"Drafting an Understanding of Densified and Polished Concrete" *(ICC09E)*

Presentation Notes

Slide 1: Title Slide

Slide 2: Course Description

Slide 3: Learning Objectives

Slide 4: What is Concrete?

Take a little bit of rock, sand and water, add some cement and you've produced just about the most natural flooring and building product available. What was good enough for the Romans over 2000 years ago is still good enough for us today.

Concrete is a mixture of cements (11%), course aggregate (41%), sand (26%), water (16%), and naturally entrapped air (6%). Additives may be included in the mix design to enhance certain properties.

Focus will be on the most standard flooring mix design – ASTM C150 Type I for portland cement. It is important to be aware of all negative ramifications when including admixtures to a mix when densifying and polishing. Admixtures benefits range from improving strength, workability and cure time, to enhancing waterproofing and aesthetics. For polished concrete, it is important not to include air entrainment, and to minimize the amount of fly ash replacement for cement.

Note: You can't polish air, and fly ash extends the strength gain out to as much as 90 days, in addition to altering the color and having reduced workability

Slide 5: Concrete Flatness and Finishing Help Determine the Final Outcome

Finishing techniques, screeding techniques (laser screed vs. manual screed), edge finishing vs. machine finishing, and flatness of the concrete all influence the final outcome of the polished concrete.

Slide 6: Concrete Flatness Determines the Overall Look and Aggregate Exposure (1)

The flatness of the concrete directly influences the outcome of the grind and polish. Looking at the straight edge over the uneven concrete surface, you can see low spots. As the high spots are ground, it will begin to expose aggregate. This will create uneven aggregate exposure – high spots with heavy aggregate exposure and low spots with minimal aggregate exposure.

Slide 7: Concrete Flatness Determines the Overall Look and Aggregate Exposure (2)

These two photos show the results of low spots (on the left) and high spots (on the right). This is the uneven aggregate exposure that can be created when the concrete pour is not flat. A floor flatness (FF) level of 40 or above can really help to avoid these issues.

Slide 8: Concrete Flatness and Finishing Help Determine the Final Outcome

These two floors were polished by the same crew, with the same equipment, densifier, and process. The only difference was the flatness of the concrete before the grinding and polishing began. This is a good representation of the finished difference between a wavy and a flat poured concrete floor.

Slide 9: How to Produce Densified & Polished Concrete - Step 1: Grind the Floor

There are 3 basic steps to polishing concrete. The first step is to grind the concrete floor with specialized 3 or 4-headed grinding machines and industrial diamonds. These diamonds scratch the concrete, effectively grinding the concrete surface. This initial grinding step can remove imperfections, mastics or coatings that are already on the floor. On a new floor, grinding can remove trowel marks, or can be used simply for aesthetic purposes, expose aggregate and achieving a terrazzo look.

Slide 10: Exposed Aggregate Levels

Class A – Cream Finish: A very minimal, light grind. Cleans up trowel marks but leaves as much of the cream as possible. This exposed aggregate level requires a floor flatness (FF) level of 40 or above in order to achieve this cream look.

Class B – Salt/Pepper Finish: Looks like salt and pepper on the floor where the sands and fines are exposed.

Class C – Medium Aggregate

Class D – Large Aggregate

The amount of grinding determines the amount of aggregate exposure achieved. In order to achieve uniform aggregate exposure, it's important that the floor be flat.

Slide 11: How to Produce Densified & Polished Concrete – Step 2: Apply a Densifier

The second and most important step for the longevity and sustainability of polished concrete is to apply a densifier. As the densifier is worked into the floor surface, it is drawn down into the floor through capillary action. Drawing the densifier down into the concrete is important, especially with recently ground concrete floors (which have effectively been "opened-up") than with a hard-steel troweled one.

A liquid densifier chemically reacts with the calcium hydroxide present in the concrete and creates a harder, more abrasion resistant surface by forming crystals within the pores. As these crystals fill the pores, it creates a dense surface (approximately about 1/16" – 1/8"), hence the term "densifier.

