



Best Practice

Title: Polished Concrete Floors
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Introduction

This document provides insight on what considerations and decisions should be made when contractors compile a specification for the polishing of a concrete floor.

A number of positive results can be achieved by polishing concrete, not just in terms of aesthetics but also by the practicalities of a polished concrete floor. By polishing concrete, the wear zone—or the top 0.125 inches of the concrete surface—is honed to provide a more durable surface. The result is a smoother surface that is easier to clean and has increased durability and longevity.

The characteristics of polished concrete are:

- Abrasion resistance
- Durability
- Longevity
- Reduced maintenance
- Aesthetics
- Light reflection

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1. What to Expect

1.1. Densifiers

There are several types of densifiers on the market, including sodium, potassium, lithium and magnesium. These chemicals all do the same thing, but react at different rates. They react with the calcium hydroxide generated in the hydration of cement. This reaction creates calcium silicate hydrate (CSH). The CSH content represents the hardness of the concrete paste matrix. Calcium hydroxide creation begins when water meets cement and precipitates to the top of the concrete surface throughout the life of the concrete. This process slows with hydration. However, the unreacted calcium hydroxide on the surface, unless densified, reacts with carbon dioxide to form calcium carbonate or “dust.” This reaction is accelerated when additional carbon dioxide is introduced through exhaust from gas fired heaters. This calcium hydroxide continues to generate throughout the life of the slab and, though polished or covered with floor coverings, will precipitate to the surface.

1.2. Grinding and Polishing

- 1.2.1. The process of removing concrete stock from the surface by creating a scratch pattern is also known as grinding. The lower the quantity of diamonds used in a matrix, the deeper the scratches created. Like wood working, scratches are removed by introducing finer diamonds. In order to remove scratches, operators must double the volume of diamonds in the matrix used previously. For instance, 50 to 100 to 200, and so on. When stock removal is completed, operators can move to the *Polishing* stage but must drop back one level. For example, 100 metals to 50 resins.
- 1.2.2. Diamond Matrix – Originally there was one type of matrix, but now the industry has progressed to several different types. The basic type used for grinding is a metal matrix and polishing is generally performed using a resin matrix. However, a number of new types have been developed that provide better warring and performance for the varying hardness and softness of concrete surfaces. These include hybrid, coppers and porcelain designs. The contractor should select the most suitable diamonds and matrix to do the job, based on the equipment being used and the finished objective.
- 1.2.3. The process of grinding usually begins with metal diamonds, hybrids and sometimes resins, but with aggressive diamond levels like 6 metals, 16 metals, 30 metals or 50 metals. Various manufacturers have different opinions on the point where concrete surface stock is being removed and polishing begins. Note: it is necessary to start with grinding to remove material from the surface to expose more calcium hydroxide, which the densifier will react with to harden the surface. The start point for polishing needs to be determined by the contractor when a test area is worked on. A common start point is to use 50 metals.
- 1.2.4. Polishing is considered to begin when concrete surface stock has been removed and the surface has been honed for durability and gloss. It is not necessary to polish some floor surfaces using high diamond numbers, especially if the floor will not be subjected to heavy abrasion. A high gloss factor can be achieved using protective sealers while working at more reasonable polish levels, thus removing extra cost. Note: the protective sealers will not necessarily replace abrasion resistance, but can improve stain resistance and aid in lowering maintenance costs.

1.3. Concrete Polish Finish

- 1.3.1. Flatness – It is important to achieve as flat a floor as possible, in order to resist the abrasion it will be subjected. Concrete should be considered as “peaks and valleys.” The polishing process reduces the peaks and increases the surface area. This is achieved by polishing with higher diamond pads, i.e., 800, 1,500, 3,000. Gloss and flatness have been used synonymously in the past, but can lead to confusion. It is recommend that these be considered separately.
- 1.3.2. Gloss – High gloss floors increase maintenance requirements. They can also be misconceived as being slippery, when in actual fact they are not. The key is to match the gloss to the desired objective. A car showroom may desire a high gloss (greater than 55) while a grocery store may want a more manageable gloss (greater than 30 and less than 45). A residential home, even in the kitchen, will not have as much abrasion traffic as a grocery store, and therefore does not need a high flatness level. A manageable gloss is better suited. The abrasion factor and a specified maintenance budget need to be considered before specifying gloss levels.

