AIA Presentation CDI03
Drafting and Understanding of Densified Concrete

Slide 1 Introduction and explanation of AIA CE credit.

Slide 2 Course Description. This course will provide an understanding of the benefits and limitations of chemically densified and hardened concrete. It also includes a discussion on how chemical densifiers work, how they are specified, and in which types of buildings they are most appropriate. It also includes information on the environmentally friendly properties of chemical densifiers, and how they promote worker safety. Information on cost and long-term maintenance is also reviewed.

Slide 3 Learning Objectives. Upon completion of this course, the design professional will be able to:

1. Explain the densifying process and differentiate it from traditional floor coatings
2. Understand the properties of chemical densifiers, and how they work.
3. Differentiate among methods of densifying.
4. Identify the sustainable attributes of concrete in terms of materials, indoor air quality, and energy savings and how this can contribute to earning LEED certification
5. Identify the benefits of densified concrete floors in terms of design, maintenance, energy savings, and occupant health.

Slide 4 What is concrete? Concrete is a mixture of cements (11%) course aggregate(41%), sand (26%), water (16%) and naturally entrapped air (2%) (Additives may be included in the mix design to enhance certain properties)
In this presentation focus will be on the most standard flooring Mix Design – ASTM C150 with Type I for Portland cement. It is important to be aware of all ramifications of including admixtures in a mix when densifying concrete
Admixture benefits range from improving strength, workability and cure time to reducing water requirements.
For denisfied concrete, it is important not to add too much fly ash. Normally, fly ash should account for no more than 20% of total cementitious value by weight.

Slide 5 The basics of concrete hydration. When water is added to the cement mix the C3S (Tricalcium Silicate) hydrates for approximately 3 days and creates Calcium Silicate Hydrate (CSH). Tri calcium silicate accounts for the early strength of the concrete. The CSH provides the “cementing” action between the sands and aggregates to form concrete. Starting approximately 7 days following the placement, the C2S begins to react, and will continue to do so for many months. It also creates CSH. Dicalcium silicate accounts for the long-term strength of the concrete. At approximately 28 days, 95% of the hydration has occurred.

Slide 6 Challenges from poor finishing and protection. Chemical densifiers can be used on new or existing concrete. On existing concrete, however, the floor surface need to be properly prepared before a chemical densifier can be used. Here we see the challenges that are presented when coatings and mastics are still present. The residue needs to be stripped off or otherwise removed, and the floor needs to be brought to the point where it is clean, bare concrete. Chemical denisfiers have to be able to penetrate the surface so they can react. If there is anything on the floor that prevents penetration, then the results will be less than optimum. Surface preparation depends entirely on what is on the surface of the floor. There are different guidelines, procedures, and products to use, depending on whether the floor is covered with paint, glue, acrylic, urethane, epoxy, or just dirt and grime.

Slide 7 Limitations of Coatings and Coverings. In the past, coatings have been used to compensate for limitations of concrete. However, coatings create an expensive on-going maintenance program and are affected by vapor drive.
You experience: Scratching, peeling, chipping, bonding affected by moisture, tire marking, high cost, environmental concerns. Some coatings are useful for very specific purposes, like killing bacteria, or dissipating static charges. No coatings, however, will provide permanent results. Over the life of a floor, they have to reapplied many times. Each reapplication involves down time, material, and labor.

Slide 8 The shortfalls of concrete hydration and the need of chemical densifiers. 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. Notice that the concrete on the right is more dense, with fewer voids. This is the results of crystalline propagation. Note the tightness and uniformity of the cured, densified concrete.

Slide 9 What is densified concrete? Densified concrete is concrete that has been chemically altered by means of inorganic chemical reactions. The properties of a concrete floor treated with a chemical densifier are that the surface is much harder and resistant to abrasion, the floor is much easier to clean because it is more dense, and the concrete is free of calcium hydroxide that is the source of concrete dust. On hard, steel-troweled concrete, chemical densifiers provide the added benefit of a permanent and attractive sheen, and well as a significant reduction in tire marking from forklifts. These properties accrue in the top, or finished cap of a concrete floor, to a depth an 1/8th to a 1/16th of an inch.

Slide 10 How concrete densifiers work. As the densifier penetrates into the floor surface, it is drawn down into the floor through capillary action. It reacts with calcium hydroxide to form additional calcium silicate hydrates, or CSH, which are the primary bonding agent with the concrete. Some higher-end denisfiers also react on another level. That is, they react with existing CSH, which occurs randomly, and through oxygen bonding, the restack, or repolymerize the CSH into ordered structures. This adds to the strength and stability of the concrete.

