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Feature

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Polishing to a Shine

Considerations for concrete floors

By Mark B. Vogel

The range of flooring finishes available is vast, each having its own individual place and performance characteristics. As such, owners and design professionals must evaluate many factors to determine the best choice for a structure's given needs and what its environment will allow. One flooring option gaining popularity is polished concrete. Although polished concrete is relatively new in North America (approximately 15 years), it can offer many advantages over other flooring options.

Polished concrete is a breathable system that is not subject to failure from ground-borne moisture migration. While the finished surface is water-resistant, it still allows vapour transmission through the slab, unlike epoxy or vinyl composite tile (VCT), which are not breathable and have a tendency to fail due to moisture migration. Repair or replacement of these types of systems can be costly and create downtime in a revenue-generating environment like a retail space. When properly installed and maintained, polished concrete can last the life of the structure, avoiding the time and labour of reinvesting in a second or third flooring system.

The basics

Polished concrete is achieved through a sequence of steps ranging from initial grinding and prepping the floor to finish polishing. This may include ensuring flatness and removing existing coatings or sealant, polishing sequences to remove scratch patterns created by previous grinding processes, as well as increasing light reflectivity and shining. Polished concrete is not a coating that requires replacement or special maintenance programs. However, the performance of this process and the floor's integrity are highly dependent on a high-quality liquid hardener and densifier being used.

As a common flooring system in residential and commercial applications, polished concrete can be used in almost any interior space, although it is not recommended for exterior projects. Acid rain has a tendency to prematurely etch the surface and cause early deterioration of the shine. To add interesting esthetics, integral colours, dyes, and edge-tinting products can also be incorporated.

Costs associated with maintaining a polished concrete surface are dramatically lower than other flooring systems—regular maintenance entails using a neutral pH concentrated daily cleaning solution. An auto scrubber applies the cleaning solution and buffs the surface, while vacuuming excess cleaner and dirt particles, leaving no residue. This cleaning method can save the owner in excess of 50 per cent in maintenance costs compared to paint systems, two-part epoxy, epoxy mortar, and VCT. Other flooring systems, such as VCT and cure and seal, require special waxes and strippers to maintain

them. Costly repairs and/or replacements can exceed the system's up-front price tag, making the initial choice of a floor crucial to long-term considerations.

In addressing safety aspects, a true grinding and polishing system with the highest degree of shine (*i.e.* 3000 grit) and polish exceeds the Occupational Safety and Health Administration (OSHA) and the *Americans with Disabilities Act (ADA)* for coefficient of friction and slip-resistance, which are generally used as guidelines in jurisdictions without similar regulations. (Design professionals should consult their authority having jurisdiction [AHJ] to ensure local and provincial accessibility regulations are being met.) This flooring system can create a safe environment with increased light reflectivity that is highly desirable in today's litigious society.

Wet versus dry polished concrete

When installing a dry polished concrete system, pre-separators and vacuum systems are used to remove and control airborne dust, as well as contaminants. This dry powder (*i.e.* cement particles) can be safely disposed or recycled. Incorporating a green or low-to-zero volatile organic compound (VOC) hardener and densifier can contribute to an environmentally responsible system. In contrast, a wet polished concrete relies on a wet slurry to remove concrete particles, requiring special disposal methods.

Concrete is a durable material and can be specified as part of a sustainable design solution. With the increased popularity of specifying polished concrete in buildings such as schools, hospitals, prisons, and restaurants, a green system, such as a dry polished concrete floor, is a viable option.

Design professionals looking to specify a sustainable grinding and polishing system should look for ones using environmentally responsible products (*e.g.* densifiers and hardeners compliant with VOC regulations), tooling, and practices (*e.g.* vacuum systems are essentially 99 per cent airborne dust-free).

The light reflectance on this warehouse floor was attained by specifying polished concrete. Attaining the right shine depends on the number of diamond disc grinder passes.

Step by step

A true grinding and polishing system requires a five- to 10-step process, depending on the floor's desired shine and its original condition. The number of steps is highly dependent on the existing concrete's condition, requiring a visit to the site and analysis. The three main degrees of shine are semi-gloss, gloss, and high-gloss finish, equating to final grits of 800, 1500, or 3000. Some manufacturers provide information that matches up the desired levels of shine to a corresponding product number or name. This author recommends a site mock-up to identify the slab's capabilities and its ability to polish. Additionally, this allows for an understanding of the desired level of shine needed for that building, as well as for owner and occupant satisfaction.

