ENHANCING THE PERFORMANCE OF CONCRETE FLOORS THROUGH THE USE OF CHEMICAL DENSIFIERS

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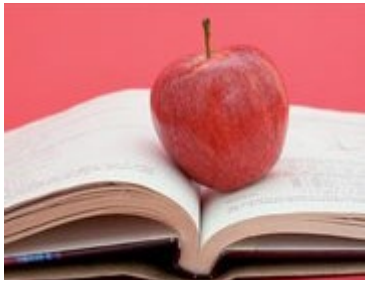
Course Objectives



To understand:

- The shortcomings of untreated concrete floors
- The practices that can undermine the performance of untreated concrete
- The advantages and disadvantages of coatings
- The advantages and disadvantages of floors treated with densifiers
- How chemical densifiers work
- How densifiers are applied
- Where chemical densifiers are specified
- How chemical densifiers are used in conjunction with other concrete technologies
- The differences among and between chemical densification products

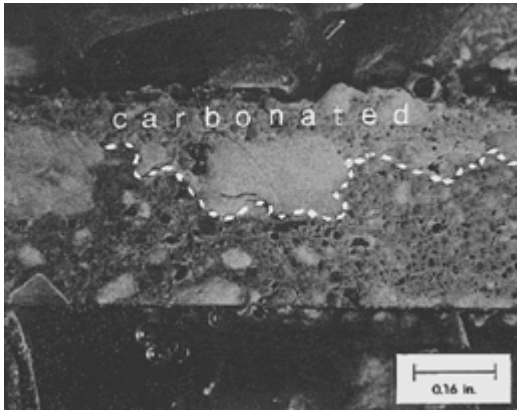
Common Problems on Concrete Floors

- Even tightly finished concrete is microscopically porous, allowing contaminants to enter and stain the surface.
- Over time, concrete is prone to wear and erode, creating traffic patterns in the floor surface.
- Concrete creates dust from efflorescence.
- Concrete does not develop a glossy finish by itself. Most concrete floors become relatively dull and unattractive over time.
- Light and dark areas create an uneven appearance.

Common phenomena that worsen problems on concrete floors

- Carbonation
- Poor surface water-to-cement ratio
- Poor mix design

Carbonation



Mix water reacts with CO2 to form carbonic acid. This in turn reacts with calcium hydroxide to form calcium carbonate at the expense of calcium silicate hydrates (CSH).

- Occurs most commonly in enclosed areas that are heated but poorly ventilated.
- Surface is soft, chalky, and excessively dusty. Prone to erosion.
- Severe cases can be to depths of up to ½ inch. (1.27 cm)
- Can be prevented by properly venting heaters to outside, or using heaters that produce no CO_2.

Poor Water-To-Cement Ratio Which Results From Adding Water

- Water-to-cement ratio is the amount of water (by weight), divided by the amount of cement (by weight), in a concrete mix.
- Normal water to cement ratio should be between .45 and .50 for good structural integrity on an industrial floor.
- Finishers often add water at time of finishing to make concrete more workable. This increases the ratio dramatically, compromising the surface.
- Concrete at surface gains no strength. Surface is soft, dusty, and prone to wear.

Poor Mix Design

- Too much water in the mix
- Not enough cement to produce intended compressive strength
- Poor water-to-cement ratio
- Inappropriate use of admixtures
- High content of fine aggregate.

Membranes: The Traditional Approach To Sealing and Protecting Concrete Floors

The most common membranes are all members of the plastics family, and are organically derived:

Acrylics

Urethanes

Epoxies

Advantages Of Membranes

- Inexpensive (Acrylics)
- Immediate sheen
- Slip resistance
- Variety of colors
- Acid resistance options
- Conductive and static dissipative options
- Can cover up blemishes and imperfections

Disadvantages Of Membranes

- Scratching, peeling, chipping
- Bonding is affected by pH and moisture
- Tire marking
- Multiple reapplications over life of floor
- Expensive
- Extensive surface preparation
- Environmental concerns due to VOCs
- Yellowing and discoloration

Conceptual Differences Between Chemical Densifiers and Coatings

- Coatings are not integral to the concrete.
- Coatings simply lie on top of the floor surface.
- They are not chemically reacitve.
- They do not achieve permanent results.
- Coatings are organic.
- Coatings require frequent replacment.
- Chemical densifiers are permanent, sustainable, chemically reactive, inorganic, and integral to the concrete.

