By leaving building owners a description of floor properties and expected behavior, contractors can help to reduce callbacks and potential litigation

BY ARMAND H. GUSTAFERRO

Most of my clients for the past several years have been attorneys or parties involved in construction litigation. Many of the cases have dealt with industrial or commercial concrete floors on grade. I have long advocated that contractors, in conjunction with architects and engineers, furnish building owners with manuals detailing the expected behavior of concrete floors and offering advice for floor inspection, maintenance and repair. I believe this type of manual can reduce callbacks and help avoid litigation.

Listed here are some of the items that could be included in a comprehensive owner's manual on concrete floors.

Part 1. FLOOR DESCRIPTION

1.1 Subgrade/subbase. Describe the subgrade material, its moisture content when compacted and the degree of compaction. If a subbase was included, describe the material used and its degree of compaction. Also include the subgrade or subbase modulus based on measured values from plate tests or the California Bearing Ratio test, or on estimates from the subbase description or classification. Finally, include an estimate of total and differential settlement if one is available. Much of the information for this section will be found in a soils report provided by the geo-technical specialist for the project.

1.2 Vapor retarder. If a vapor retarder or vapor barrier was installed, give the type (low- or high-density polyethylene, fiber-reinforced paper or premolded membrane), manufacturer and thickness. Also say whether the vapor retarder or barrier is in contact with the concrete or separated from the concrete by a granular layer. If the latter, give the thickness and composition of the layer.

1.3 Slab thickness. Give the nominal floor thickness and the variations that should be expected. For example: “Nominal thickness is 5 inches. This means that the average thickness is 5 inches with a standard deviation of ___ inch.” Fill in the blank with the floor crew’s standard deviation based on data from similar floors the crew has placed.

1.4 Concrete mix. Give the mix proportions, including data on cement type, admixtures and aggregates. Give the nominal maximum size of the coarse aggregate. Also give concrete temperature, slump and air-content ranges.

1.5 Concrete strength. Give the average concrete compressive strength and the strength range from cylinder tests. Include the age at which the strengths were measured and whether the cylinders were cured in the lab or field.

1.6 Reinforcement. Include the reinforcing steel amount and location, such as #4 bars spaced at 16 inches in both directions and located 2 inches below the top surface.

1.7 Joint details. Include details from the project drawings, noting any modifications that were incorporated. Give the depth of sawed joints and the waiting period in hours after floor finishing before the joints were sawed.

1.8 Dates or period of placement. This can simply be the time period during which the floor was placed (such as July 7-25, 1998), or it can be a sketch of the floor giving the dates each section was cast.

1.9 Method and duration of curing. Give the typical time interval between completion of finishing and initiation of curing. If a curing compound was used, give the brand name and coverage rate in square feet per gallon (or square meters per liter). If another curing method was used, describe the method and its duration.

1.10 Joint filler. Indicate which joints were filled, when and how deep. Also give the brand name and manufacturer of the filler.

1.11 Flatness and levelness. If floors were measured for flatness and levelness, record the measurement method, results and elapsed time after placement at which the measurements were made.

1.12 Other relevant information. Describe any unique treatments the floor may have received, such as a protective sealer or a dry-shake hardener. Specify where the product was used and the application rate. Also give the brand name and manufacturer of the product. Specifically exclude from the report any elements you are not responsible for installing. For example: “Sump pumps in washout pits and related plumbing accessories are not described in this manual.”

Design loading information also is of use to the building owner and may protect you from future lawsuits if the floor is subjected to loadings higher than those for which it was designed. Floors may be designed for vehicle-axle loads, uniform loads within aisles, rack and post loads, or column and wall loads. Record these design loads, which can sometimes be found on the drawings or in the general notes for the drawings.

