Repairing industrial floors

If ignored, some floor defects significantly reduce the life of a floor. Others are more forgiving.

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Most industrial floors take a lot of abuse. They're subject to repeated heavy loads, hard wheel traffic, impact forces, abrasive wear, and sometimes aggressive chemicals. If floors haven't been properly designed and built, they may develop defects and wear out well before the expected design life. Most defects, however, can be corrected.

Repairing defects before too much damage has occurred prolongs the life of the floor. And costs are reasonable when repairs last. But for long-lasting repairs, band-aid approaches won't work. Repairs that work correct the cause of the defects as well as correcting the symptoms.

Most floor problems we've seen fall into one of four classes:

- Curling and curling-related distress
- Joint deterioration
- Cracking
- Excessive surface wear

Some of these problems require immediate action to keep them from growing worse and interfering with floor performance. Others may be more cosmetic than structural. Evaluate each before devising a repair strategy.

CURLING

Curling is one of the most common defects found in floors. The floor surface dries faster than concrete on the subgrade. As the surface dries, it shrinks, and the slab curls upward at joints, cracks, and edges.

With the new emphasis on flatness, there's a tendency to place wetter concrete that permits the extra straightening and finishing operations needed for flatter floors. But wetter concrete is more likely to shrink excessively and lead to greater curling.

Figure 1. Deflection measurements are taken as a loaded forklift crosses over a joint. Too much deflection means floor life will be shortened and maintenance costs will be high.

The bump created at joints where slabs have curled isn't always a problem. Even when there's as much as ¼ inch of curling, slow forklift traffic may not be affected if the forklift loads are heavy enough. But loss of subgrade support causes slab movement as forklifts pass over the joint. Joint edges start to chip and deteriorate. A crack may form parallel to the joint, and rocking of the slab section accelerates joint deterioration. Wires embedded in the concrete for automatic guidance systems may break. The speed with which joints deteriorate depends on how much movement takes place in the curled slab.

Detecting curling and assessing severity

Sometimes curling is so bad that operators hear a "kathunk" when their heavy forklift goes over the slab. Other times the movement can't be heard but can easily be felt by standing on the joint as a forklift passes over it. These methods for detecting curling are crude but show that a problem exists.

We precisely measure movement at

Figure 2. Drilled cores give information about floor thickness, height of wire mesh, and location of delaminations.

Figure 3. Undersealing grout appearing at joint edges shows that voids under the slab have been filled.

a joint or crack to assess the severity of curling. With a modified Benkelman beam, commonly used to measure pavement deflections, or with dial indicators mounted on a stand, movements can be measured to the nearest 0.001 inch (Figure 1). We then categorize the potential for distress based on differential movement from one side of the joint to the other:

- Movements of 0 to 0.005 inch indicate excellent joint performance and little curling.
- Movements of 0.005 to 0.010 inch indicate acceptable joint performance and tolerable curling.
- Movements of 0.010 to 0.017 inch are in the gray area. Repairs may improve floor performance but may not be cost-effective. Without repairs, the floor might deteriorate twice as fast but could still last 10 years without requiring major work.
- Movements of 0.017 to 0.030 inch are severe enough to cause deterioration that's three to four times as fast as normal. Problems such as joint deterioration and guidance wire breaking could occur within 2 years.
- We've measured joint movements of 0.05 to 0.10 inch under forklift traffic. Joint deterioration is unavoidable when the concrete deflects this much. It's only a matter of time before the floor fails.

Coupling the movement measurements with weight, amount, and type of traffic determines what repairs are needed.

Repair methods

Restoring subgrade support is the first step needed in correcting curling problems. Undersealing the floor with a cementitious nonshrink grout fills voids beneath the curled edges. To do this, our crews make a series of holes on each side of the joint or crack where curling has occurred. The holes are typically 9 to 18 inches from the joint and 2 to 4 feet apart. Although the holes can be made with a rock drill, we prefer a core drill. Each hole costs about $2.00 more, but core drilling has several advantages.

