UV)-stable;
- dye—though not always color-fast, translucent dye can be long-lasting when specified with the right chemistry (the carrying agent should also be compliant with VOC requirements); and
- pigment—a UV-stable colorant that can be applied dually with some densifiers for better attachment to the floor.

Eight: The polish process

A polished concrete floor is generally considered such after it has been cut using 800- to 3000-grit resin-bonded abrasives and displays a high-gloss sheen before any topical treatments are added to the surface. Using ASTM D 523-08, *Standard Test Method for Specular Gloss*, or ASTM E 430, *Standard Test Methods for Measurement of Gloss of High-gloss Surfaces by Abridged Goniophotometry*, can yield an acceptable gloss.

Nine: Repair and maintenance

Some manufacturers provide a maintenance schedule for facilities after having a floor processed to maximize its beauty and durability. Cleaning products that are pH-neutral and will not etch, stain, or otherwise degrade floors are recommended, along with equipment suitable for that facility.

A pH-neutral enzyme-degreaser can be used as needed or otherwise instructed in the manufacturer's recommended maintenance schedule. When the project

Gloss needs to be measured as well as evaluated by architect and owner in its environment. High gloss with direct sun can light up a room, while the same gloss in an artificially lit room does not. See also the photo on page 20.

is a public, commercial, or industrial facility, preference should be given to use of an automatic scrubbing unit in conjunction with sustainable maintenance programs.

Conclusion

The challenges of specifying a ground, honed, and polished concrete floor are greatly minimized, and project outcomes are more assured, when a systems approach is utilized for project documents. The systems approach treats concrete processing as coherent whole rather than unconnected actions. It addresses the compatibility of the equipment, abrasives, chemistry, and process necessary to achieve the polished concrete floor envisioned by the project owner and architect.

Crafting an á-la-carte specification, without a real understanding of the implications of incompatible process components, creates problems starting with mix design through floor maintenance. It can also compromise the green or sustainable qualities of a polished concrete floor.

Additionally, incorporating current or existing ASTM standards for concrete floor construction into the construction documents will help support the performance specification. Results are objective and measurable, and less likely open to interpretation or degree. The intent is to make 'polishing,' as it relates to concrete floors, more of a defined process and result in keeping with green and sustainable practices, and not just an ambiguous aesthetic description. **CS**

Notes

[1] The work of Howard Jancy, CSI, CDT (Jancy Associates) is acknowledged in creating this article. Jancy is a founding board member of the Decorative Concrete Council (DCC), an affiliate of the American Society of Concrete Contractors (ASCC).

[2] Most of these standards are performance-based; there is currently nothing for increased gloss, abrasion resistance, or coefficiency readings, but some definitions have been proposed by the Concrete Polishing Association of America (CPAA).

[3] This author has seen a lot of unnecessary failures. If a specification calls for "polished concrete," one contractor might say "I will burnish with a sealer, and it will be polished," while another says "I will grind it like natural stone, and it will be polished." The specifier needs to communicate specifically what is required. In the end, the architect may have to repay for the floor to be done the way the owner wanted because it was not made clear in the spec.

[4] The concrete polishing industry has adopted this standard since moisture issues associated with resilient floors can also create problems for the colorants, densifiers, and micro films used.

ADDITIONAL **INFORMATION**

Author

Jason Barnes is a product developer, consultant, and educator for manufacturers. He has more than 20 years of experience in the flooring industry, having spent the last seven on developing a sustainable systems approach to polished concrete. Barnes offers further resources on several websites, including www.greenpolishing.com. He can be reached at jason@guengineeredpolishedconcrete.com.

Abstract

Currently the concrete-polishing industry is lacking the standardization relative to the equipment, chemicals, and process. Additionally, each of those elements can be supplied by different sources, without thought to compatibility by a specifier. This article constructs/explains the elements of a polishing specification based on ASTM and comparable published standards or guidelines to ensure objective, quantifiable, and consistent results within a green paradigm.

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