High-quality grinding and polishing machinery is used to attain a polished surface. Machinery usually offers three to four head types with three to eight diamond pads or segments on each of those heads. These machines rotate at a slow to medium speed (*i.e.* approximately 350 to 1400 rpm). Speed is variable to the type of concrete and the diamond grit being used on that pass.

Multiple passes are made over the concrete surface with each step moving to a higher grit diamond segment. Each essentially removes the scratch pattern from the previous one. This is commonly referred to as 'sanding wood,' where a coarse or low-number grit is used to remove a material and flatten the surface before moving to a progressively higher grit for a smooth finish. The higher the grit, the higher the shine.

The degree of polish or shine is not directly related to slip resistance. A 400-grit finish is usually less slip-resistant than a 1500- or 3000-grit final finish. A wet floor has peaks and valleys in the surface's landscape. When a person walks on it, his or her shoe has a tendency to hydroplane. On a completely flat floor, such as one with a 1500- or 3000-grit surface, the water is pressed out from under the person's shoe, putting it directly in contact with the concrete surface and actually making it stick to the surface. The same is true of a highly waxed and wet car. Pushing a fingertip across the surface causes a squeaking sound as it grabs, even though the car is shiny and appears to be slippery.

Attaining the desired level of shine depends on the number of passes with the diamond disc grinder, as each step flattens the floor more and more, as well as increases light reflectivity. Systems with four steps or less do not accurately reflect a true grinding and polishing system, which entails a five- to 10-step process, including hardening and densification at the proper stage and application rate. These types of systems are commonly referred to as topical, as they deal in a very small percentage of surface depth, causing early wear and loss of reflectivity. These types of systems tend to wear very fast and lose their shine. If a surface is improperly prepared and densified, it will not retain its polish. A multi-step process with proper densification is important, as this is the foundation for the final floor finish and ultimately provides its performance and longevity. While topical systems usually cost less, these systems can fail within the first six to 12 months.

True grinding and polishing techniques are divided into two categories. Metal-bonded diamonds (16- to 150-grit) are used in the grinding phases, while resin-bonded diamond segments (100- to 3000-grit) are used in the polishing stages. Metal-bonded diamond segments are used to remove high spots, imperfections, and contaminates, such as cure and seals, along with types of mastics or chemicals. The grinding phase is also referred to as prep work. While grinding may have only one to three steps, this phase occupies 60 to 65 per cent of the total time required to complete the floor. Floor grinding and proper prep work is vital to a successful polished concrete flooring system and this becomes apparent in the finished product.

Resin-bonded diamonds are used to polish and remove the scratch pattern created by the previous step. These can be done at increased rates of speed as the grit becomes higher and less material is removed from the surface. As the

A 110-volt multi-surface machine can be used in the polishing and grinding process.

grit number rises (*e.g.* 100, 200, 400, 800,1500, and 3000), so does the floor's degree of polish, shine, and reflection capabilities.

Densifying polished concrete

Once the metal-bonded diamond phase and prep work is complete, the densification process begins. This is one of the most important stages because its successful application is directly proportional to the longevity of the finished floor's shine and performance. A densifier works by chemically converting the weak calcium hydroxide ($Ca[OH]_2$) as well as calcium carbonate ($CaCO_3$) compounds in the concrete to form beneficial calcium silicate hydrate (CSH). This material is insoluble in water and highly resistant to water, acids, and other chemicals. The formation of CSH is proportionate to increasing concrete hardness and density by replacing $Ca(OH)_2$ (*i.e.* soluble lime). Once the pores are filled with CSH, moisture migration from the surface to the substrate is inhibited. This process also produces a hard, dense, and sealed surface that usually increases abrasion resistance by more than 50 per cent.

