Before You Build...

HOW TO AVOID COMMON FLOOR PROBLEMS

20 Steps You Can Take to Avoid Common Floor Deficiencies

In any given year our staff will inspect several hundred industrial floor slabs, many of which have problems to some degree. While problems vary in severity, they are seldom unique. Rather, they tend to be the result of the same mistakes time and time again.

The purpose of this technical paper is to share our observations in the hope that you can avoid these common mistakes on your current or future projects.

PROBLEMS IN THE DESIGN PHASE

1. Loosely Drafted Construction Documents

When contractors review plans and specs they can soon determine the capabilities of the designer and "the tone" of the project. A tightly drafted floor spec and complete floor details will tell the contractor that the floor is of critical importance. Avoid wide open material and procedural specs that basically allow the contractor to design the floor. Show the proposed joint layout, provide complete jointing details, specify allowable concrete additives, list acceptable products by name, minimize the use of the broad term "or equal." In construction, the term "or equal" is often interpreted as "or cheaper."

By drafting tight construction documents you are not saying that you won't listen to a concrete contractor's suggestions, many of which may be excellent. You are simply making it incumbent upon him to fully justify each recommendation.

2. Specifying or Allowing Additives

There are numerous concrete additives on the market, all claiming wonderful benefits. But what is not always apparent are the possible side effects the additives cause. For example, some additives delay the appearance of bleed water, thus delaying the finishing. Others may allow more rapid slab shrinkage, adding to curl problems.

Concrete additives can be helpful in achieving certain results (better finishing characteristics, etc.), but they should never be considered a substitute for a good basic mix design, proper placement by qualified contractors and adequate curing.

3. Minimize Shrinkage and Curl

Excessive (or rapid) shrinkage and slab edge curl can affect even the best designed floor. You can minimize shrinkage and curl by paying attention to the proper mix design.

a. Use the largest aggregate possible. Coarse aggregate occupies space without shrinking.

b. Water and cement both add significantly to shrinkage and curl. Insist upon a low water/cement ratio from the ready mix supplier.

c. Avoid high strength concrete mixes. Concrete strength is measured by compressive strength, and floors seldom, if ever, fail in compression. To achieve higher strengths you must use more cement, which adds to shrinkage and curl.

Many in the industry equate low slump with low shrinkage. This is true to a degree, but aggregate size and water/cement ratio are likely of greater importance.

4. Joint Spacing; Closer, More Square

The trend over the past decade has been to make slab panels larger, and thus have fewer joints. The reasons most commonly cited are:

a. It costs money to create and fill more joints.

b. In theory, it costs the owner more in floor maintenance if he has more joints.

c. Designers are extending the spacing between columns, which in turn tends to extend joint spacing.

These reasons are all valid, but we often fail to consider the effect of normal shrinkage on joints. As a rule of thumb, a typical 6" thick slab may shrink 1/8" in every 20'. Thus, a 1/8" cut every 20' will eventually open to 1/4". This means the joint has opened 100%. Consider what this means to a semi-rigid epoxy joint filler that may be able to accommodate only 5-10% expansion. By bringing your joints closer together you minimize the degree of filler-to-concrete separation that will occur.

Now consider random cracking. The larger the slab panel, the greater the potential for random cracking. It all comes down to a choice between joints or cracks, and joints are definitely less expensive than cracks. To cut and properly fill a joint will cost approximately $2-$2.50/lf, and you have an aesthetically pleasing floor. And joints are relatively easy to maintain. Random cracks, on the other hand, are unsightly and will cost $3-$5/lf to cut out (chase) and fill. And cracks are much more difficult and expensive to maintain than joints.

Now lets talk about the panel shape. Concrete shrinkage causes an even stress build-up across the slab. Thus, a 15'x15' panel shrinks equally across all directions. But if you have a 15'x20' panel, the stress will be greater across the 20' dimension.

Cracking of Oversized Panels

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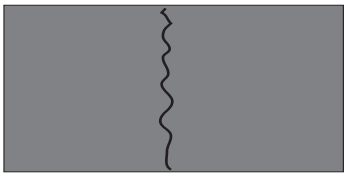
It is quite likely a crack will occur dividing the 20′ span into two 10′ segments.

The bottom line is this: you have a choice between joints or cracks. You can reduce the effects of cracking by heavily reinforcing the slab. But reinforcing does not prevent cracks...it merely holds them tight at best. And reinforcing costs money. You need to consider the trade-offs carefully in your design.

