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Figure 1. CTL staff have been using Vaisala's HMI41 hand-held moisture meters and HMP44 measurement probes for relative humidity measurement in concrete slabs.

Investigating floor moisture problems

Using Automated Long-Term Monitoring of Relative Humidity

In recent years, CTL has focused on the problems caused by excessive moisture in floors. To investigate moisture problems affecting floor coverings in buildings, CTL staff have been using Vaisala's HMI41 hand-held moisture meters and HMP44 measurement probes for relative humidity measurement in concrete slabs.

Since 1993, Construction Technology Laboratories, Inc. (CTL) staff have become increasingly involved in troubleshooting moisture problems in concrete floors with moisture-sensitive floor coverings. Resilient floorings such as vinyl sheet, vinyl composition tile, linoleum, and vinyl-backed carpet are all susceptible to problems when excessive moisture and alkalies from concrete react with adhesive or cause plasticizer breakdown.

Professional solutions

Since many of the projects we evaluate are a considerable distance from our home office, the hand-held meter requires separate trips to the jobsite. We need to drill holes and place probes, then a return trip to take readings at least three days later after the probes have equilibrated in the concrete. To reduce travel costs and to collect more detailed data, we decided to begin using automated data logging instruments and to leave probes in place for several months.

Data logging of relative humidity levels in the concrete provides a method to obtain accurate readings and to track changes with time. Calibrated probes are installed into the drilled concrete holes. The

The authors of the article: Howard Kanare (left) and Terry Willems.

probes are linked to a data logger that reads, averages, and records the relative humidity at preset intervals up to many months.

Thorough studies of vinyl-backed carpet tiles

Vinyl-backed carpet tiles had been installed in a medical facility on two concrete substrates: a slab-on-ground and an adjacent elevated lightweight concrete slab cast on ribbed steel deck. Carpet tiles installed on the elevated lightweight concrete were well-bonded and did not exhibit distress. However, carpet tile was curling and debonding on the slab-on-ground. The slab-on-ground consisted of a 5-inch (125-mm) thick, normal weight concrete slab cast on 7-inch (175-mm) sand layer on top of an 8-mil (0.2-mm) plastic vapor retarder. The vapor retarder sheet should have kept moisture from entering the floor system from below, but moisture was somehow getting to the underside of the carpet through the concrete. Vaisala HMP44 relative humidity probes were selected to study the situation.

CTL placed HMP44 probes in six locations, three in the slab-on-ground and three in the lightweight concrete slab (see Figure 2). Six probes were 'match calibrated' together to provide the best possible precision. The probes were placed at depths of 1, 2, and 3 inches (25, 50, and 75 mm) and connected to an ACR SmartReader Plus seven channel data logger. This compact, self-contained logger has a 10-year lithium battery and can be unplugged from the data collection system and mailed to our laboratories for downloading data. Humidity readings were averaged every eight seconds and recorded once every hour for approximately two months.

Revealing RH results

Two useful results came from the data collected over two months. First, the results (see Figure 5) indicated that in the area of distressed carpet on the slab-on-ground, moisture levels were very high, averaging about 97 % RH at two-inches (50 mm) below the top of the slab. By contrast, the elevated slab had 70–75 % RH at the same depth. Humidity below 85 % is generally considered acceptable for floor coverings. Above this level a host of problems can occur, including mold and mildew, adhesive degradation, plasticizer breakdown, and dimensional changes of flooring such as curling and shrinkage. These forms of distress cause maintenance problems and can lead to trip-and-fall hazards.

A second result from the data was knowledge that the elevated slab was drying while the slab-on-ground was actually becoming wetter, even though the floor was nearly two years old! The data indicated that the concrete slab-on-ground was reaching equilibrium with the wet sand below.

The Figure 5 shows the slab-on-ground was gaining moisture until the end of November 1999 and began to maintain a steady internal RH after that date. By contrast, the elevated slab continued to dry at a fairly constant rate. (The steep rise in the curves seen from 2–6 November is due to the probes reaching equilibrium with the surrounding concrete which takes 3–4 days after placement.)

Cost-effective approach to monitoring

Upon excavation of a portion of the concrete floor, we determined that the granular layer directly below the slab contained 7 % moisture (by weight), sufficient to replace the moisture lost from drying the slab during construction, before flooring was installed. We calculated that the slab-on-ground would take many years to dry sufficiently for moisture-sensitive floor coverings. Therefore, we recom-