Core drilling eliminates dust. This is particularly important in plants where dust could damage equipment. The dust from a rock drill can also block entrance to voids we want to fill with grout.

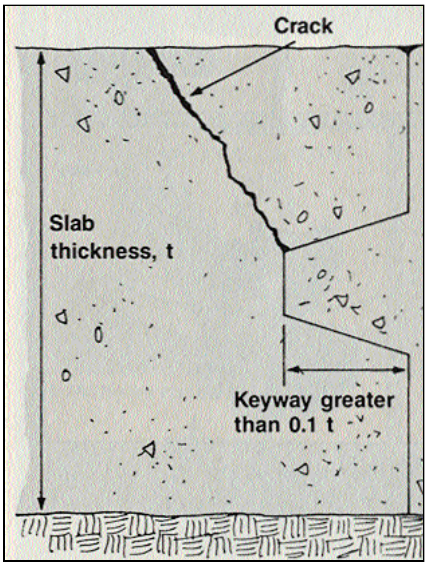

Figure 4. A keyway that's too large may cause slab cracking above the female side of the keyway.

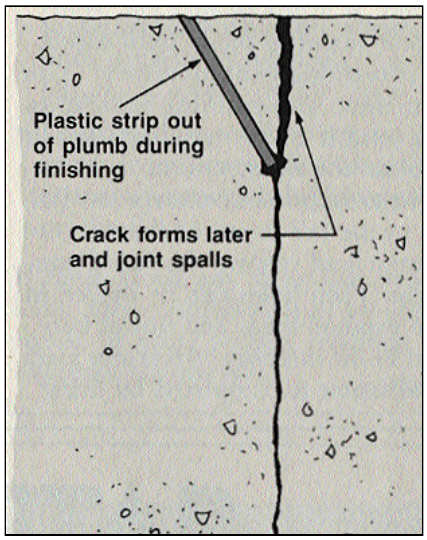

Figure 5. Crack-inducing plastic strips used at joints may not remain vertical during finishing. Then a lip is formed at the joint, later breaking under traffic.

Examining the core can give valuable information about why a floor failed (Figure 2). Variations in core lengths show how floor thickness varies within the area drilled. If the core drill cuts through wire mesh, the core shows height of the mesh in the floor. And we sometimes find evidence of floor delamination by examining the cores.

It's also easier to patch holes drilled with a core drill. There's less spalling at the edge of the hole and the patches look neater and last longer if patching material doesn't have to be feathered.

Grout for undersealing is pumped into the core holes at low pressure, usually less than 10 psi. It's a much thinner grout than the kind used for slabjacking and should not lift the slab. Ingredients include portland cement, fly ash, limestone dust, water, and a fluidifier or water-reducing agent. Workers measure grout fluidity with a flow cone to ensure that it's fluid enough to flow into the small voids that need to be filled.

Our crews judge undersealing progress by watching for grout to appear in adjacent core holes and come up through the joint (Figure 3). Once we're done pumping, we plug the core hole with a wooden plug and move to the next one. Our normal grout requires 24 hours of curing before the floor is ready for traffic, but by vary-

ing the grout composition we can reduce the curing time and get the floor back into service sooner.

Sometimes, undersealing is all that's needed to correct mild curling. Other times, the bump at the joint has to be removed by grinding. When forklifts carry light but bulky loads such as cereal boxes, a fairly small bump will cause the loads to shift. If that's the case, we grind concrete on each side of the joint after the undersealing has been done. If there's also deterioration at the crack or joint where a slab has curled, joint repair is also needed.

JOINT REPAIRS

Joint spalling is often a result of joint movement caused by curling. But there are other possible causes. In keyed construction joints, a keyway that's too large may cause slab cracking above the female side of the keyway as shown in Figure 4. If a crack-inducing plastic strip was used to form a control joint, the strip may not remain vertical. This creates a cantilevered lip that later breaks off (Figure 5).

