When nonbreathable floor coverings such as vinyl or rubber sheet goods, plastic-backed carpeting, or vinyl composition tile will be installed on concrete floors, the floor-covering adhesive affects flooring performance in at least two ways:

- The concrete surface can absorb water from a water-based adhesive. The water then dissolves alkalis in the concrete, increasing the pH. The increased surface moisture content and pH can have a harmful effect on adhesion of the flooring to the concrete substrate; and

- The pulloff strength of the adhesive is dependent on adhesive composition, so some adhesives perform better than others at a given concrete moisture content or moisture-vapor emission rate.

This article presents some preliminary data showing how flooring performance may be affected by these two factors.

When selecting a flooring adhesive for your project, information about moisture sensitivity of the adhesive would be helpful.
They continued weighing periodically until no further weight was lost, and expressed the total water or solvent loss in fluid ounces per square foot of surface to aid in visualizing the amount of water or solvent lost.

Finally, they calculated the total potential absorbed water per 1000 ft² of contact surface for comparison with the commonly specified moisture-vapor emission rates of either 3 or 5 lb/1,000 ft²/24 h.

Results of these measurements are shown in Table 1.

During the open time, the adhesives tested lost an average of about 10% by weight of the water or solvent they contained. The total water or solvent loss averaged about 2 fl oz—a quarter cup—per ft² (about 630 ml/m²). Based on the open-time results, about 90% of this water or solvent could be absorbed by the concrete substrate after the floor covering was applied. Some water or solvent also could be absorbed by the concrete instead of evaporating during the open time. The last column in Table 1 shows that an average of 130 lb (almost 16 gal.) of water or solvent per 1000 ft² must either be absorbed by the substrate or evaporate. Thus, it’s likely that the adhesive adds significant water or solvent to the concrete surface after the floor covering is placed.

**ADHESIVE EFFECT ON pH**

To investigate the immediate effect of water-based adhesives on surface pH, the technicians also spread a water-based adhesive on a dry concrete slab that had an initial pH of 9. They placed 1 x 2-in. (25 x 50 mm) flat plastic plates on the surface before applying the adhesive, then removed the plates to leave bare concrete surfaces after the adhesive was applied (Fig. 1). At 15-s intervals, they then measured the pH of the concrete on the bare surfaces using pH indicator strips. Only a few minutes after the adhesive had been applied, the surface pH rose from 9 to 11.5. This indicated that alkalis had been brought into solution quite quickly, exposing the adhesive to a high pH environment that was unrelated to concrete mixing water or external moisture sources other than the adhesive.

**COVERING THE FLOOR INCREASES MOISTURE-VAPOR EMISSION RATE**

Using relative humidity measurements, Hedenblad found that internal moisture in a concrete slab redistributes after the slab receives a floor covering. To measure the effect of floor coverings on moisture-vapor emissions, Suprenant and Malisch allowed a 4-in.-thick slab (100 mm) with a 0.40 w/c and a 2-in.-thick slab (50 mm) with a 0.31 w/c to reach moisture-vapor emission rates of 3.0 and 2.6 lb, respectively, while drying from the top only. Each slab was then tightly covered with plastic sheeting for 10 days to stimulate...
the effect of adding an impermeable floor covering without any appreciable change in ambient temperature.

On the 10th day, two holes were cut in the plastic covering each slab, with each hole just large enough to be enclosed by the transparent cover for a calcium-chloride test kit (ASTM F 1869). A lab technician glued down the covers with an adhesive and used duct tape to ensure an airtight seal. After 72 h, the measured emission rates were 3.4 and 3.8 lb for the 4- and 2-in.-thick slabs, respectively. Thus, the vapor-emission rate for both slabs had risen above the commonly specified 3-lb value that permits floor-covering application.

Based on this data, it shouldn’t be surprising that when a section of failed floor covering is removed, the moisture-vapor emission rate is higher than the 3- or 5-lb maximum value required by the flooring manufacturer before the flooring can be installed.

**ADHESIVE STRENGTH VERSUS VAPOR-EMISSION RATE**

Suprenant and Malisch tested the pull-off strength of several different flooring adhesives that were applied to concrete slabs with varying moisture-vapor emission rates. Low rates (1.4 and 1.8 lb/1000 ft²/24 h) were for a 20-year old existing floor, while higher rates (3.7 to 7.8 lb/1000 ft²/24 h) were for test slabs that were more than 6 months old. Technicians cut 12-in. (305 mm) square, 1/8-in.-thick (3 mm) vinyl composition tiles into thirds to produce three 4 x 12-in. (100 x 305 mm) strips that were core-drilled to produce three 2-in.-diameter (50 mm) tile plugs. This allowed three pull-off tests for each adhesive tested (Fig. 2). The technicians followed adhesive-manufacturer’s recommendations for adhesive thickness, trowel size and open time when spreading each adhesive to cover an area on the concrete surface about the size of the tile strip. After waiting until the recommended open time had been reached, they placed the 4 x 12-in. (100 x 305 mm) strips on the adhesives and pounded the strips into place. Then they placed the 2-in.-diameter (50 mm) plugs into the drilled holes and pounded them down.

After the adhesive cured for three days, a fast-setting epoxy was used to attach a 2-in.-diameter (50 mm) steel disc that had a 1/2-in.-diameter (13 mm) threaded rod welded to the top. A 500-lb (2.5 kN) capacity hydraulic ram was attached to the threaded rod and used to pull the tiles off the floor.

Pull-off strength test results for the existing floor (moisture-vapor emission rate of 1.4 and 1.8 lb) showed:

- Epoxy-based adhesive average strength was 128 psi (880 kPa);
- Two solvent-based adhesives averaged 11.0 and 29.5 psi (76 and 203 kPa); and
- Six water-based adhesives ranged from 7.0 to 38.5 psi (48 to 265 kPa).

Figure 3 shows the pull-off strength test results for concrete slabs with varying moisture-vapor emission rates. There is a trend toward decreasing strength with increasing emission rate, as shown by the dashed lines, but there are some anomalies in the data. Also note the wide spread between the top and bottom dashed lines. Some adhesives performed much better than others, but performance wasn’t necessarily related to the generic adhesive class. For instance, the water-based #1 adhesive outperformed the solvent-based #2 adhesive, but the solvent-based #1 adhesive outperformed the water-based #2.

**INDUSTRY CHALLENGES**

Based on the limited data presented here, we need answers to the following questions:

- Is adhesive performance affected by water in the adhesive causing an increased concrete-surface moisture content and pH? Do adhesives with low initial moisture contents perform better than adhesives with higher initial moisture contents?
If the measured pH of a concrete surface is higher than the maximum value recommended by the adhesive manufacturer, how can the pH be lowered without acid etching the surface?

Can the reliability of the calcium-chloride test for moisture-vapor emission rate (ASTM F 1869) be improved by drying the floor until the required MVER is achieved, covering it with plastic sheeting for a given period, then measuring the MVER again?

Can adhesive manufacturers supply information for their products that gives an indication of pull-off strength (or other performance indicator) at differing moisture-vapor emission rates for the concrete substrate?

Answers to these questions can help us to optimize the variables we must deal with. Floor-moisture problems clearly illustrate the interrelationships among quality, cost, and schedule by confirming the fact that either maximizing construction quality or minimizing costs often has an adverse effect on schedule.

References

Selected for reader interest by the editors

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