

MAINTENANCE AND PROTECTION OF CONCRETE FLOOR SLABS IN EXTREMELY HARSH, HEAVY-DUTY ENVIRONMENTS

BY DAVID FLAX

When it comes to the heavy-duty abuse of concrete floor slabs, mines, foundries, tracked vehicle maintenance, and solid waste transfer stations have it all: impact and point loading, abrasion, thermal shock, chemical attack, and others. In this article, we will look at a proven, time-tested method to handle this abuse.

IMPACT AND POINT LOADING

Two systems have commonly been used to address this condition. The first is to put railroad rails in the floor slab upside down so that the flat part is facing up and is flush with the floor slab surface. It sounds like a great idea because it takes a lot to damage a railroad rail. The problem, however, is that the concrete infill between the rails doesn't bond to the rails, which means that for every rail

installed, two joints are created. As a result, chipping and spalling of the concrete infill occurs at the joints from impact and point loads. Figure 1 shows an anode storage area in an Arizona copper mine. The copper anodes weigh hundreds of pounds each and forklifts are continuously placing a dozen or so of them at a time (none too gently) onto the slab. This constant impact causes inches of concrete spalling between the rails as seen at the top of Figure 1. As a side note, steel plates have also been tried instead of the rails, but they come with their own issues. One is that concrete joints around them chip and spall as described above. The other problem is that because they are not bonded on the bottom and the coefficient of thermal expansion for steel is so much higher than concrete, they buckle as temperatures rise. This problem is exacerbated if they are used outdoors. Because of these problems, rails and steel plates are no longer commonly used.

The second system to address impact and point loading on floor slabs is to use an iron aggregate topping. Such toppings have been in use for the better part of a century and are primarily comprised of small iron aggregate and chemical admixtures in a cementitious mortar. These toppings have 18,000 psi (124 MPa) compressive strength at 28 days and provide about 6 to 8 times the impact resistance of plain concrete. The LA Rattler test¹ in Figure 2 shows the dramatic improvement in impact resistance with iron aggregate. Figure 1 shows an iron aggregate topping being used to replace the damaged and deteriorated concrete between steel rails. More than a decade later, this repair is still functioning beautifully.

Figure 3 shows a tracked vehicle maintenance bay. The damage shown on the left in this figure is primarily from impact and point loading, but also



Fig. 1: The problem with railroad rails and the solution with iron aggregate topping

from abrasion, caused by a typical tracked vehicle (upper right in figure). To repair the damage, an iron aggregate topping was placed (lower right in figure) at a minimum 1 in (25 mm) thick, using proper surface preparation and keyed edges at the perimeter of the repair area. This repair was completed over four years ago and it still looks almost like new.

ABRASION

In most cases, the abuse of the floor slab is not limited to just one thing. For instance, the same monstrous tracked vehicle in a maintenance bay will damage the floor with high point loads of the steel tracks and impact from dropped parts and tools, but also from abrasion. When tracked vehicles move straight forward or back, there is not a lot of abrasion, but their steel tracks grind on the concrete surface causing tremendous abrasion when they turn. The test apparatus for ASTM C779², “Standard Test Method for Abrasion Resistance of Horizontal Concrete Surfaces” is shown in Figure 4. For the test, steel disks are loaded and pressed down against the sample, and then rotated for an hour, which wears a donut-shaped impression into the surface. The depth of the impression is measured as relative abrasion resistance.

The chart in Figure 4 shows results of ASTM C779² testing where plain 4,000 psi (28 MPa) concrete was the control and assigned a value of 100, and