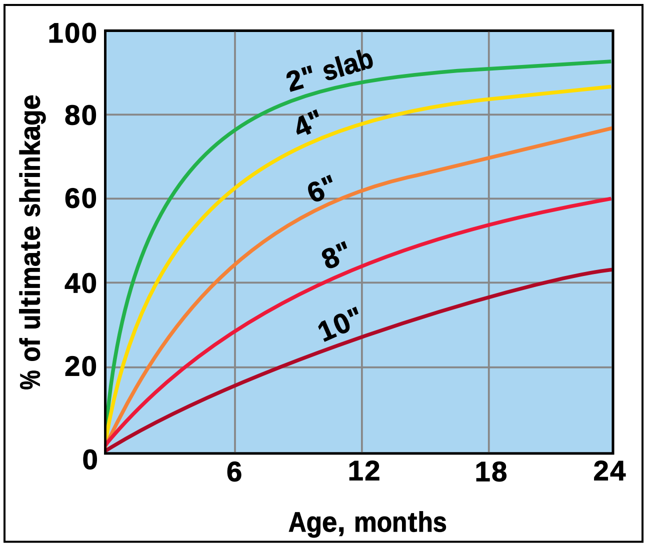

Figure 1. Thick floor slabs shrink more slowly than thin slabs. After a year, an 8-inch-thick floor slab may still not have reached 50% of its ultimate shrinkage.

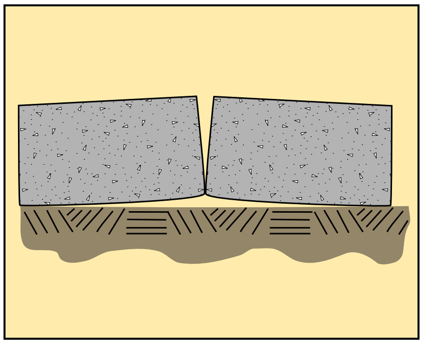

Figure 2. When a concrete slab surface dries faster from the top than the bottom, shrinkage causes the edges to curl upward. Curling usually is most noticeable where joints intersect.

Part 2. BEHAVIOR OF CONCRETE FLOORS

This section describes some of the common floor characteristics that owners notice. It might also include a disclaimer such as: “Even though we constructed this floor using generally accepted standards, and took precautions to minimize future problems, all concrete floors may eventually exhibit some random cracking and variations in flatness that are usually related to changes in moisture content.”

2.1 Shrinkage of concrete floors on grade. Explain that all concrete shrinks as it dries. Drying and shrinkage occur over a long period of time, with thick slabs shrinking more slowly than thin slabs. A copy of Figure 1 could be included.

2.2 Curling. In slabs on grade, the top portion of the slab shrinks more than the bottom. Thus edges or corners of the slab at joints or cracks

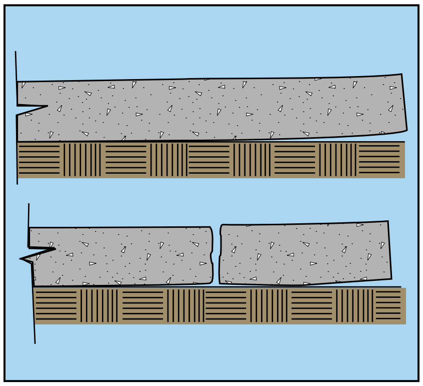

Figure 3. The weight of curled slab edges causes tensile stresses at the top of the slab. When these stresses exceed the concrete tensile strength, the slab cracks.

tend to curl upward. Explain that curling is a natural phenomenon that causes concrete surfaces at joints to be slightly higher than the rest of the floor, especially where joints intersect. A copy of Figure 2 could be included.

2.3 Differential settlement. Explain that floors may settle due to consolidation of the subgrade soil or the subbase. Differential settlement can cause cracking, faulting (differences in floor elevation at a crack or joint) or unlevel floors.

2.4 Cracking. Explain that both shrinkage and curling induce tensile stresses in the slab. Concrete is weak in tension so when the stress exceeds the tensile strength of concrete, the concrete cracks. A copy of Figure 3 could be included. To minimize such cracking, joints are incorporated in the floor to create planes of weakness where the cracks will occur. Nevertheless, some cracking should be expected, otherwise no reinforcement would be needed. Reinforcing steel is incorporated in slabs on grade to minimize crack widths and vertical displacement at cracks.