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- 1.3.3. Aggregate Exposure – The most misunderstood aesthetic in polished concrete. Aggregates that are used in the concrete mix design are normally not durable aggregates. They are placed in the mix design for displacement, reducing shrinkage. Therefore, when these aggregates are exposed, they represent the weakest portion of the floor. Without the concrete matrix to hold them in, aggregate pops occur, leaving voids or divots. In addition, densifiers only react with calcium hydroxide generated in the hydration of cement. They **DO NOT REACT WITH AGGREGATE**. Therefore the concrete matrix is harder than the aggregate. Temperature changes on the surface caused by exposure to sunlight or cool weather can cause aggregate pops. A “salt and pepper” exposure is recommended to achieve an optimum surface for abrasion resistance and durability.
- 1.3.4. Color – The color of concrete is not always the same. The addition of “fly ash” can create a darker gray. Remember, fly ash is a pozzolan created by the burning of coal at coal fired generation plants. Slag, a byproduct of steel, is another pozzolan that is lighter in color. It contributes to green points, but is not as cheap. If using integral color or dying, you should consider slag if using a cement replacement.

1.4 Uniformity

This will be greatly dictated by how even the original floor is when grinding is complete.

1.5 Hardness

This is a result of densification and polishing. The degree of hardness should be established as a minimum of 6.5 Mohs Hardness Pencil Test.

1.6 Slip Resistance

This is a calculation of coefficient of friction. In actuality, a higher polished floor has more surface area, thus the coefficient of friction is greater resulting in more slip resistance. This is hard for people to visualize because a gloss finish innately looks more slippery.

1.7 Water Resistance

Densified floors allow for water transmission both ways. Densification and polishing is not a barrier system, thus the problems with peeling and blistering are not an issue. The surface will be breathable in both directions, from the top and the bottom of the slab.

1.8 Stain Resistance

Polished concrete is not a barrier coating as explained above. Because the surface is tighter it does increase stain resistance over trowel finished concrete. However, it will not prevent staining. A protective sealer will increase the resistance, but NOT make the surface “stain resistant.” Good maintenance practices are required to minimize staining.

1.9 Maintenance Requirements

Specifying maintenance requirements is an extremely important part of the work. All surfaces need to be maintained. This is NOT a maintenance free system. Proper standards and frequency of maintenance should be based on the projected activity of the surface. Maintenance costs can be reduced over the service life of a concrete polished floor in comparison to other floor covering materials.

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2. New Concrete Surfaces – 03312 Cast in Place Concrete Slabs

2.1. Concrete Mix Design

Attention to this portion of the specification will affect the desired result of concrete polishing. Failure to achieve an optimum surface ultimately increases job costs and may leave a contractor unable to meet the desired finish.

- 2.1.1. Cement content – Should be developed for a mix design using Type I Portland cement that will achieve a minimum of 4,000 PSI.
- 2.1.2. Fly Ash content must be less than 15% - Exceeding 15% conflicts with the chemical reaction of hardening and creates flat spots where minimal reaction with densifier is achieved, thus low gloss from polishing
- 2.1.3. Air entrainment admixtures are not needed for interior slabs. The addition of air allows for durability against freeze thaw. Cement naturally entrains air, thus additional air entrainment will not be needed. Excess air entrainment can result in a damaged slab when ground for polishing.
- 2.1.4. Aggregate exposure – This is controversial when attempted within the normal mix design material. Exposure of fine aggregates is recommended while large aggregates are discouraged. Aggregates used in the mix are inserted as fill, not aesthetics. Large aggregates are usually found deeper in the concrete than the wear layer. Exposure of these tends to compromise the durability of the surface, meaning in most cases that they will NOT be as hard and durable as the concrete paste. Exposure to a lot of large aggregate will minimize the surface hardness by limiting the amount of concrete paste that can be densified and polished. If large aggregate exposure is desired, see section 2.6 regarding “Seeding Floor Surface for Exposure of Large Aggregate.”