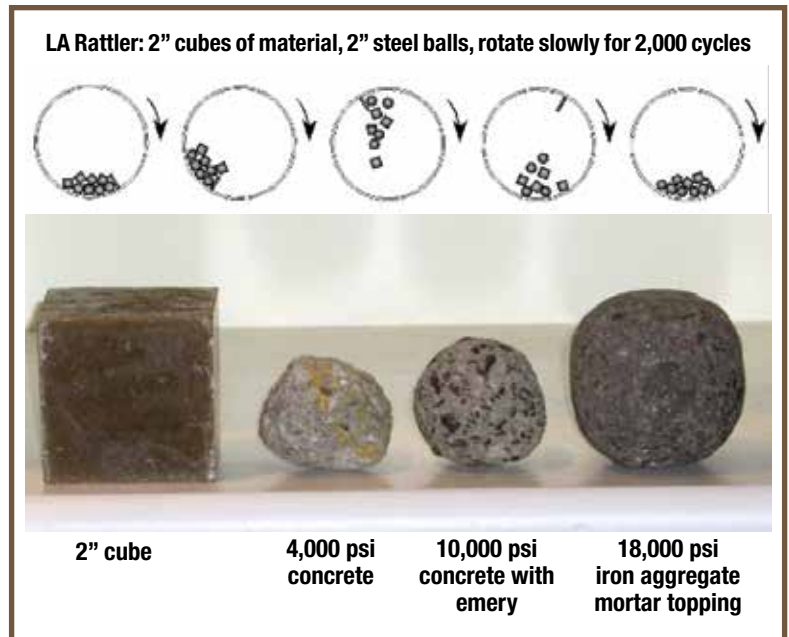


Fig. 2: Iron aggregate dramatically increases impact resistance



Fig. 3: Tracked vehicle maintenance bay and iron aggregate topping

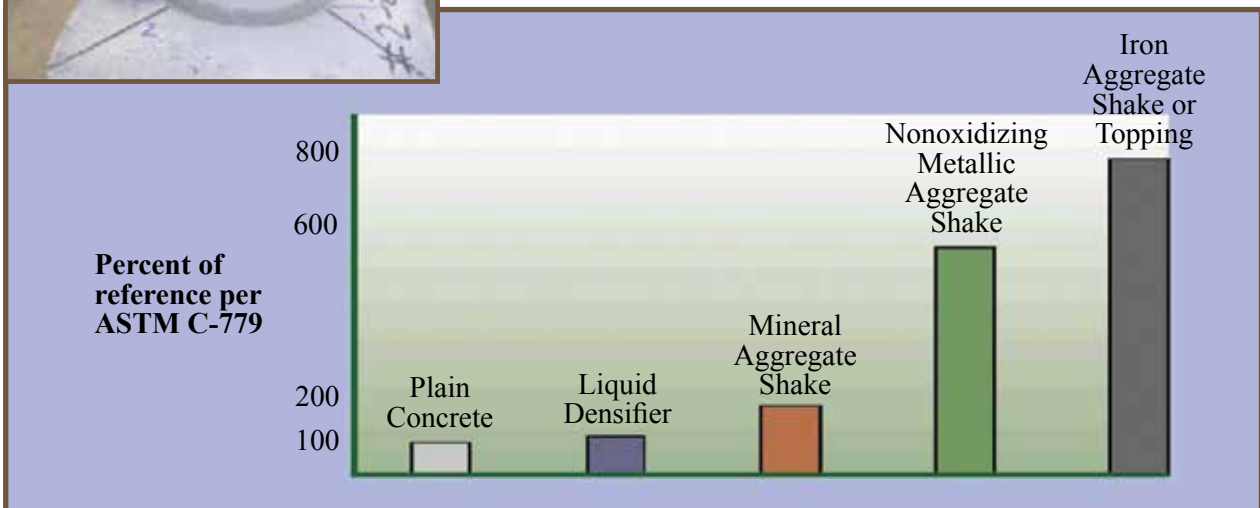


Fig. 4: Iron aggregate dramatically increases abrasion resistance

other materials were compared to this control. Liquid densifiers provide a little extra abrasion resistance. Mineral aggregate dry shakes typically contain trap rock, quartz, or emery along with cement, chemical admixtures and sometimes color, tested at 200, twice the abrasion resistance of plain concrete. That is a substantial improvement that can be beneficial in big box stores, warehouses, rubber tired vehicle maintenance facilities, etc.; however, that is not good enough for the abuse we're talking about in this article. Non-oxidizing metallic aggregate products are at 600, six times the abrasion resistance of plain concrete, and have the advantage of the aggregate not rusting. The white, light reflective version is commonly used in bus maintenance garages and airplane hangars where the light reflectivity creates a brighter, safer working environment along with a great increase in abrasion resistance.

The winner at 800 is iron aggregate dry shakes and toppings at eight times the abrasion resistance of plain concrete. This means that in the time it takes to wear away 1/8 in (3 mm) of the iron aggregate material, 1 in (25 mm) of plain concrete would have worn away. Or, more likely, the plain concrete would have been repaired once or twice already. The abrasion resistance of the iron aggregate is the same whether it is a thin dry shake or a minimal 1

in (25 mm) thick topping. The difference is that dry shakes are not great for high impact and point loads because they simply transfer the loads to the concrete below, and when the concrete fails, the dry shake goes with it.