Part 3. PREPARATION FOR FLOOR COVERINGS

3.1 Removal of curing compound. Give instructions on curing-compound removal, or refer the owner to the manufacturer of the curing compound (include the manufacturer's address and telephone and fax numbers).

3.2 Drying time. Tell the owner that installers of moisture-sensitive floor coverings or coatings usually require floors to reach a water-vapor emission rate of 3 to 5 pounds per 1,000 square feet per 24 hours. As stated in section 2.1, however, floors dry slowly. Depending on the floor design, concrete properties and drying conditions, the time needed to reach required emission rates can range from a few to several months. Report test results for water-vapor emission, including the date of the test reading. A copy of Figure 4 could be included.

3.3 Surface pH. Flooring installers may also require a minimum pH for the concrete floor surface. Concrete generally has a pH of 11 to 12. As the floor surface reacts with atmospheric carbon dioxide, the pH decreases but seldom falls below 9. Thus, a surface pH requirement below 9 may not be attainable, even though some flooring installers require a lower pH. Report test results for pH, including the date of the test reading.

Part 4. ROUTINE MAINTENANCE

4.1 Joint maintenance. Explain that because concrete shrinks, joints widen with age (but at a diminishing rate). This can cause the joint filler to lose contact with one or both of the slab edges, reducing slab edge support. Therefore, tell the owner to delay filling the joints for as long as possible to minimize the separation of the filler from slab edges. If the filler separates from a slab edge by more than the width of a credit card, suggest pouring filler into the narrow void to re-establish contact. If the filler separates from both slab edges, instruct the owner to remove the filler and replace it with new filler.

Explain that at isolation joints, some differential settlement should be expected since isolation joints are designed to permit columns, floors and walls to settle independently. Without these joints, severe cracking of the floor or of the adjoining structural elements might occur.

4.2 Cleaning floors. Recommend that the owner use only cleaning materials specifically recommended for concrete floors. Acids and strong alkalies should not be used on concrete because they attack the concrete and will etch or even dissolve some of it. If lift trucks or other vehicles ride on the floor, suggest keeping the floor clean of hard, sharp items such as nails or metal fragments, which can become embedded in tires and gouge the concrete.

Part 5. REPAIRS

5.1 Routine inspection. Floors subject to severe wear should be inspected frequently. Conditions the owner should note and consider for repair include slab deflection at joints (curling or faulting), cracks, debonded joint filler, chipped joints, gouges and popouts, erosion, and delaminations.

5.2 Slab deflection at joints. Slab curling often results in a loss of subgrade support beneath the slab edges at joints. On floors carrying vehicular traffic, the slab edge can deflect when a vehicle approaches the joint. The vehicle then impacts the edge of the adjacent slab. This not only interferes with vehicle operation, it can chip the slab edges. Tell owners to stabilize edge movement before repairing chipped joints or cracks. Repair contractors can treat slab movement by undersealing the joint. The high surface can then be ground down using a terrazzo-type grinder.

5.3 Cracks. Explain that cracks thinner than a credit card and with no edge chipping usually can be left unrepaired, unless, as in the case of a food-processing plant, they can harbor bacteria and cause a health hazard. Wider cracks with no edge chipping can be repaired by pouring a medium-viscosity joint filler into the crack and shaving or grinding the surface flush after the filler cures. Cracks that have suffered edge chipping should be routed and filled with an appropriate filler.

5.4 Joint filler. Fillers that have cracked or are not in complete contact with the concrete should be replaced. In some cases, additional filler should be poured into the joint. Tell the owner to follow the filler manufacturer's instructions.