Densification accomplishes 3 basic results:

1. Prevent dusting
2. Hardens the floor substantially
3. Transforms porous concrete into a solid mass

It is important to note that densifiers are NOT coatings. Densification is an internal chemical reaction. There is no coating or anything left on the surface of the concrete to wear away or be replaced. It becomes a permanent, integral part of the concrete surface.

Slide 12: Petrographic Analysis of Concrete

Here you are looking at the physical attributes of concrete magnified 2500 times through an electron microscope.

Slide 1 on left: Cured concrete prior to the addition of a modified sodium-silicate densifier.

Slide 2 on right: Cured concrete following densification with the addition of a modified sodium-silicate densifier.

Note the tightness and uniformity of the cured, densified concrete.

Slide 13: Not All Densifiers are Applied Equal

Densifiers should be flooded onto the surface and allowed to penetrate for 30-60 minutes in order to achieve true densification. Applying densifiers at a rate more than 300 ft^2/gal will result in a diminished chemical reaction. This limited densification reduces the hardness and sustainability.

In order to reduce costs, some applicators and manufacturers are applying the densifier at a very light coverage rate. This is keeping the floor from reaching full densification and long term results and may require re-densification down the road.

Slide 14: How to Produce Densified & Polished Concrete – Step 3: Polish the Floor

The third and final step is to continue polishing the floor until achieving the polish level specified by the architect. Much like sandpaper that starts off with lower grits and larger bits of sand on the sandpaper (similar to the grinding step), polishing requires finer grit diamonds to close up the pores of the floor and polish the floor. Polished concrete, when chemically densified and mechanically refined produces a natural floor that delivers aesthetics, performance and life-cycle cost savings

Slide 15: Polish Gloss Levels

Level 1: Low gloss

Level 2: Medium gloss

Level 3: High gloss

Level 4: Very-High gloss

Slide 16: Benefits of Polished Concrete (1)

A picture tells a thousand words. This before and after photo shows the transformation of old concrete into polished concrete. You can see in the before photo the chalky appearance of the concrete, contrasted against the after photo which shows a polished floor where the pores have been closed-up and the overall appearance harder and shinier.

Slide 17: Benefits of Polished Concrete (2)

It is important to note the performance criteria of polished concrete floors.

- Increased reflectivity up to 30%
- Increased impact resistance up to 21%
- Meets ANSI requirements for coefficient of friction
- Meet's OSHA and ADA SCOF standards up to 800 grit
- Lowest life cycle cost of any flooring surface
- Increased abrasion resistance of up to 400%

There are a number of recognized manufacturers of silicates and/or siliconate blends. It is important to request third party verification of each product to qualify the manufacturer's claims. These particular results can only be achieved by one particular concrete polishing system. Request independent testing from the manufacturer prior to writing performance based specifications for concrete polishing.

Slide 18: Limitations of Densified & Polished Concrete

As you look at this photograph you can see the light reflectivity created from the densification process, but you also see that without removing the laitance by grinding, the visual appearance of the floor will be very mottled and irregular.

It is not acid resistant, and requires additional protection. For food grade acids in a restaurant, grocery store, or cafeteria, we would recommend some additional protection. For concentrated acids, like battery acid, we recommend an acid resistant coating, rather than polished concrete.

It nis not elastomeric and will not cover cracks or holes.

It will not hide variations in concrete color.

A minimum 28 day cure time (hydration period) is recommended before grinding and polishing.

It is not salt resistant, although a well-designed walk-off mat system will address the salt resistance at building entrances.

Slide 19: What Are Your Color Options with Polished Concrete?

There are several color options for polished concrete. Integral color (color mixed within the concrete), dry shake (color within the additive added to the surface of the concrete), dyes and stains (topically applied). All of these options are good for a new concrete floor. If working with an existing concrete floor, only dyes and stains can be used.