The metal-bond grinding stage opens the concrete, allowing for the application of the densifier using a sprayer or squeegee at a rate of 16 to 19 m^2/L (175 to 200 sf/gal). The liquid is then allowed to soak in for 10 minutes. Next, it is scrubbed into the surface for 15 to 20 minutes (or until gel formation) with a broom or (preferably) an auto scrubber for optimum penetration. This is followed by a light misting of water, then re-scrubbing the floor and flushing the remaining material off the surface with water approximately 30 to 40 minutes of total start-to-finish time, depending on the heat and wind conditions. This author recommends referring to the manufacturer's directions, as methods used to apply hardeners and densifiers can vary.

If the densifier is allowed to dry on the surface, it may leave a white residue or haze. When large sections or globs of densifier are left on the surface, they are very difficult to take out and may actually stain the concrete a dark colour. Water can help in removing the remaining densifier. Normal temperature and humidity ranges for application vary among manufacturers and following recommended procedures can ensure a successful application.

The installer can extend densifier application by adding more of this material in the first 15 to 20 minutes, or water after 20 minutes. Doing so thins it out as it gels to help facilitate deeper penetration and set up for the removal of excess product. The entire densification process takes approximately 30 to 45 minutes. Gel formation and re-gel formation can be used as a guide for determining when this step is complete. The surface is then allowed to dry for 24 hours before the resin-bond diamond segments are used to polish to the desired level. It is critical the manufacturer's recommendations be followed at all times.

As previously mentioned, a densified surface is hard, dense, and sealed. In contrast, an undensified surface has hard and soft spots. The latter can abrade and create a micro-pitting or pothole effect, reflecting light in multiple directions and diminishing the polish. As this abrasion continues, the floor starts to fail and loses its shine, since there is nothing to stop it from deteriorating. Using a densifier increases the density of the top wearing surface to stop abrasion due to wear and carbonization—it holds the surface intact and allows the shine to remain. This creates a water- and stain-resistant surface that is also chemical-resistant and accepted by various bodies, including Agriculture and Agri-Food Canada (AAFC) and the Canadian Food Inspection Agency (CFIA).

Although optional, one further step involves applying a type of topical or penetrating agent to immediately seal the surface until the densifier can fully develop to its potential. Since the densifier must fill all voids in the concrete through a chemical reaction, sealing does not immediately happen and is in fact, highly dependent on the concrete's porosity. Although its main purpose is to increase abrasion resistance, sealing and chemical resistance are a good by-product or feature of a quality hardener and densifier.

Adding colour

Colouring offers endless alternatives to grey concrete and can provide more options to specific types of structures and their uses. There are several methods of colouring a polished concrete surface. One is to use an integral colouring admixture that offers a uniform colour throughout the slab.

Light reflectance attained with a polish like this one can actually help save on lighting costs for office enivronments like the one above.

Polished concrete is not subject to failure from ground-borne moisture migration. While the finished surface is water-resistant, it still allows vapour transmission through the slab, unlike many other traditional flooring products.

Another option is to dye the concrete using a micronized organic pigment in a solvent carrier, allowing for endless colour combinations and edge tint options.

A further colouring method is to use a chemical stain. However, since this material remains active for long periods, it can affect the level of shine. Additionally, it requires use of free lime, which the densifier needs to do its job. Another method is to use shake-on colour, which is a high-strength aggregate. However, this material greatly affects the polishing process and can leave hard and soft spots on the surface that can cause grinding equipment to dig divots in the floor.

Integral colour should be added directly to the mix prior to placement at the batch plant, or to the cement truck before unloading. Dyes are normally applied after the 400-grit polishing phase. A second coat may be added later in the processor at the end to increase the colour's effect or intensity. Care should be taken to wash the surface of dyed sections with water and allow it to completely dry before continuing to the next polishing phase. It is critical the manufacturer's recommendations and instructions for application procedures be followed. Care must be taken that instructions specific to polished concrete are followed as directions can vary for other colouring applications.

Having concrete floors shining with increased light reflectivity may not only be pretty, it can also be advantageous in a litigious world.

Conclusion

With the vast amount of flooring options available, design professionals must look at all available materials and products to fulfill the needs of the structure and its occupants. Considerations such as durability, safety, maintenance and up-front costs, replacement, and sustainability are critical factors in specifying a flooring system.

Polished concrete can address various options and offers solutions to many current flooring requirements. Using programs such as Greenspec, green building rating programs, and AAFC can only benefit everyone. Concrete is one flooring option providing an economical, safe, cost-effective, and long-term solution.

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