2.2. Concrete Placement and Finishing Contractor Certification

Certification by ACI is essential to make sure you have a knowledgeable contractor on the job. Some verbiage from other specifications: *“The concrete floor finishing subcontractor Lead Finisher and at least two additional members of the finishing crew shall be certified under the Concrete Flatwork Finisher Training and Certification Program as granted by the American Concrete Institute and shall be present during application.”*

2.3. Flatness/ Levelness

The ability to provide a flat surface impacts the aesthetics of the polished concrete floor. Use of F_f #'s and F_l #'s helps provide tolerances that can be measured by the concrete finisher to insure he or she achieves the desired result. Failure to use high tolerances can result in a wavy floor, which can ultimately lead to uneven exposure of aggregate.

- 2.3.1. Recommended F_F 50 and F_L 35 with a tight tolerance for error suggest, +/- 10%
- 2.3.2. Recommend an outside testing firm confirm numbers with replacement of slab and concrete contractors cost for failure to comply.

2.4. Placement

The method of placement will impact the result for flatness.

- 2.4.1 Vibrating screeds tend to roll the concrete and help create high and low spots. A laser screed or cutting screed is recommended to help insure a flatter surface.
- 2.4.2 Smooth and re-straighten surface using an 8- to 10-foot-wide bull float. Apply in two directions at 45 degree angle to strip.
- 2.4.3 Wait until the bleed water sheen has disappeared.
- 2.4.4 Float surface with one or more passes using a power float. First float pass should be across the width of the strip.

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- 2.4.5 Re-straighten surface following paste-generating float passes using 10-foot-wide highway straightedge. Use in two directions at a 45 degree angle to strip. Use supplementary material to fill low spots.
 - 2.4.6 Make multiple passes with a power trowel.
 - 2.4.7 Re-straighten surface after trowel passes using multiple passes with weighted highway straight edge to scrape the high points. No filling of the low spots is done at this stage.
- 2.5 Finishing
- How this affects the aesthetic result:
- 2.5.1 Multiple directions, four directions to reduce waves. i.e., north/south, east/west, northwest/southeast, northeast/southwest.
 - 2.5.2 Surface does not need to be hard trowel finished, just close surface for curing only.
- 2.6 Seeding Floor Surface For Exposure Of Large Aggregate
- If this aesthetic is desired, selection of hard aggregates to compliment the surface hardness and density of aggregate on the surface can be achieved by seeding surface. This also enables the polishing contractor to reduce the grind depth, because the large aggregate to be exposed will be at the surface. Densification is minimized, as densifiers only react with calcium hydroxide generated in the concrete paste. By following the correct method, there will be less exposure of this substance on the surface.
- 2.7 Role of Curing
- Curing is needed to complete hydration of the entire slab. The first seven days are critical and, depending on the depth of the slab, an extension of time may be required. Concrete hydration developing calcium hydroxide can continue in excess of 30 or even 90 days, depending on the depth of the slab.
- 2.7.1 Wet Curing is recommended as cures will need to be removed either chemically or mechanically. Blankets are sometime used in conjunction with water. These tend to cause salts to rise to the surface and depending what will be done to the surface may require chemical cleaning before grinding.
 - 2.7.2 Chemical cures are available for interior slabs. These utilize densifiers which help protect the surface and can be easily removed with chemical cleaners. All slabs using some form of chemical cure do require cleaning to insure surface is not compromised for densification.
- 2.8 Surface Protection
- Protection of the slab surface is of extreme importance to achieve a successful aesthetic appearance. This should be the responsibility of the general contractor.
- 2.8.1 Inform all trades of their responsibility and liability.
 - a. Prevent oil, hydraulic or acid spillages on the concrete surface
 - b. Protect the surface from abrasion, gouging or scraping
 - 2.8.2 Utilize breathable material like cardboard or other protective materials to cover the concrete. It is not recommended to use sheetrock or plywood, as these materials will allow evaporation of moisture at a different rate than the joints, leaving curing lines. In some cases, the moisture causes color bleeding on the floor. **DO NOT COVER WITH NON-BREATHABLE FILMS**, like visqueen for example.
 - 2.8.3 Daily cleaning before and after polishing is recommended to insure the surface is clean and free from imperfections that may affect the desired result.