Slide 11 Benefits of densified concrete. Chemical denisfiers provide permanent results because they do not leave a film or membrane on the surface of the concrete. Rather, they chemically densify the concrete itself by means of inorganic chemistry. The result is a floor that is resistant to abrasion, free of dust, and very easy to clean. These products do not typically need to be reapplied. The more a treated floor is exposed to traffic and cleaning, the better it looks over time.

Slide 12 Limitations of densified concrete.

Acid resistance – Concrete treated with a chemical densifier is still concrete. It is harder and more dense, but it is not resistant to acid attack.

Salt attack- Heavy concentrations of salt will also attack a floor treated with a chemical denisifier. Floors with regular exposure to road salts, for example, should be cleaned on a regular basis so that the salt is not allowed to accumulate in the surface.

Since chemical densifiers are not coatings, they do not cover blemishes or imperfections in the floor surface.

Not elastomeric – It will not span cracks.

Will not hide variations in the concrete color.

Slide 13 Where are concrete densifiers used? Chemical denisfiers are used in a variety of facilities. Main markets for this category of products are retail facilities with exposed concrete floors, industrial facilities like warehouses and distribution centers, manufacturing plants, and exhibit halls inside of conventions centers. Other markets include correctional facilities, like jails and prisons, parking decks, and data centers.

Slide 14. Imparting a sheen on interior slabs. Chemical denisfiers are usually applied to hard, steel-troweled concrete floors. On tightly compacted surfaces, these products can provide floors that are resistant to abrasion, easy to clean, and free of dust. They also develop a permanent and attractive sheen with traffic and cleaning, once the facility is operating. If an early sheen is desired, these floor surfaces can be burnished with a high-RPM buffing machine and an abrasive medium like a black pad or sandpaper. An early sheen can also be developed by scrubbing the floor repeatedly with an auto scrubber and medium-aggressive nylon brushes.

Slide 15 Silicates vs. siliconates.
Both silicate and siliconate denisfiers are used to treat concrete floors. Silicates are recommended because of their complete inorganic chemistry, and stronger chemical reaction.

Siliconates may be slightly more resistant to water penetration in the early months, but not over the long term. They are also partially organic, and cannot create the same kinds of crystals as silicate molecules, which have four oxygen sites. Siliconates tend to oxidize over time, and they also wear off when exposed to traffic.

Both types of products are spray-applied at 200 square feet per gallon. They are allowed to dwell on the surface for about 30 mintues, during which they are broomed to aid penetration into the surface. After a minimum of 30 minutes of dwell time, they are flushed very thoroughly from the surface with copious amounts of water. Surface should be broomed during flushing to loosen an excess material. Spent material and flush water are then squeegeed off the surface. Flushing and removal can also be automated with a floor scrubbing machine.

Slide 16. Comparison of silicates vs. colloidal silica. Standard silicate-based most commonly use salts of sodium, potassium or lithium. During the chemical interaction the silicate reacts with calcium hydroxide to form addition calcium silicate hydrates, or CSH, which is the main bonding agent in concrete. are worked in with a broom in order to break surface tension and penetrate pores
Main characteristics of this chemical reaction are that it:

Increases the abrasion resistance of the concrete surface
Eliminates dust coming from the floor.
Increases the density of the surface, making it easier to clean.
Allows the floor to develop a permanent and attractive sheen.

Any silicate-based densifier will be beneficial to a concrete floor as long as :

It is applied with a brooming action that ensures penetration within the pores
That it is applied with a sufficient amount of densifier to provide adequate coverage and penetration, ensuring a complete reaction.

Colloidal silica does not attach itself to a sodium, potassium or lithium to be carried into the concrete
Colloidal silica is a nearly pure version of silica sand, or simple silicon dioxide.
Colloidal silica is generally recommended by the manufacturers to be applied at 400-500 sfpg.

Main characteristics of this process are:

Attaches itself to the concrete, as opposed to having a chemical reaction.
Is applied topically with a microfiber pad, and is allowed to dry on the surface.
It does not have the ability to create a crystallization which will grow and close the pores and increase repellency

Slide 17 Where do you specify densified concrete? Chemical densifiers are normally called out in CSI Division 3, Concrete. Typically they are specified under 033000, Part 2, Products or Materials, Flooring Treatments, Seal or Hardening Compounds. Sometimes, however, they are specified in Divison 9 under Section 96100.