5.5 Joint chipping. Tell the owner that repair of chipped joints can sometimes be done by in-house maintenance personnel, depending on the extent of the joint chipping. If large areas are chipped, a repair contractor will probably be needed. For small-scale repairs, some joint-filler manufacturers recommend sawcutting just outside the chipped areas to a depth of ½ to 1 inch then pouring a mixture of joint filler and sand into the opening. Openings wider than 1¼ inch require placing a thin board in the middle of the opening to form a new joint, reconstructing the slab edges with a rigid epoxy mortar, removing the board and filling the joint with an approved filler.

5.6 Gouges or popouts. Although these surface defects may not get worse with age, they can create a hazard. Tell the owner to drill out any problem areas with a core drill to create perpendicular patch walls and then fill the void with a rigid epoxy mortar.

5.7 Differential settlement (faulting) at cracks or joints. Explain that if vertical displacement interferes with operation of the facility, repair contractors can use slab-jacking procedures to raise or level the slab surface.

5.8 Special repairs. For floors experiencing extensive problems such as the delamination of toppings or coatings or severe surface erosion, recommend that the owner use the services of a repair contractor.

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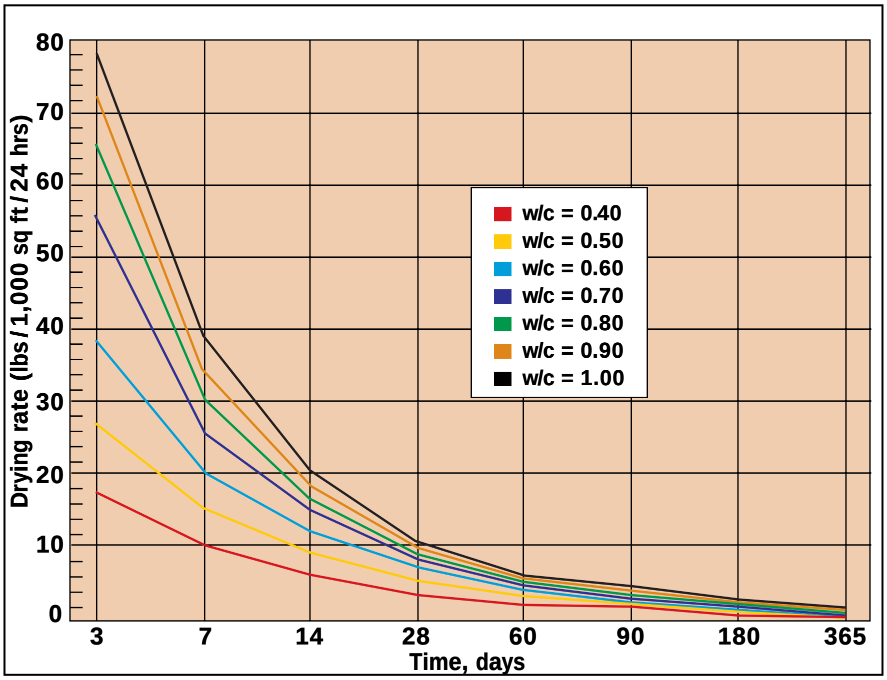

Figure 4. Unless the floor concrete has a very low water-cement ratio, it can take three months or more to reach the commonly required water-vapor emission rate of 3 pounds/1,000 square feet/24 hours.

Additional reading

Boyd Ringo and Robert Anderson, *Designing Floor Slabs on Grade,* 2nd ed., The Aberdeen Group, Addison, Ill., 1996.

Armand H. Gustaferro, "Are Thickness Tolerances for Concrete Floors on Grade Realistic?" *Concrete Construction,* April 1989, pp. 389-391.

William F. Perenchio, "The Drying Shrinkage Dilemma," *Concrete Construction,* April 1997, pp. 379-383.

Bruce A. Suprenant and Ward R. Malisch, "Are Your Slabs Dry Enough for Floor Coverings?" *Concrete Construction,* August 1998, pp. 671-677.

Steve Metzger, "A Closer Look at Industrial Floor Joints," *Concrete Repair Digest,* February/March 1996, pp. 9-14.

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