Problems With Coatings Have Led To Chemical Densification As An Alternative

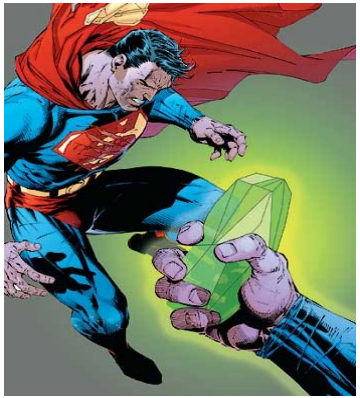
Chemical denisifers:

- Are easy to clean
- Can provide a permanent sheen
- Can eliminate concrete dust
- Resist abrasion
- Resist tire marking
- Do not need to be reapplied
- Do not peel, scratch, or delaminate
- Can remediate existing concrete
- Allow concrete to “breathe”

How Chemical Densifiers Work

- Penetrate the finished surace and react with hydrated lime
- This reaction produces additional crystals that fill in the voids in the surface, making it more dense and easier to clean.
- Reaction also hardens the surface by converting soft calcium hydroxide into hard calcium silicate hydrates, which are the primary bonding agent in concrete.
- This reaction also reduces dust, which is normally caused by the efflorescence of calcium hydroxide.
- Some densifiers also extend and “re-stack” existing CSH by means of oxygen bonding.

Limitations Of Chemical Densifiers



- Acid resistance
- Salt resistance in wet/dry environments
- Steel wheels under heavy load
- Carbonated floor surfaces
- Surfaces with a high water-to-cement ratio
- Delayed sealing
- Not elastomeric - will not span cracks
- Do not cover up blemishes

Typical Facilities In Which Chemical Densifiers Are Used

- Warehouses
- Distribution centers
- Manufacturing facilities
- Convention centers
- Stadiums
- Aviation hangars
- Retail space
- Food processing
- Data centers
- Educational
- Correctional

Application of Chemical Densifiers

- Spray on a clean concrete surface
- Baseline coverage rate: 200 square feet per gallon
- Broom or scrub to aid penetration
- Allow to dwell for 30-40 minutes
- Re-treat or broom over areas that tend to dry out
- In hot conditions, lightly mist with water
- After 30 minutes, flush thoroughly with water, leaving only the material that has penetrated.

Application of Chemical Densifiers, Continued

- One application is normally sufficient to achieve the desired results
- Most products are environmentally friendly, although some are not
- Flushed residue can generally be removed to sanitary sewer drains
- On existing surfaces, floor may typically be used three hours after application
- Application may be made to new or existing concrete, provided the surface is clean
- Some products can be used to cure newly-placed concrete

Specification of Chemical Densifiers

- Normally specified in concrete section of specification (Division 3).
- Sometimes specified in finishes (Division 9).
- Specification should include guidelines for protecting floor from spills and leaks.
- Most often specified on interior, steel-troweled slabs on grade.
- Certified applicator should be recommended.
- Specifications sometimes include burnishing or buffing to develop an early sheen.

Timing of Chemical Densifier Properties

SEALING:

- Delayed. Ongoing chemical reaction & crystalline densification.
- Water normally begins to bead within 90 days.
- Oil should bead within six to eight months.
- Water from cleaning hastens the sealing process.
- Stains can be forced out as long as floor is being cleaned.

HARDENING AND DUSTPROOFING:

- Within hours or days.

SHEEN:

- Develops within four to six months.
- Can be immediate if floor surface is burished or cleaned frequently before opening.
- Floor must be cleaned regularly to maintain sheen.

ALL BENEFITS ARE PERMANENT

Basic Mix Design Guidelines For Optimum Performance of Chemical Densifiers

- .45 to .50 water to cement ratio
- 4” to 6” slump
- 4000 psi 28-day design strength
- No higher than 20% fly ash or other pozzolans, as a percentage of total cementious value by weight
- Avoid chloride-based accelerators

Basic Placement and Finishing Guidelines For Optimum Performance of Chemical Densifiers

- Strike off with laser screed
- Don’t begin troweling until bleed water is gone
- Use riding trowel machines
- Trowel to achieve a compact, dense, smooth surface
- Use pan trowels for flatness and levelness
- Do not add water during finishing

Use of Chemical Densifiers with Other Concrete Technologies

- Tilt up construction
- Dry shake floor hardeners
- Admixtures
- Steel fiber and fiber reinforcement
- Pozzolans: fly ash, GGBGS, silica fume

Tilt-Up Construction and Chemical Densifiers

- Chemical densifiers may be used in conjunction with bond breakers in tilt-up construction
- Densifier may be applied before or after the panels are lifted.
- If before:
  - Densifier should be applied to casting bed as a cure as quickly after troweling as possible.
  - Excess densifier must be thoroughly flushed from slab surface following soak-in period.
  - Chemical densifier is normally compatible with bond breaker, and vice versa
- If after:
  - Slab must be cleaned and stripped of curing agent and/or bond breaker before densifier is applied.