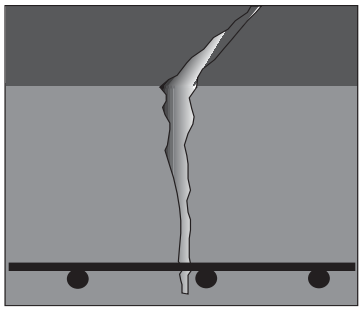


Cracking of Irregular Panels

5. The Myths of Mesh

The first myth about mesh is that it will prevent cracking. It doesn't. It merely holds the cracks tight, *if* properly placed. The second myth is that mesh adds compressive strength to the slab, if properly placed. It doesn't. The third is that the mesh can be properly placed, as in the top half of the slab. If you were to core 100 projects, it's almost a guarantee that you will find the mesh on the grade or in the bottom half of the slab about 90% of the time. In view of this, why specify mesh at all? If you need to reinforce the slab, consider using reinforcing bars chaired to the proper height.

One more point should be made about mesh. If it does end up in the bottom half of the slab, it may actually add to both the frequency of cracking and the surface width of your cracks. And you paid extra for this.



Effects of Mesh Near Bottom

6. Dowel the Construction Joints

The ideal floor is one where all slab panels work together in unison as traffic passes over the joints. Construction joints create a total separation between panels, thus creating the potential for one panel to deflect under load while the adjacent panel stays up, resulting in joint edge spalling. The use of smooth dowels at construction joints can assure that both panels work together under load.

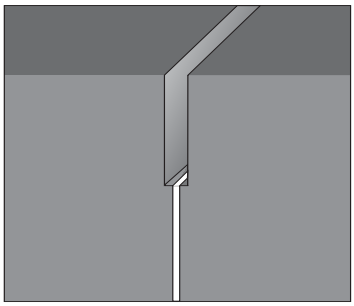
To be effective dowels must be properly spaced and aligned and greased on one end to allow for joint movement.

7. Construction Joints Should Be Saw Cut

Construction joints have two major disadvantages.

a. The edges may be inherently weak because they are finished less densely than the rest of the surface.
b. Unlike a saw cut joint, there is no base to support the eventual joint filler.

We recommend that all construction joints in traffic paths be saw cut to a depth of 1". Saw cutting removes (or at least reveals) weak edges and creates a base for the filler. Additionally, saw cut joints will look neater and stand up to traffic longer without maintenance.



Saw Cut Construction Joint

8. Don't Over-Specify Flatness

Some owners and designers specify higher flatness numbers than they really need. There are several disadvantages to this practice:

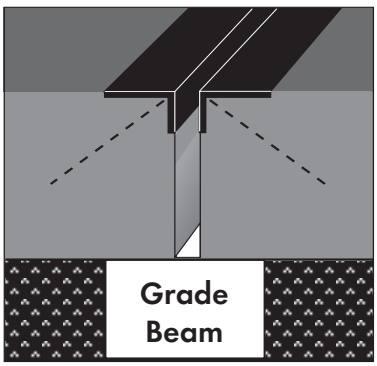
a. A higher flatness number will result in higher concrete bids
b. If the flatness number is too high, the concrete contractor assumes that flatness is the primary criteria for the floor. Durability must always be the primary criteria of any floor.

Before you specify a flatness number we suggest that an acceptable existing floor be tested. Many, if not most, conventional warehouse floors can get by with a F35-40. If no acceptable floor is available to measure, contact a flatness consultant such as FACE Consulting (1-800-FNUMBER) for advice and assistance.

9. Joints at Doorways Through Walls

Joints where two separate slabs meet at doorways, such as at fire walls or into separate storage rooms (coolers, etc.), are frequently found to be suffering severe spalling. Sometimes the cause is that this was a butted joint and never filled.

In some cases the designer used a premolded filler to isolate the two slabs. Both approaches are wrong and inappropriate. If hard wheeled vehicles will pass over this junction, an armored joint should be provided. The most durable armoring is usually a steel angle assembly.



Armored Joints at Doorways

10. Properly Specifying the Floor Joint Filling

Some owners and designers still tend to treat floor joint filling as an afterthought, something incidental to the actual floor. This thinking fails to recognize that;

a. Because joints are an interruption in the surface, joint filling must be considered as a vital link in the floor surface system.