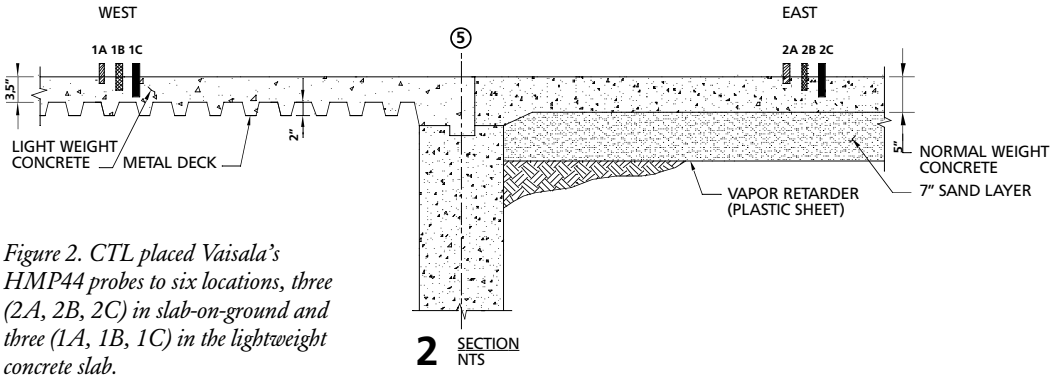

Figure 2. CTL placed Vaisala's HMP44 probes to six locations, three (2A, 2B, 2C) in slab-on-ground and three (1A, 1B, 1C) in the lightweight concrete slab.

Figure 3. A typical problem of adhesive failure caused by excessive moisture in concrete. Some water-based adhesives are re-emulsifiable and can become gummy losing adhesion between the concrete and the vinyl-backed flooring.

Figure 4. Carpet tile was curling and debonding on the slab-on-ground.

mended to the facility owner that the existing flooring should be replaced with less-moisture-sensitive flooring.

Data logging wiring cannot be installed everywhere in a building due to the traffic patterns, uses of the facility, and cost. In addition to logging with several probes, we also placed probes in several remote locations throughout affected areas of the building and read those with the HMI44 handheld meter. Results of the monitoring program indicated potential problems existed in other parts of the building as well. After reviewing the data, the construction contractor agreed to replace the carpet tiles with a more breathable floor covering and monitor the building for future problems.

We presented the findings to a meeting of architects and construction contractors who were able to see graphically how moisture was moving into, and out of, the floors they had built. They learned a valuable lesson about how to prevent this sort problem from occurring by careful architectural detailing in new construction.

Important investigative tool

The combination of accurate relative humidity measurements and long-term monitoring is an important tool for investigating floor moisture problems. Now, we can document drying history, look for changes due to ambient conditions, relative differences between different portions of the building, and predict slab drying times.

The amount of data recorded results in a high level of confidence in our predictions. By establishing moisture profiles within the slab, trends are easily seen. While monitoring of concrete relative humidity is just one part of our investigation, the advantages of data logging has led us to new understanding of long term moisture levels within concrete. ■

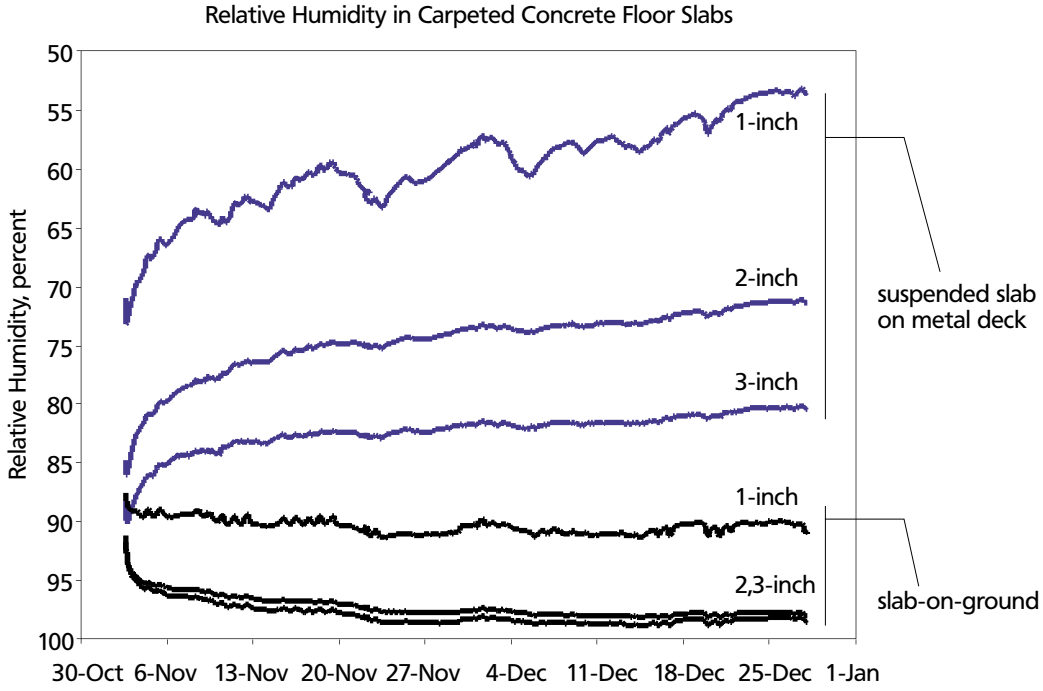

Figure 5. Results of data collected over two months, related to relative humidity is carpented concrete floor slabs.

CTL – Professional solutions for moisture problems

Construction Technology Laboratories, Inc. (CTL) perform research, testing and consulting on a wide range of construction materials. With a 75-year history, CTL is known worldwide for its solutions of construction or performance problems. The company has its main office and laboratories in Skokie, Illinois, with 130 staff, including chemists, geologists, ceramists, architects and civil and structural engineers.