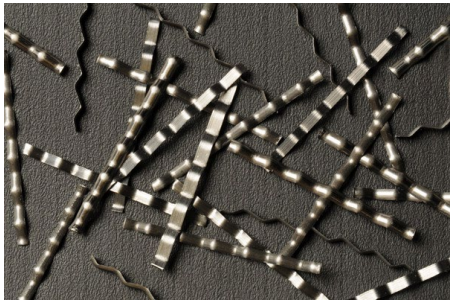
Dry Shake Floor Hardeners and Chemical Densifiers

- Surfaces treated only with dry shake hardeners are typically harder than those treated only with chemical densifiers.
- Dry shake hardeners cost much more per square foot than chemical densifiers.
- However, surfaces treated with chemical densifiers are *hard enough* for most applications, like heavy foot traffic and heavy forklift traffic.
- In addition to hardness, chemical densifiers add other benefits: sheen, ease of cleaning, and resistance to tire marking.
- Densifiers may be used with dry-shake hardeners to produce an exceptionally hard surface. Densifiers will, in effect, *harden the dry shake hardener* by reacting with the extra portland cement.

Concrete Admixtures and Chemical Densifiers

- For slabs on grade, concrete admixtures normally include accelerators, retarders, shrinkage reducers, plasticizers, water reducers, and air entrainment, depending on time of year and slab use.
- These admixtures are generally not known to adversely affect the performance of chemical densifiers, nor vice versa, with the possible exception of some shrinkage reducers.
- This assumes all admixtures are added in the correct doses and as directed by the manufacturer’s instructions.

Densifiers Used with Fiber and Steel Fiber Reinforcement



- Used as an alternative to traditional welded wire fabric, fibers made of steel, polypropylene, or nylon are added to the concrete mix for reinforcement.
- These products, when used as directed, provide three-dimensional, rather than single-plane reinforcement.
- Densifiers may be used on concrete containing any type of fiber, the densifiers react with the paste surrounding the fibers, but not with the fibers themselves.

Densifiers Used with Pozzolans

Blast Furnace Slag

Fly Ash

Silica Fume

- Pozzolans are siliceous materials used as cement substitutes in concrete.
- They consist usually of fly ash from coal combustion, or ground and granulated blast furnace slag from steel production, or silica fume from the production of metal alloys.
- Pozzolans develop cementitious properties when they react with by-products of cement hydration.
- They can reduce heat of hydration, improve impermeability, increase long-term strength, and decrease water demand.
- Fly ash is the most common pozzolan added to concrete mixes in the United States.
- Chemical densifiers can be used on concrete containing pozzolans. Doses, however, should not exceed 20% of total cementitious materials by weight.

Maintenance of Concrete Floors Treated with Chemical Densifiers

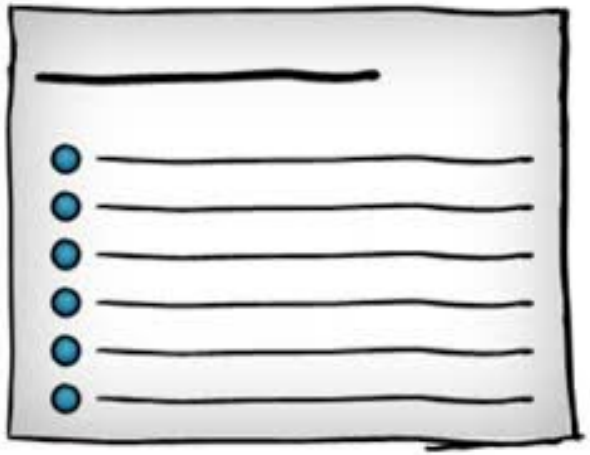
Initial Cleaning

- Floor should receive a very thorough initial cleaning prior to opening of facility. Cleaning should include powersweeping, scraping, stripping, scrubbing, and sanding if necessary. Oil stains should be removed with degreasers or oil emulsifiers.
- Early sheen can be developed with a scrubbing machine or high-speed burnisher equipped with aggressive pads, brushes, or sandpaper.