Slide 20: Dye/Stain with Topical Sealer vs. Polished Concrete

Both of these floors received the exact same acid stain. The left floor had acid stain applied to bare concrete, and then received a topical sealer. As you can see, the sealer wore away and the acid stain wore off. The floor on the right is a 2-year old Mexican restaurant that received a densified and polished finish with acid stain applied. The increased abrasion resistance (as a result of concrete densification) protected the acid stain from wearing off. Polished concrete will protect both acid stains and dyes from being "walked off".

Slide 21: St. Peter's Hospital

The photographs on this and the next slide show a wonderful example of the ability of a properly densified floor to protect, not only the floor, but also the acid stain or dye.

This hospital floor has no topical protection and it stands up beautifully 12 years later.

Polished concrete works well in both schools and healthcare facilities because it does not support the growth of mold/mildew, allergens or dust-mites, and it is a dust-free surface. They run a dust mop and a wet mop over the floor as needed. No other maintenance is done to these floors.

Slide 22: Todd Beamer High School

This high school has withstood heavy traffic and abuse schools can take. The maintenance consists of dust mopping and running a scrubbing machine as needed. No reapplication of color, or any other products. The longevity and ease of maintenance can be seen in these photos.

Slide 23: Polished Cementitious Terrazzo

The process of concrete densification and polishing can also be used on cementitious terrazzo as in this automobile dealer showroom. In this photo, a 20 year old cementitious terrazzo is able to breathe and shine again. In the past, terrazzo was traditionally waxed and buffed to maintain its shine and protection. Grinding, densifying and polishing allow uncovers the natural shine, color and clarity of a cementitious terrazzo. It eliminates the on-going high cost of maintenance of waxing, striping and buffing. Grinding, densifying and polishing is the long-term solution for cementitious terrazzo floors - both old and new.

Slide 24: Broadcast Aggregate or Recycled Glass

The appearance of a terrazzo floor can be achieved by broadcasting aggregate or recycled glass into the surface of the newly poured slab, and then performing the grinding steps to expose the aggregate or glass in a relatively uniform and terrazzo-like appearance.

Two examples are:

- Upper left - Whole Foods in Toronto cast with large aggregate
- Lower right- Russellville High School in Arkansas cast with recycled black and red glass

Slide 25: Bennet High School, Salisbury, MD

With maintenance budgets shrinking and LEED in the back of the owner's mind, the architect set out to find a flooring solution that fit into LEED requirements, would be aesthetically pleasing and would require less maintenance than traditional VCT (vinyl composition tile). The solution was to use the existing concrete sub-floor and mechanically process and highly refine the surface to a polish with diamond abrasives for a polished concrete floor.

The consistent large aggregate exposure was achieved by seeding into the pour, and then exposing the aggregate through the grinding.

Slide 26: Analyzing an Existing Floor for Polished Concrete (1)

It is important to analyze an existing floor to make sure it is a good candidate for polished concrete. Consider the following questions: What type of floor prep is needed? Coatings removal? Existing coverings? Pour backs? Patching? Mock-ups and samples are needed to verify the final look of an existing floor.

Slide 27: Analyzing an Existing Floor for Polished Concrete (2)

Several examples of what can be seen on an existing floor – pour backs, ghosting from tile glue, different aggregate exposure. These should all be taken into consideration when polishing an existing floor. Some customers love the “industrial chic” look and appreciate the natural appearance of concrete, along with the durability, ease of maintenance, and environmental characteristics of polishing an existing floor.

Slide 28: Express Headquarters, Columbus, OH (1)

The headquarters for clothing retailer EXPRESS, in Columbus, Ohio, won the *2012 Polished Concrete Award* in the Commercial category.

Stone tiles and ½” of thin-set had to be removed with a shaver in order to get to the bare concrete. The concrete was then ground to expose large river rock, after which a sodium silicate densifier was applied to the concrete surface and then polished.

Slide 29: Express Headquarters, Columbus, OH (2)

The brightness and ease of maintenance is exactly what this customer was looking for. Notice how vibrant the floor looks with no overhead lighting and just side lighting.