Repair methods

To repair deteriorated joints, our crews make a sawcut at the edge of the deteriorated area (Figure 6), then remove all the cracked and crumbling concrete. Usually this is only a partial depth operation, but sometimes concrete is removed all the way to the subgrade or base course.

The type of forklift traffic determines how strong the repair material has to be for a partial-depth repair. Forklifts with hard wheels instead of pneumatic tires are hard on joint edges. When the joint edge is exposed to this kind of abuse, we use a closed-system epoxy mortar for repairs. Enough epoxy binder is added to a sand aggregate to completely fill air voids between particles. This material is usually installed to depths of ⅛ inch to 1¼ inches and gives excellent impact and wear resistance.

A groove cut in the partially hardened epoxy at the location of the old joint separates the edges of the abutting slabs so they move independently. Alternatively, the groove can be sawcut after the epoxy has cured. If a groove isn't cut, epoxy repair material binds slabs together preventing joint movement. This can cause slab cracking parallel to the joint if there's any further slab contraction or expansion.

In areas where concrete has failed to the full depth of the slab, we sawcut and remove the failed concrete. Then holes can be drilled in the exposed faces and dowel bars can be set in epoxy to transfer load. The repair is completed by using an accelerated-strength-gain concrete mix so floors can be ready for use within hours.

CRACKING

Cracking is a common floor problem but one that doesn't always require a repair solution. Uncontrolled cracks are unsightly and the effect on floor appearance bothers some owners. However, there's no repair method that completely hides cracks. Some repairs make them even more apparent. Repair methods that require routing the crack also increase the chances of spalling at the crack edges. Anytime a crack is widened, more area is exposed to hard wheel traffic.

Isolated shrinkage cracks may not require repairs. If they aren't too wide (less than 0.04 inch), there's still enough aggregate interlock to transfer loads across the cracks. In that case we recommend doing nothing with the cracks unless edge spalling has already started. If the slab is structurally reinforced, the rebar should hold cracks together. If a plain concrete slab contains wire mesh or temperature steel, and cores show that the steel isn't laying in the subgrade, the cracks aren't likely to open too much.

Repair methods

Sealing may be all that's needed for some crack repairs. Cracks are objectionable in food processing plants, for instance, because they can harbor bacteria. A floor coating may help to keep the cracks clean but will seldom seal the crack entirely. To seal cracks, a flexible sealant works best when further crack movement is expected.

If there's excessive cracking or evidence of settlement and faulting at the cracks, we recommend first finding out why the settlement occurred. A soft base or subgrade is responsible for many cracking problems we investigate. Poorly compacted soils, soil shrinkage, or poor drainage are possible causes.

We have some simple but effective tests that help us spot subgrade problems. We first core drill 2-inch-diameter holes in the floor. Then we do a blow count by driving a #6 rebar into the subgrade with a 16-pound sledge hammer, counting the number of blows to drive it the first 6 inches, second 6 inches, and so on to refusal. We drill at least one hole in the center of a slab where the concrete appears to be firmly seated and drill other holes near joints or in cracked areas showing signs of faulting. Comparing the blow counts tells us where areas with low bearing capacity are located.

We also pour 5 gallons of water down the holes and measure the time it takes for the water to flush down. In a well-seated slab it takes a long time for the water to run underneath the slab. But if there are voids beneath the slab, water runs out quickly.

If the slab has settled, slabjacking often corrects the problem without requiring any further work. As the slab is raised, some cracks close tightly enough to prevent spalling under traffic. Others open wider but still may be narrow enough to not affect floor performance. If there has already been some chipping and raveling at the crack, or if it's 1/8 inch wide or more, crack filling might be needed.