Ongoing Maintenance

- Scrub floor frequently with good high pH detergent, aggressive brushes, and at least 100 lbs. of down pressure.
- Avoid acidic detergents, d-limonene, or cleaners that contain sulfates or hydroxides.
- Clean at least two or three times per week.
- Use liberal amounts of water, as this accelerates the sealing process.
- Clean spills quickly.

Types of Chemical Densifiers On The Market Today



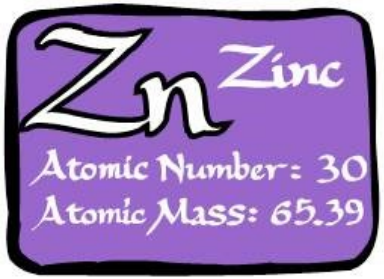
There are basically three types of chemical densifiers on the market today:

- Low end: Inexpensive silicate and water curing products
- Mid-range: Products containing magnesium and/or zinc florosilicates
- High-end: Enhanced silicates or siliconates.

Basic Facts About Inexpensive Silicate Curing Products

- Typically applied cost per square foot: 2 to 4 cents, depending on size of the floor.
- Typically used to cure the slab in anticipation of later applying a sealer/hardener.
- Convenient because they allow concrete finishers to quickly cure the slab at the end of the day without excessive labor.
- Compatible with high-end densifiers, as long as slab is clean.
- Not recommended for hot or adverse curing conditions.
- Curing performance is unproven.
- No permanent sealing, hardening, or dustproofing.
- Typically applied at at 300 to 400 square feet per gallon.
- Little to no warranty.
- Consist only of silicate and water.

Basic Facts About Magnesium or Zinc Fluorosilicates



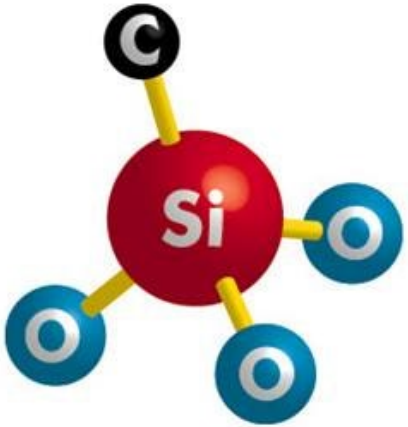
- Require mixing at job site.
- Must be applied at least 14 days after slab placement.
- Multiple applications, usually two or three, required in varying dilutions.
- Usually magnesium and/or zinc fluorosilicates or silicoflourides.
- Not known for sealing properties.
- Reasonably good at hardening and dustproofing.
- Limited warranties, usually one year or less.
- Toxic. Heavy metal content.
- Typically applied cost per square foot: 6 to 8 cents, depending on size of floor.

Basic Facts About Enhanced Silicate Or Siliconate Products

- Typical cost per square foot: 11 to 20 cents, depending on size of floor.
- Provide hardening and dustproofing benefits within hours or days.
- Usually develop attractive and permanent sheen on hard, steel-troweled surfaces.
- Sealing benefit, once accrued, is permanent. However, seal does not develop for several months.
- Require regular cleaning and maintenance for optimum performance.
- Warranties range from six months to 20 years.
- Performance varies, but in general provide better results than the inexpensive silicate cures or the florosilicates.

Basic Facts About Enhanced Silicate Or Siliconate Products

Silicate Molecule



Siliconate Molecule

SILICATES

- Silicates have one silicon atom bonded to four oxygen atoms.
- Four reactive oxygen sites allow for formation of three-dimensional tetrahedral crystals when the silicate reacts with the concrete.
- Tetrahedral crystals are the strongest and most stable molecular structures.
- The reactivity of silicates allows for more thorough extending and re-stacking of the polymers already in the concrete.
- Completely inorganic chemistry.