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3. Existing Concrete Surface – 03362 Stained and Polished Concrete

Polishing existing floors is possible whether they are cured for longer than a week, or if they are covered with other floor covering materials. It should be noted that a number of issues can arise with existing floors, especially from those covered with other floor covering materials. First is the fact that the contractor does not know what is underneath the floor covering. The floor could be waved, requiring utilization of leveling materials, or it could have cure marks from VCT like picture framing, checker boarding, cracks or divots. **DO NOT ASSUME THE FLOOR IS PRISTINE.** Evaluation of the surface is essential before developing a specification. The method of removing previously used floor covering material is crucial to achieving the objective.

3.1. Evaluation

Evaluate the surface before the specification, and re-evaluate the surface before the job starts.

- 3.1.1. Waves – Waves in the floor can contribute to uneven exposure of aggregate, particularly large aggregate.
 - Measure the distance between waves utilizing a straight edge and tape measure. Check north/south and east/west. Map out waves on the floor plan.
- 3.1.2. Curl at joints and terminations and cold joints – These are areas where uneven curing has occurred. The surface has dried out faster than the mass, thus causing the surface to pull back and creating a raised area. Again, the result of grinding will be the same as above in the waves.
 - Measure with a straight edge to confirm curl and mark out on floor plan.
- 3.1.3. Existing coverings – **DO NOT ASSUME THE FLOOR IS PRISTINE** under the covering.
 - It is recommended that before a specification is developed, an area is selected to remove some floor covering to evaluate the surface. If possible, remove in several different areas to get a better idea of the situation. This will help in compiling a correct specification and bid for the work.
 - a. Look to determine what type of underlayments were used. i.e., gypsum, cement, or synthetic
 - b. Check for surface imperfections. i.e., cracks, divots, delamination or aggregate exposure
 - c. Evaluate penetrations and supports to determine the extent of edge work, and consider what will be required to create the desired finish
 - d. Check for curing marks, i.e., picture framing or checker boarding
 - Test the concrete surface for hardness with a Mohs Hardness pencil. The contractor should make sure that the concrete is being tested, not the underlayment
 - Resilient floor covering or cure and seal– This can be anything from acrylic sealer, cure and seal, linoleum, urethane, thin film epoxy to trowel down epoxy.
 - a. **BEAD BLASTING THE SURFACE IS NOT RECOMMENDED, EXCEPT AS A LAST RESORT.** Cutting coverings from the surface is a better solution.
 - b. The covering material should be removed chemically or mechanically. The surface needs to be chemically cleaned to remove solvents created by mechanical removal driven into the concrete. Failure to remove these materials will result in problems with color and gloss. The solvents in the concrete will provide imitation polish gloss levels that will dissipate over time.

3.2. Evaluating Concrete Prior to Work Commencement

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4. Quantitative Benchmarks

- 4.1. Gloss
- 4.2. Hardness
- 4.3. Slip Resistance

5. Quantitative Benchmarks

- 5.1. Grinder Machines
 - Weight and size
 - Drive
 - Cutting Footprint
- 5.2. Diamond Tooling
- 5.3. Burnishers
- 5.4. Burnishing Pads
- 5.5. Auto-scrubbers

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