Slide 18 Why do you specify densified concrete? Concrete floors are inherently dusty and are prone to wear in traffic lanes. Densifiers harden the floor surface so it begins to shine, rather than erode, with traffic.
Densifiers also make it much more difficult to lay down tire marks. If tire marks do occur, they are much easier to remove. Through an ongoing process of chemical densification, these products also make the floors much easier to clean. With regular maintenance stains become less and less noticeable. These products also lock up calcium hydroxide, which normally causes dusting in concrete. On hard, steel-troweled surfaces, they also create a permanent and attractive sheen if the floor is cleaned on a regular basis. All of these results are permanent, at least with high-grade densifiers.

Slide 19 What is the difference between densified and polished concrete? Densified concrete has been treated with a liquid product that renders the floor surface easy to clean, free of dust, and resistant to abrasion. Densifiers are applied to hard, steel-troweled surfaces, but also to broomed surfaces or floated surfaces. They develop a sheen only when they are applied to smooth, dense concrete. The are appropriate primarily in the industrial and commercial markets. The sheen on densified floors can be accelerated with pads, sandpaper, or scrubbing.

Polished concrete employs a system of a liquid hardener used in conjunction with diamonds to achieve much higher levels of sheen. Polished concrete floors are usually smaller, but they are used in a broader category of facilities, like schools, municipal buildings, offices buildings, and retail stores. Polished concrete can be used to achieve a very high gloss level, even a mirror finish. Because polished concrete employs diamonds, and involves several passes over the floor, it is much more expensive.

Slide 20 Coloring Densified Concrete. Densified concrete can be integrally colored as in this residence on the left. With integral color, there are no limitations to the color of the floor. The color is also throughout the entire slab, therefore, if the floor is ever damaged, it is easier to repair, without losing the original color, or having to blend in a color. Integral color is the most consistent and uniform option for coloring a concrete floor. Color can also be introduced into densified floor by means of colored dry shake hardeners, which are applied to the floor during floating and troweling. On existing concrete, color can be introduced using dyes or stains. Dyes generally provide more uniform coloration, while stains provide a more mottled appearance.

Slide 21 Sustainability and LEED. This is a Dr. Pepper/Snapple distribution center in Victorville, California. Chemically densified floor that contributed to a Silver LEED designation. Sustainability can be mean many different things, but in a construction and building environment like this, it refers to the longevity of the products used. Sustainable products are those that do not need to be replaced frequently. This concrete floor has been treated with a chemical densifier that carries a 20-year warranty. The floor is hard and dense enough that it does not need to be replaced at all. If this floor had a coating or a floor covering, that would not be the case. All of these products wear out, and are therefore not as sustainable as a hardened, densified concrete.

Slide 22 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.

Slide 23 Environmental Benefits of Chemical Densification. LEED assigns a point value to each of these credits, which encourages project teams to strive for increasingly sustainable buildings, while recognizing that some aspects of buildings (such as energy use) are more important than others (bicycle parking). At the end of the project, all the points are added together to determine the final certification level, from LEED Certified at 40 points, all the way up to LEED Platinum at 80 points – out of a 100 base-point system (110 total points, counting the 10 available bonus points).

Slide 24. Take the LEED Credit. Eliminates need to use floor temporary floor coverings or topical sealers
Does not have to be replaced, resurfaced or re-coated
Eliminates need to use adhesives (No emissions)
Supports no combustion
Easy to maintain, using only water and cleaner
Completely water-based. No volatile organic compounds.
Lasts for the life of the floor.
Promotes heating/cooling benefits from thermal mass of the floor. See next slide for specifics.

As we show potential credits available within each category you want to remember that these are " available" credits for which densified concrete can be a contributing factor, but not that densified concrete "gives" you the credits.

Exposed concrete flooring can enable effective use of the thermal mass properties of the concrete, helping to stabilize indoor temperatures throughout the year. This allows the space to remain thermally comfortable through a wider range of outdoor conditions, and reducing the energy needs to maintain comfort when heating and cooling is required. Effective use of thermal massing strategies can even allow the use of smaller heating and cooling systems, yielding first cost savings in addition to ongoing reductions in energy use.

Slide 25 Take the Leed Credit. Use of densified concrete flooring can breathe new life into existing concrete floors retained as part of a building reuse project (Option 1. Historic Building Reuse, Option 2. Renovation of Abandoned or Blighted Building, or Option 3. Building and Material Reuse), and extend their useful life.

Additionally, new construction projects pursuing this credit using a whole-building LCA (Option 4. Whole-Building Life-Cycle Assessment) may be able to take credit based on the improved life-cycle performance of densified concrete floors through an extended useful service life and improved performance.

Note the photo on the right compared with the same floor 12 years later, shown in the photo on the left. This is the kind of longevity that can be achieved by using floors that have been chemically hardened and densified.