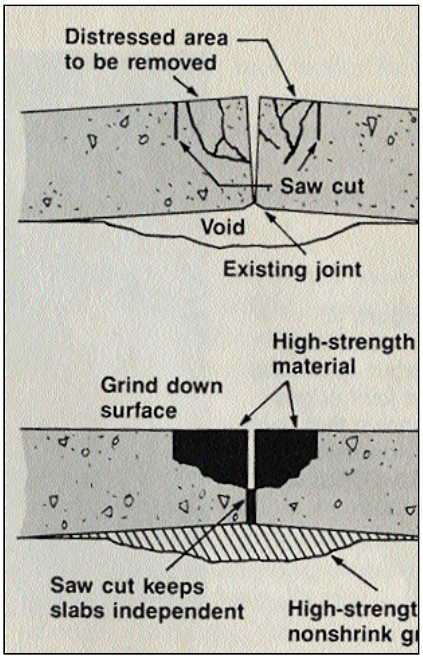

Figure 6. To repair joints, sawcut the edge of the deteriorated area and remove the damaged concrete. Epoxy mortar is a durable repair material.

Figure 7. Coatings won't fill in eroded or badly spalled areas. A topping or overlay is needed.

For ⅛-inch or wider cracks, we've done some crack filling with an air-operated caulking gun. After cleaning the crack with compressed air, we use a two-component flexible epoxy with a long pot life and apply it through a 1/16-inch orifice at the end of the nozzle. Epoxy usually has to be added several times before the crack is full.

For some floors, cracks may have to be repaired by epoxy injection. However, if subgrade support has been reestablished by either undersealing or slabjacking, it's not usually necessary to bond the slab back together for structural reasons. Injection might be needed if cracks must be filled to keep out moisture, harmful chemicals, or other contaminants.

EXCESSIVE FLOOR WEAR

Floor wear can take several forms:

- Dusting caused by construction defects such as too wet concrete, carbonation, or poor curing
- Deeper wear caused by abrasive materials under forklift wheels or by aggressive chemicals or molten metal spilled on the floor
- Deep spalls caused by impact forces from heavy objects such as metal castings being dropped on the floor

If there aren't any structural problems, these conditions can be corrected by using sealers, coatings, toppings, or overlays.

Repair methods

Choosing the best repair method requires the owner to decide how much to spend and how long the repair has to last. Dusting can sometimes be stopped by simply applying a water-based sealer. This is a low-cost solution but it may not last long. The sealer penetrates, leaving only a thin, relatively weak film on the concrete surface. It might have to be reapplied every 6 months even under moderate traffic. We sometimes suggest putting down a test application of several materials in a high-traffic area of the floor. Then the owner can observe the sealed area for a time and evaluate performance.

The next step up in both longevity and cost is a coating placed to a thickness of 10 to 40 mils. Epoxies and urethanes are two commonly used coating materials. Two-component versions of either material have good hardness and chemical resistance but aren't as easy to apply as the one-component products. Urethanes are more resilient than epoxies and are less likely to chip. But they may not bond as well to the concrete floor. An epoxy primer can be used to improve adhesion.

Coatings won't fill in eroded or spalled areas (Figure 7). Toppings that range from ⅛- to ⅜-inch thickness will fill these areas and with proper finishing leave a smooth-surfaced repair. Self-leveling cementitious or epoxy toppings can be used, but be aware that none of these products is truly self-leveling. Some finishing skill is needed to produce a flat surface.

When a superflat surface is needed, we recommend applying a thin-bonded concrete overlay with a minimum thickness of 1¼ inches. This material can be finished to the close tolerances required for floors in high-rack warehouses but the cost is higher than for other surface repair methods.

For any repair that requires a coating, topping, or overlay, surface preparation is a key step. Most coating or topping failures are caused by poor preparation methods. We prefer to shotblast surfaces before coating them, but some contractors use chemical cleaning methods. Whichever method is used must remove all dirt, oil, chemicals, and weak concrete to ensure a good bond.

LASTING REPAIRS SAVE MONEY IN THE LONG RUN

One of the biggest problems we have is convincing the owner that root causes of floor problems have to be corrected. Some floor defects such as random shrinkage cracks can be left as is. Some surface problems can be covered with a coating or topping that will prolong the life of the floor and is much cheaper than floor replacement. But if floor defects that originate in the subgrade or base are simply covered up, the repairs won't last. The most economical repair method is the one that corrects the cause, even though the initial cost of the repairs may be higher.

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