Slide 30: Existing Floors – Spall Repair

Floor repairs and color matching is an art. You can see in these two examples the need for finding a good match. Both floors will perform well, but the one on the right blends in much more. Mock-ups and finding the right contractor will influence the final outcome of these types of repairs.

Slide 31: Existing Floors – Crack Repair (1)

Cracks can be filled with polyurea joint filler, then shaved flush with the floor.

Slide 32: Existing Floors – Crack Repair (2)

Before and after, color matching is key to blending those cracks away. Filling the cracks help repair the floor structurally, and make it look aesthetically pleasing as well.

Slide 33: Avoid Future Cracks with Proper Joints

The primary purpose of saw cuts/contraction joints are to help direct the placement of the cracks that will naturally occur during curing.

The photo on the right is an actual crack formation in the curing of a slab. As you can see, it is directly below the joint. Saw cuts should be 25% of the depth of the slab. A 4" slab should have 1" saw cuts.

Slide 34: Joints: The Effect On Your Finished Floor Performance and Appearance

1. Preparation
2. Place backer rod if needed
3. Fill joints with a 2-part, 100% solids polyurea
4. Finished shaved joint

The primary purpose of joint filling is to improve the structural integrity of these joints, but it also keeps the joints from filling with dirt and debris, and gives the floor a nicer look.

Slide 35: Mercadona – Home Improvement, Spain

This is a home improvement store in Spain. The original joints were never filled. As a result, the joints broke down, spalled and became a trip hazard. In order to fix these joints, they had to be cut out, spall repair had to be installed and then the joints had to be re-cut and re-filled. This could have been avoided by using a good joint filler in the beginning

Slide 36: Joint Fillers – Structural and Part of the Architectural Design

Here are two examples of using joint fillers as part of the design of the building. On the left is a hotel in Costa Rica. Small saw cuts were done in a rectangular pattern to give the appearance of tiles. On the right is a Big O Tire store where the white joint filler was used to contrast against the black floor. The joints and joint fillers can become part of the design element.

Slide 37: Certified Applicators & Artisans Are Key!

Grinding, polishing, crack repair, spall repair, coloring, edge/hand polishing, overlayments, etc. should be done by certified applicators and artisans. Skilled craftsmen with experience should be used.

Slide 38: Writing Proper Specifications

Be sure to use CSI Master Format-2014 for well written specifications. It is written to create consistency and accountability. Ensure everyone understands them, from office to field, and that everyone buys-off on the need to follow them. Know the ramifications of changes. Know when the choice isn't an option

03 35 43	Polished Concrete Finishing
03 35 43.13	Polished and Dyed Concrete Finishing
03 35 43.16	Polished and Stained Concrete Finishing
07 91 26	Joint Fillers
09 01 60	Maintenance of Flooring

Slide 39: Well-Written Specifications, Mock-Ups and Samples Get Everyone on the Same Page

Specifications, mock-ups and samples help get everyone on the same page. The beauty of concrete is that it is a very natural product. However, being natural means that there can be different sizes of aggregate exposed. Each floor can have a different color and look. There are many variables when dealing with a natural product. Just like the uniqueness in marble and granite, each concrete floor has unique characteristics. The customer should understand the unique and natural character of concrete.

The concrete flat worker needs to understand their important role in creating a flat and well-finished floor. The concrete polisher needs to know the aggregate exposure and polish level desired. If everyone has the same expectations, through well-written specifications and samples, they can all be on the same page.

Slide 40: Sustainability and LEED

The daVinci Arts Middle School, High Performance Classroom Building in Portland, Oregon was the first public school building to achieve LEED Platinum and Net Zero Classifications.

What is sustainability? In ecology, sustainability is how biological systems remain diverse and productive. Long-lived and healthy wetlands and forests are examples of sustainable biological systems. In more general terms, sustainability is the endurance of systems and processes.

Polished concrete is very durable and gives great endurance as a flooring system. It is also easily maintained, creating a truly sustainable floor.