Slide 26 Take the LEED credit. Concrete floors that contain no integral organic-based surface coatings, binders, or sealants are considered inherently non-emitting sources, and automatically comply with the Low-Emitting Materials credit requirements set forth by the United States Green Building Council. Most chemical densifiers are completely water-based, so they contain no Volatile Organic Compounds.

Slide 27 Take the LEED Credit. Projects using exposed concrete floors benefit from reduced temperature swings, and increased occupant comfort due to the thermal mass. In areas where concrete floors are exposed to the sun, the floor will absorb the heat, store it, and then release it slowly.

Slide 28 **Worker Safety.** When chemically densified concrete floors are exposed to traffic and cleaning, their appearance improves with time, especially in terms of gloss. When floors develop a sheen, they reflect more light, which promotes visibility and brightness in the work place. This in turn contributes to greater morale, productivity, and of course worker safety**.**

Slide 29. Work Safety. Inhaling dust from concrete can be harmful. Liquid densifiers can eliminate concrete floors as a source of dust, although some do this better than others. Calcium hydroxide, which normally causes concrete floors to dust, is locked up, and can no longer pass into the air. Dust from erosion is also halted because densifiers harden the floors to the point where they do not break down with traffic.

Slide 30. Maintenance of densified concrete floors. Floors should be cleaned regular with an auto scrubber.
Use medium-aggressive nylon brushes. Use a high pH detergent. Floors should normally be cleaned at least 3-4 times per week, if not daily. Regular cleaning prevents dirt from building up, and it also increases the sheen on the floor surface. Acids, hydroxides and sulfates, which are found in some cleaners, can cause the concrete to become dull. It is best to avoid these ingredients in floor cleaning products.

Slide 31. Proper maintenance Specifications. When discussing cleaners, the pH level of the cleaner is generally the first topic. It is extremely important to note that the most important relationship between the pH level of the cleaner is its relation to the pH of the floor surface. The concrete surface, after a period of curing and hydration is generally in a range from 9.5 to 10 pH. This pH level requires a cleaner with a pH of neutral or higher that is specifically formulated for concrete. A cleaner without these properties can damage the floor surface.

Slide 32. Cost per square foot of floor coverings. This chart, which was obtained through 3rd party sources, shows the true cost of many different flooring options over time, including coatings and floor coverings. On the bottom row of the chart, you can see that densified concrete is not only among the most durable options, but is by far the least expensive to maintain, both annually and over a period of 10 years.

Slide 33. Denisfied concrete used in airline hangars. Densified and hardened concrete can be used in a variety of industries and applications. This slide shows where densified concrete has been used in the aviation industry. Since hangars and manufacturing space are exposed to heavy traffic, densified concrete is a great choice in this industry. Pictured are a Delta Airlines hangar in Erlanger, KY, DHL Cargo in Leipzig, Germany, and Boeing Aircraft in Everett, Washington.

Slide 34. Densified concrete in a distribution center. Distribution centers are subjected to heavy forklift and foot traffic. Hardened, densified concrete is also a great choice for these facilities. The sheen and surface density of a good chemical densifier are seen in these photos of a distribution center done of Alberto Culver in Jonesboro, Arkansas.

Slide 35 Parking Decks. Multi-level parking structures also receive a lot of vehicular and foot traffic. This parking deck at Century City in downtown Los Angeles was treated with a leading chemical densifier back in the very early 1960s. The floor has developed a marbeline patina. Instead of eroding with traffic, it has developed an attractive sheen. Even after 60 years of use in a major urban area, the concrete is holding up extremely well.

Slide 36 Retail facilities. In retail facilities, concrete floors receive high levels of foot traffic, as well as traffic from shopping carts, forklifts, and pallet jacks. This Bunning's home improvement store in New Zealand is no exception. Even after years of use, this floor demonstrates so signs of wear of erosion. A good maintenance program keeps these floors clean and glossy.

Slide 37 Correctional. Jails, prisons, and penitentiaries all have a lot of exposed concrete. These facilities have also become an excellent market for chemical hardeners and densifiers. This jail in Saugus California shows no signs of wear or erosion even after many years of heavy foot traffic. It is evident that is floor is a hard, dense working surface with an attractive sheen and no dust. These results are permanent because they are achieved through inorganic chemical reactions. There is no organic film, coating, or membrane that can scratch, chip, or delaminate.

Slide 38. Conclusion This concludes our presentation on properties and benefits of chemical densifiers. We have discussed the properties of concrete, and how these products enhance the performance of concrete floors. We have reviewed how they work, how they are applied, their environmentally friendly properties, differences among and between different chemical densifiers, how they compare to coatings, and how they save money. We have also reviewed several case studies and examples of chemical densifiers in real-world settings. Thank you for your time and attention.