Some readers are probably thinking that the iron aggregate will corrode and cause problems. Iron aggregate will rust, but it will not corrode. This is an important distinction. Because the iron aggregate is small, discontinuous, and surrounded by cement mortar, there cannot be corrosion. Corrosion requires continuous steel and corrosion currents such as we often see with reinforcing steel. As the cement paste wears from the surface, exposing some of the small iron aggregate, there may certainly be some rust on the surface if water is present, but it will not travel and cause corrosion or other issues. However, an orangey look on the surface of the iron aggregate will be noticeable, an aesthetic concern in some places, but not in the heavy-duty facilities with highly abused slabs that we are talking about here. In those applications, performance is all that really matters and aesthetics are not even a consideration.

THERMAL SHOCK

A prime example of thermal shock is shown in Figure 5, a steel foundry. The front-end loader carries molten steel to the molds, and along the way it spills some, badly deteriorating the floor slab from the thermal shock. The existing steel rails didn't do much good either. In fact, the rails made the situation worse because as the concrete disintegrated between them, the ride became rougher and more molten steel spilled, causing even more damage. Note that the steel chains on the tires of the front end loader shown in this figure are not for traction, but to prevent the rubber tires from catching fire as they roll through the spilled molten steel. These chains caused the concrete to deteriorate even more quickly. This pavement slab was repaired with an iron aggregate topping that was placed not only between the rails but a couple inches over the rails to bury them completely. This facility has operated for years since this repair and the topping is still doing great. In fact, they have performed the same type of repair at many of their other facilities.

CHEMICAL ATTACK

Solid waste transfer stations are a good example of the need for chemical resistant floor slabs. Figure 6 shows the process. A garbage truck dumps onto the tipping floor where there is plenty of impact as construction debris, cranks, etc., hit the floor slab (upper left in figure). A steel tracked vehicle drives over the trash (lower left in figure) to break



Fig. 5: Iron aggregate topping for thermal shock



Fig. 6: Solid waste transfer station tipping floor—impact and point loads, abrasion, and chemical attack

it up as small as possible so that more can fit into a container that will be hauled to the landfill. Obviously, there is plenty of point loading from this process. The next step is to use the blade to push the broken up garbage to the pit where it falls into a container to be hauled away. Abrasion galore in this process. The photo on the right in Figure 6 shows an even more aggressive piece of equipment. Imagine the damage from those steel wheels as they crush the trash and then push it to the pit. And through all of this, the floor is being bathed in chemicals as the bottles and containers in the trash are crushed and broken, such as restaurant food wastes, sulfuric acid, citric acid, chlorine, paint thinner, cleaning compounds, detergents, solvents, salt, cola, beer, etc.

The key to minimizing the chemical attack of concrete is to keep the chemicals on the surface, rather than letting them soak into the concrete. In military terms, we could say it is easier to defend a frontal attack than a surround and conquer attack. The best way to determine the ability of a product to resist the penetration of liquids is ASTM C1202³, "Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration," also known as the rapid chloride permeability test. Iron aggregate topping material measures 314 coulombs by this test, which is considered "very low," so liquids tend to remain on the concrete floor surface.

CONCLUSION

Concrete floor slabs take a major beating from impact and point loading, abrasion, thermal shock, and chemical attack. For many decades, the iron aggregate product that we have been discussing here has successfully been resisting this abuse in

the harshest, most heavy-duty environments known—including mines, foundries, tracked vehicle maintenance, solid waste tipping floors, and other heavy-duty abusive facilities. If you need this kind of protection for your floor, iron aggregate toppings are the answer.

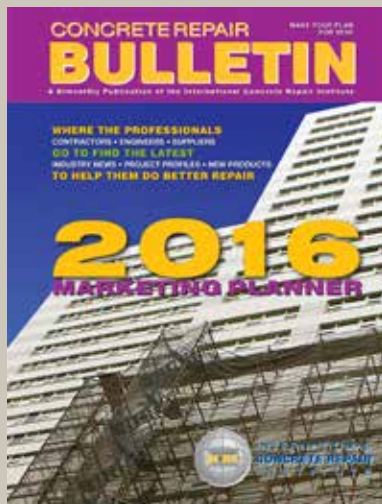
REFERENCES

1. ASTM C131/C131M, "Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregates by Abrasion and Impact in the Los Angeles Machine," ASTM International, West Conshohocken, PA, 2014, 5 pp.
2. ASTM C779/C779M, "Standard Test Method for Abrasion Resistance of Horizontal Concrete Surfaces," ASTM International, West Conshohocken, PA, 2012, 6 pp.
3. ASTM C1202, "Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration," ASTM International, West Conshohocken, PA, 2012, 7 pp.



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