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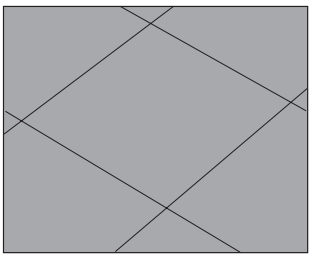
10. Specifying the Floor Joint Filling (Cont'd)

b. Each joint is a potential impact point for the wheels of material handling vehicles.

c. Since joints will continue to open for a year or two during the extended shrinkage period of the floor, joints are in effect the most vulnerable part of the floor surface.

Our literature contains extensive technical information on floor joint filling, so I won't duplicate that information here. But several critical points need to be reinforced;



Joints Are Part of the Floor Surface

a. Joint fillers should be specified in Section 03250, not 07900.

This helps make the distinction that floor joints are to be "filled," not "sealed."

b. To be effective as an edge protector, the filler must fill the entire saw-cut, taking advantage of the support offered by the base of the saw cut. Specify clearly that the filler must be installed full depth with no compressible backer rod allowed, and provide proper details in your structural drawings.

c. Do not merely specify "Product X or equal." By doing so you are tacitly implying that joint filling is not one of your major concerns. There are more than one hundred semi-rigid fillers on the market, with dramatic variables in their quality and cost. If you allow an unnamed "equal," you will likely end up with the cheapest filler, not the best filler for you floor.

d. The filler(s) you specify must match the operational demands of the floor. Fillers fall into two categories; heavy duty and moderate duty. If your facility will have heavy loads, hard (solid) wheels, or frequent traffic, specify a heavy duty filler by name.

When preparing your bid documents, remember this: the filling of joints with the most expensive product on the market will cost you $1.25 to $1.75/lf. The repair of a joint allowed to spall due to improper filler or filler installation will cost $3 - $10/lf., not to mention the downtime for repairs. Joint filling is the last place you want to cut corners.

PROBLEMS IN THE BIDDING PHASE

11. Pre-Qualify Your Concrete Contractors

With the introduction of equipment such as the Lazer Screed®* many new concrete contractors have emerged. But floor construction remains as much art as science, and there is no substitute for experience. We recommend that concrete contractors be pre-qualified. Ask them to identify a few projects that

11. Pre-Qualify Your Concrete Contractors (Cont'd)

are 4-5 years old, and talk to the owners. Your floor is too valuable to risk to an inexperienced contractor.

12. Hold a Pre-Bid Conference

Meet with your short-listed contractors before the bids are taken. Stress your demands for quality, discuss schedules, job conditions, availability of good aggregate, specs and drawings, etc. Listen to recommendations made, and make the contractors justify their reasons.

PROBLEMS IN THE CONSTRUCTION PHASE

13. Hold a Pre-Construction Conference

At least one week before the start of work hold a jobsite conference. Insist on the attendance of the owner, designer, GC/CM, concrete contractor, ready mix supplier, accessory suppliers (additives, joint fillers, etc.), the testing lab and any trades whose work might interfere with or affect the floor placement. This will be your last opportunity to discuss job conditions, mix design, schedules, pour sequence, light and ventilation, temperature, access, curing, etc. Raise all questions now rather than after the work starts.

14. Inspect the Finish Grade

A well compacted, even grade is critical. The base must have no hard or soft spots, no high or low points. Inconsistencies will cause sub-grade drag which will result in cracking. The best verification of adequate finished grade is to proof-roll it with a heavy vehicle such as a cement truck.

15. Start Curing Procedures Promptly

Once the finishing is complete, the curing process should begin immediately. Retention of moisture is critical to ensure complete cement hydration, which yields stronger and more durable concrete.

Our preference for curing is the use of a moisture retention sheet for at least seven days.

Uneven Grade Can Cause Cracking

We have seen the best experience with sheets having one plastic face and the opposite face of burlap or a synthetic absorptive material. The concrete should be re-misted whenever the sheet is temporarily removed (for cutting, etc.) or as dictated by conditions.

16. Cutting of Contraction (Control) Joints

The most difficult element in cutting is the timing. This is one prime example of the art/science equation. Cut too early and joint edges will ravel. Cut too late and the slab may already be cracking due to tensile stress brought about by shrinkage.