Slide 41: LEED as the Yardstick

LEED, an acronym that stands for Leadership in Energy and Environmental Design, is a green building certification program that recognizes new and existing buildings which achieve dozens of individual strategies, or credits, such as providing alternative transportation amenities or reducing irrigation water use.

Polished concrete has contributed to many LEED projects – including silver, gold, and platinum awarded projects.

Slide 42: Sustainability Benefits

- Energy cost savings
- Reduced life-cycle impacts
- No off-gassing
- Improved thermal comfort
- Increased daylighting

Slide 43: California Academy of Sciences

This project was awarded LEED Platinum two times making it "double platinum."

The Academy is one of the largest public Platinum-rated buildings in the world, and is also one of the world's greenest museums. Polished concrete was an important part of this recognition. Its ease of maintenance and reduced life-cycle costs, along with the reflectivity and reduced lighting needs are a tremendous asset to this project.

Slide 44: Increased Light Reflectivity = Reduced Lighting

Indoor spaces with highly reflective floors, such as polished concrete, allow for increased reflectivity, reducing lighting costs throughout the life of the building. This Volkswagen manufacturing/distribution facility was able to turn-off 1/3 of its lighting due to the reflective benefits of polished concrete. See the overhead lighting that has been shut off.

Slide 45: Enhanced Natural Lighting

Indoor spaces with highly reflective floors, such densified polished concrete, allow for increased daylight penetration deeper into the space throughout the life of the building. Daylighting has been touted for its many aesthetic and health benefits.

"Daylight environments increase occupant productivity and comfort, and provide the mental and visual stimulation necessary to regulate human circadian rhythms."

There is “high correlation between schools that reported improvements in student test scores – upwards of 10 percent – and those that reported increased daylight in the classroom.”

Slide 46: Life-Cycle Impact Reduction

Use of densified concrete flooring can breathe new life into existing concrete floors retained as part of a building re-use project and extend their useful life.

- No need for re-application
- Ease of maintenance
- Long-term performance
- Truly sustainable system

Slide 47: Create an Understanding of Maintenance (1)

- The pore structure of concrete can create problems with standard detergents.
- Concrete etches so you may have to add extra protection in areas exposed to acids.
- Hydroxides and sulfates, which are found in common cleaners, can attack and soften concrete.
- Understand the “true” purpose of topical Guard products when specifying them

Slide 48: Create an Understanding of Maintenance (2)

The pH of the cleaner is important to concrete floors. Because concrete floors have a pH of around 10, the cleaner should have a pH of 9–10 as well.

Slide 49: Create an Understanding of Maintenance (3)

Aggressive brushes used on a polished concrete floor can damage the surface and dull the floor. Soft bristles are preferred over hard bristles for standard maintenance.

Slide 50: Create an Understanding of Maintenance (4)

When clean, polished concrete floors have been shown to be one of the safest, hard-surface floors available. Rated acceptable per ANSI B-101.3.

Slide 51: Cost Per Square Foot of Floor Coverings & Finishes – 10 Year Life-Cycle

Polished concrete and color is approximately $2-$6 a square-foot which is similar or less than the other products listed. When looking at the annual maintenance costs of polished concrete per year, the cost is only $0.25.

Many times when budgets are tight it’s easy to put down a cheap product like VCT tile or sheet vinyl. But within a matter of only a few years, the need to replace these coverings require significant down time and additional costs.

Slide 52: Where Polished Concrete Can Be Specified (1)

The versatility of polished concrete allows it to be specified in numerous industries. The leading concrete polishing system has been applied to well over 250,000,000 ft^2. Although concrete polishing is a relatively new flooring option, it is not inexperienced. The following slides demonstrate some of the industries that are well-suited for concrete polishing: automotive, retail, schools/educational, warehousing and distribution, convention centers and arenas, restaurants, hospitals, and even residential.

Slide 53: Where Polished Concrete Can Be Specified (2)

No other flooring system can be used in so many different environments with such beneficial and cost effective results.

Slide 54: Pacific Audi, Torrance, CA

Here is an example of providing a cleaner, safer and easily maintained work environment, while positively reflecting on this Audi Dealership's presentation to their clients.