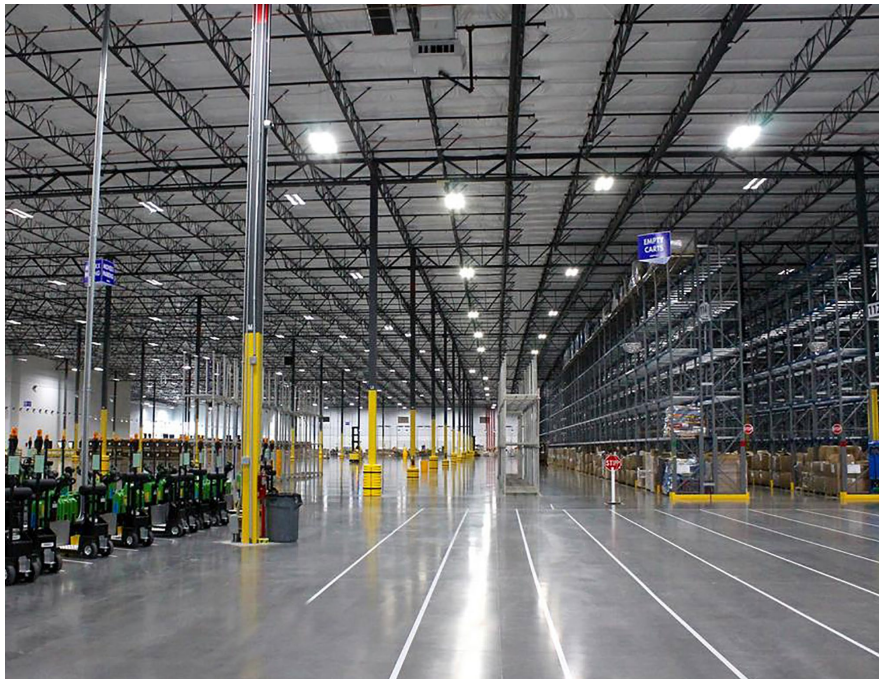
SILICONATES

- Siliconates have one silicon atom bonded to three oxygenatoms and one carbon atom.
- The carbon site, being organic, is not reactive.
- It is impossible to build three-dimensional tetrahedral crystals with only three oxygen sites.
- Siliconates may be slightly more resistant to water penetration in the early months, but not over the long term.

Project Highlight:

Chewy.com Fulfillment Center

Goodyear, AZ
800,000 sqf (2017)



Project Highlight:

Menards
Home Improvement Store

Muscatine, IA
200,000 sqf (2009)

Project Highlight:

Baltimore Law School

Project Highlight:

Coors

Project Highlight:

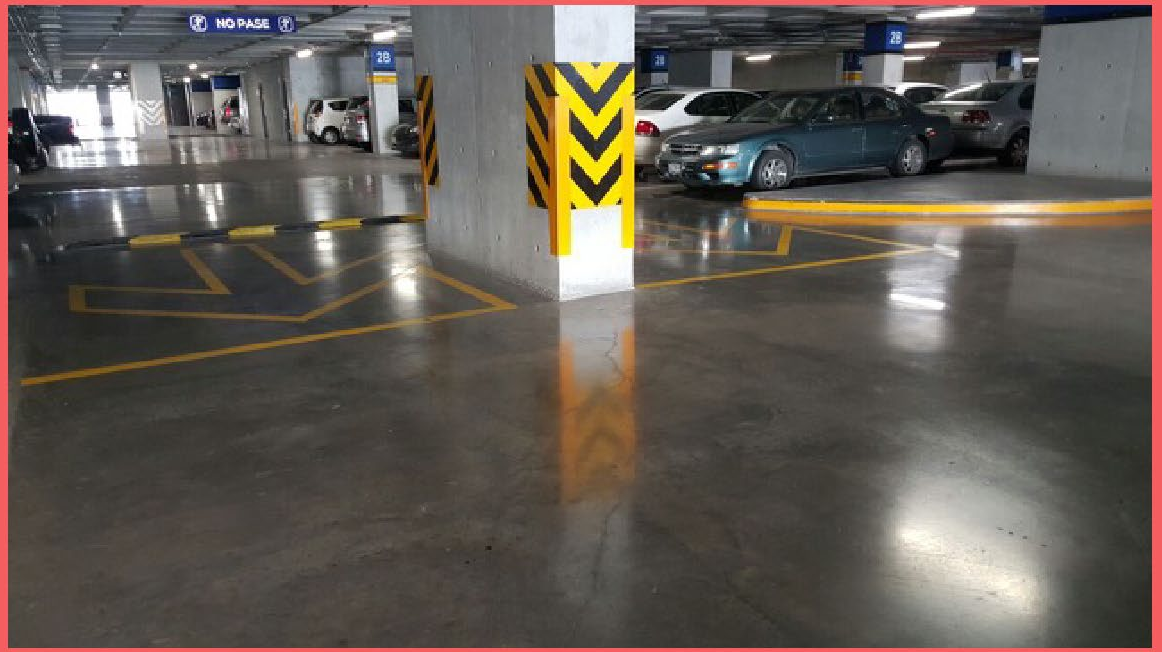
Fairfax County Maintenance Facility

Project Highlight:

Boeing | *Everett, Washington*

Project Highlight:

Parking Structure | *Monterrey, MX*



Project Highlight:

Phoenix Convention Center

Project Highlight:

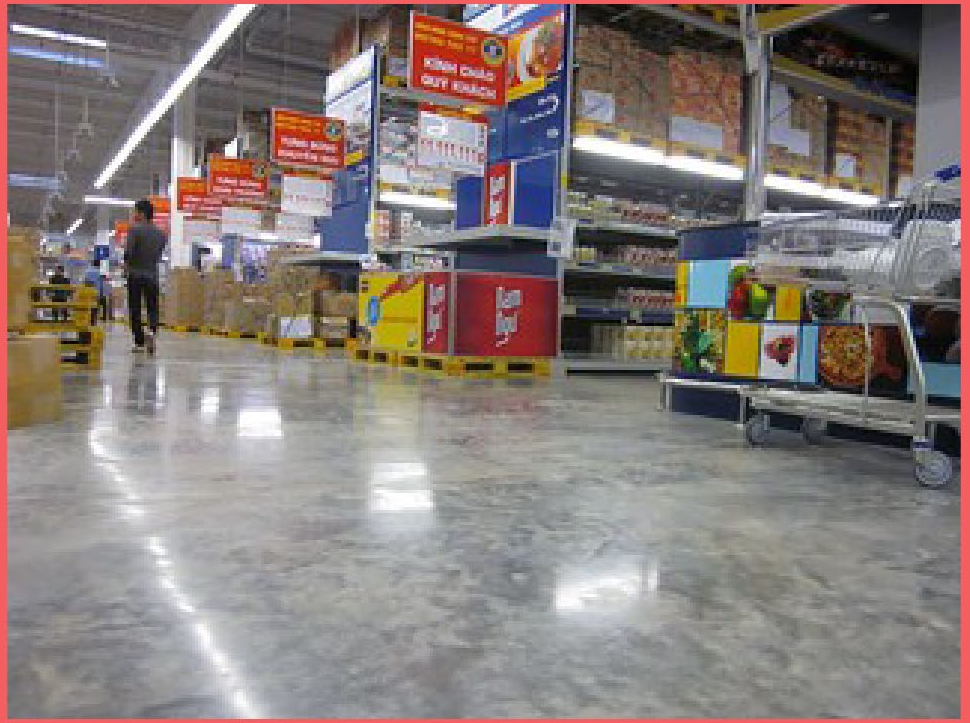
North Point Toyota | *Little Rock, AR*

Project Highlight:

DHL Hangar | *Leipzig, Germany*

Project Highlight:

Metro Store | *Vietnam*



Questions to Ask When Considering a Chemical Densifier

1. What kind of track record and reputation does the product have?
2. What kind of warranty is offered by the manufacturer? Is it in writing? Is it performance based?
3. Is the performance of the product quantified by independent testing?
4. What kind of field support is offered by the manufacturer?
5. Does the manufacturer specialize in chemical densification, or is it just a sideline?
6. How long has the manufacturer been in business?
7. How long has the product been around?
8. Can the manufacturer provide project references?
9. Does the product chemically densify the surface, or just “plug” the pores with solids?
10. How old are the floors still in service?
11. Are there floors still in service that validate the duration of the warranty?

Summary and Conclusion

- Chemical densifiers can enhance the durability and appearance of concrete floors by permanently sealing, hardening, and dustproofing.
- Rather than coating the surface, they work by means of chemical densification.
- These products can sometimes be used to remediate floors that have poor surface integrity.
- These products are a proven alternative to coatings on industrial floors.
- They are architecturally specified.
- They are typically spray applied, allowed to soak in, then flushed off with water.
- Hardening and dustproofing properties are immediate.
- Seal and sheen are delayed, but can be accelerated.
- They can be successfully used with other concrete technologies.
- They must be properly maintained for optimum performance.
- Not all cemical densifiers are the same in terms of their performance.