We are advocates of the new breed of early cut saws which are used within the first few hours after final finishing. There

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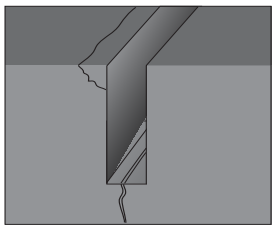
16. Cutting of Contraction (Control) Joints

are three critical things to remember in the cutting operation;

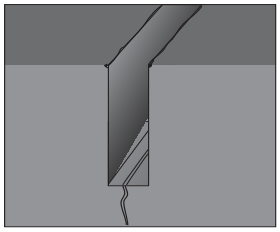
a. The timing should be such that the cut is clean, not disturbing the adjacent aggregate.

b. The blade should be appropriate for the aggregate it must cut through.

c. The base plate of the saw must be replaced in strict compliance with the saw manufacturer's instructions. Failure to comply can result in micro-fracturing of the joint edges.



Micro-Fracturing

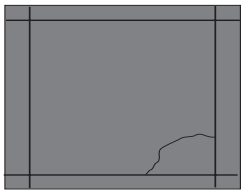


Joint Edge Ravel From Early Cutting

Some in the industry prefer to use the early-cut saws to relieve the slabs surface tension, then come back later and re-cut the joints with a conventional saw. This can be a good practice if the slab did not crack beneath the cut, or if there is evidence of micro-fracturing on the edges.

17. Avoid Premature Loading on Slabs

Concrete does not usually reach its optimum compressive strength until 14-28 days. It is always wise to avoid or at least minimize heavy loads (rack delivery, etc.) until the slab has reached adequate strength. If access must be granted, insist that material handling vehicles have pneumatic tires. All vehicles crossing the slab should be diapered.



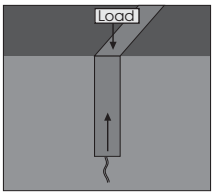
Cracking Caused by Crane Outrigger

In the case of tilt-up construction, the push for access is intense. If at all possible, keep ready-mix trucks and cranes off the floors and especially off panel corners.

18. Proper Filling of Floor Joints

Assuming your specs and details have been properly prepared, the next critical issue in joint filling is the timing. Concrete will have significant shrinkage for a period of 1-2 years. As shrinkage occurs, the joints grow wider. Thus, you should delay your joint filling until the last possible opportunity.

In this manner you will minimize the amount of filler-to-concrete separation that occurs. After timing, the most critical element in filling is the depth of the filler. As cited earlier, a filler is most supportive of loads when the filler itself is supported by the bottom of a saw cut.



Properly Filled, Functioning Joint

Our surveys indicate that more than 70% of all projects suffer cheating in the filler installation. Refer to our Tech Sheet T-7 ***Preventing/Detecting Deficient Joint Filler Installations*** for a complete explanation of why cheating occurs and how to prevent and detect it.

Another important issue is the finished profile of the filler. Since one goal in filling is to avoid impact points, a filler should be finished flush with the floor surface. This is best achieved by over-filling, allowing the filler to cure into a solid, then shaving the filler off flush with a razor.

19. Provide for Correction of Filler Separation

No matter how long you are able to defer your filler installation, filler-to-concrete separation will still occur. This is because a filler that is firm enough to support traffic cannot be flexible enough to accommodate significant joint opening.

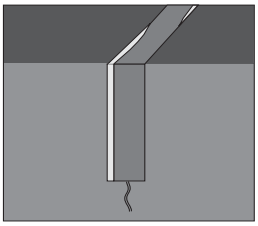
There are two basic means to provide correction of separation;

a. Provide in your specs a call-back provision, obligating the installer to return to the project six months after occupancy to refill all voids credit card width or greater.

or

b. Have the owner accept responsibility for refilling separation as part of his maintenance operations.

For further discussion of this subject and the refilling process read our technical sheet T5.



Joint Filler Separation

20. Use Common Sense in Crack Correction

There are very few slabs placed that do not have cracks. Hairline, occasional cracks need not necessarily be of concern, since aggregate interlock will keep the panel structurally sufficient. If numerous cracks occur, or if cracks are wider than hairline, an evaluation is called for.

One problem we frequently see is the practice of filling cracks with a structural epoxy, with the idea of welding the slab back together. This procedure is often done by pressure injecting epoxy into drilled port holes. The trouble comes in that the crack may still be active. If you weld an active crack, that the crack may still be active. If you weld an active crack, you will likely develop a new crack adjacent to the repaired one. Our advice is generally not to structurally weld any crack (or joint) if it can be avoided.

SUMMARY

Clearly, the twenty recommendations offered in this article won't prevent all floor problems. But they may help avoid very common and very preventable problems that occur over and over. We hope you find this article of value and further hope you will call or write us if we can help you in any way to achieve higher quality, more durable industrial floors.