This photo was taken 1 year after the facility was opened. Their entire maintenance consists of running a scrubbing machine over the floor at the end of the day to quickly remove any dirt, oil, or fluids. That is all that is needed to keep this floor looking like this for its lifetime.

Slide 55: Automotive Parts Manufacturing/Distribution, Canada

Because of the maintenance, scratching, peeling, yellowing, and vapor drive issues associated with coatings, polished concrete is quickly becoming the finish of choice in facilities historically using coatings. This 40-year old facility was shut down each year between Christmas and New Year's Day to reapply the epoxy coating. You can see on the left what the coating looked like after 1 year of traffic. Both photos were taken 1 year after use respectively.

Slide 56: Bass Pro Shop

Polished and dyed concrete adds a positive feeling to the shopping at Bass Pro Shops and delineates different sections.

Slide 57: Natural History Museum, Los Angeles, CA

Polished concrete gives this Natural History Museum adds visibility to the artwork by reflecting them off the floor.

Slide 58: Child Development Centre (Children's Hospital), Calgary, Canada

This project received the highest point total in the world for a cold climate building and is the largest LEED Platinum certified building in Canada (at that time).

The center used polished concrete in the main level, multi-purpose space. Notice the matte finish. This facility did not opt for a high polish, but wanted a lower polish level to meet the look they were after.

Slide 59: JCPenney, New York City

A beautiful white, polished and densified floor for JCPenney. This is a cementitious overlayment that was polished.

Slide 60: Bunnings Hardware Store, Australia

Hardware stores use polished concrete for its strong abrasion resistance needed for heavy foot traffic, forklift traffic, and other equipment used in these facilities. The high-polish and ease of maintenance make it the ideal flooring option for a retail facility with heavy traffic.

Slide 61: Conrad Harley Davidson, Shorewood, IL

This Harley Davidson dealership incorporated dye colors and polished concrete to create a beautiful and durable surface to fit with their beautiful merchandise.

Slide 62: Cafeteria Ruta 33, Bilbao, Spain

This restaurant's polished concrete highlights the brightness and cleanliness the owner was hoping for. The white, large aggregate was seeded into the floor during the concrete finishing and gives it a very architectural design.

Slide 63: St. Stanisclaus Kostka Church, Pittsburgh, PA

The simplicity and beauty of this dyed and polished concrete allows the amazing architecture and beauty of this church to shine through.

Slide 64: Oceanside Museum of Art, Oceanside, California

The art at this museum is visible on the walls and through the reflection on the floor. The polished concrete shows off the crisp lines and beautiful architecture of the building.

Slide 65: Manhattanville College, Purchase, New York

Schools and universities are using polished concrete for their look, sustainability, and ease of maintenance.

Slide 66: Dosha Day Spa, Portland

This acid stained, densified and polished Spa in Portland, Oregon provides a classic, high-end feel, while at the same time taking advantage of daylighting and minimal maintenance needs.

Looking at the upper left photo shows the abuse the floor can successfully take during construction. Although it was specified that the GC cover and protect the floor, its durability saved the day when a simple scrubbing brought the floor back to life.

Slide 67: HEB Grocery Store, Concordia, Mexico

Grocery stores have become big users of polished concrete because of its aesthetic benefits and dramatic reduction of maintenance compared to tile. Wal-Mart has claimed to have saved $283,000,000 in maintenance costs by switching from VCT to polished concrete in a study done on 700 stores.

Slide 68: Airport, Jackson Hole, Wyoming

This airport floor has integrally colored concrete and heavy exposed aggregate to create a very unique look that is easy to clean and handles the abuse and traffic of this environment.

Slide 69: The Ohio State University Chiller Plant

Here is an exquisite example of utilizing polished concrete outside the box – and on the exterior walls of this facility. The walls were pre-cast concrete which were polished flat on the ground, and then raised into place. Natural light is reflected off the shiny surface of the walls, through the glass fins during the day and electric light shines through them during the night, creating a rainbow effect at this Ohio State building.