# Employing the SEALED FLOOR TECHNIQUE to Resolve Underfloor Moisture Problems in Warm, Humid Climates

PART 2 OF 2

By Larry Elkin, PE

## Introduction

Part one of this paper, “Building Code Issues of Residential Underfloor Moisture in Warm, Humid Climates,” published in the October issue of *Interface* journal, explored opportunities within the existing building code to use the sealed floor technique (SFT) for installing floor insulation in warm, humid climates *(Figure 1)*. The purpose of this paper is to present a case study in which the SFT was employed to resolve an underfloor moisture problem. Data are presented that show the effectiveness of this technique, and recommendations are made for future studies.

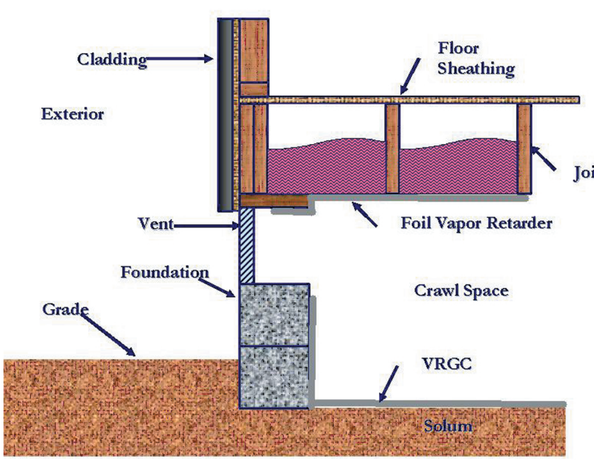



*Figure 1: Example of a crawl space treated with the Sealed Floor Technique.*

## Edisto Beach, South Carolina

In May 1999, a three-story, wood framed house was completed in Edisto Beach, approximately 30 miles southwest of Charleston, South Carolina. By July of that year, the homeowner reported cupping in the wood strip flooring. By August, several strips of the heart-pine flooring had buckled and fractured.

Complaints about wood flooring problems are common along the South Carolina coast. Based on investigations of approximately 40 homes between 1998 and 2000, it appears that crawl space moisture migrates via a combination of air leakage and diffusion through the floor assembly where it accumulates in the bottom portions of the wood flooring strips. The moisture gradient between the top and bottom surfaces of the flooring strips leads to differential expansion in the wood. The result is warping – commonly referred to as “cupping.” In extreme cases, areas of the wood strips lift from the plane of the floor (buckling) and sometimes fracture. Observations of the underside of the floor often include high moisture levels (above 20% wood moisture content) in the floor sheathing and framing, moisture staining, and low to high severity fungal growth. In the most severe cases, decay is evident in the floor framing, and the floor's structural integrity has been compromised.

Standard practice is to increase ventilation beneath the floor to control moisture. This seems to stem from the publications of the 1940s and 1950s and the basic requirements of the building code as reported by W.B. Rose (see references). Measurements, however, show that increased ventilation can add moisture to the crawl space.

A home on James Island, South Carolina, was recently repaired to remove moisture-damaged and fungus-contaminated flooring. The repairs included additional vent openings around the foundation and the installation of a vapor retarding ground cover (VRGC) that covered 100% of the solum. Within a week of returning to the home, the owner found water ponding on the VRGC, condensation on the HVAC ducts, and low severity fungal growth on some of the framing. The crawl space and exterior air conditions were measured with a hand-held hygrometer. Crawl space conditions were 75.6˚F dry-bulb and 76.2% RH (relative humidity). The exterior conditions were 84.1˚F dry-bulb and 57.9% RH. The humidity ratio of the exterior air was 0.01460 lb/lbda (pounds of water vapor per pound of dry air), while the crawl space humidity ratio was 0.01454 lb/lbda. The exterior air was slightly more humid than the crawl space; additional ventilation would have introduced more moisture into the crawl space.

The owners of the Edisto Beach home were originally informed that they needed additional ventilation beneath their home. This seemed incredible to them as their home was elevated on wood piles 10 feet above grade to comply with the requirements of SBCCI SSTD 10. The perimeter of the underfloor space was fully open on three elevations and partially open on the fourth elevation. The ventilation area far exceeded the 1 square foot per 150 square feet of floor area mandated by the 1995 CABO. Despite the large amount of ventilation, the floor framing was not being protected from moisture problems.

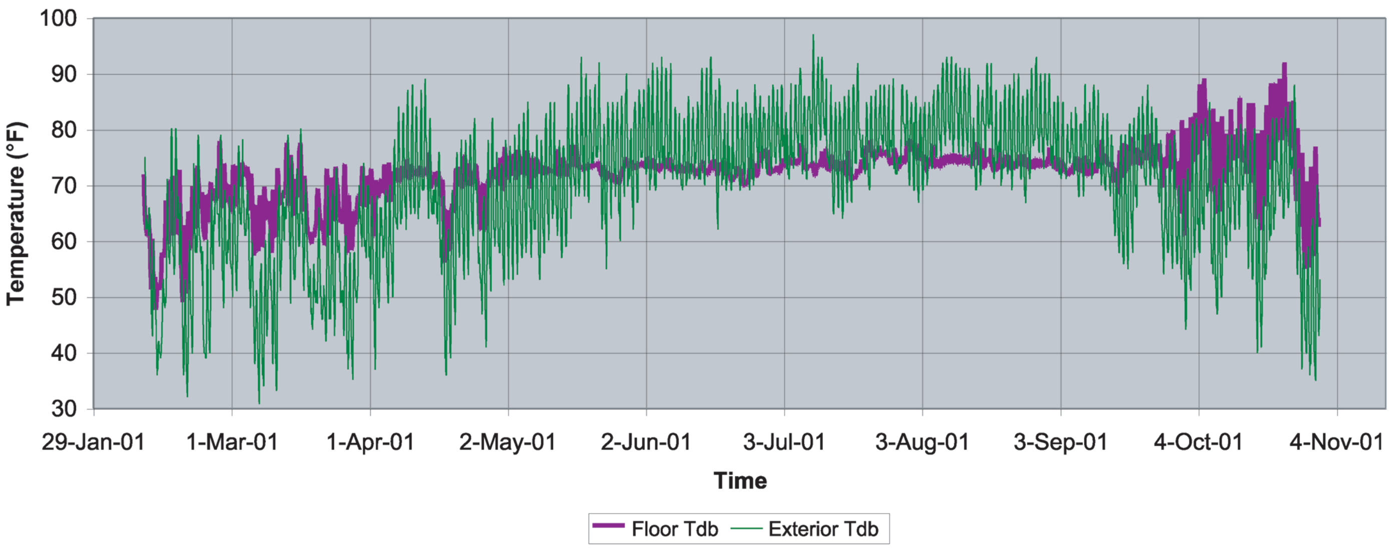
The Edisto Beach home exhibited similar floor construction to other homes along the South Carolina coast. This included strip wood flooring, finished with multiple coats of liquid-applied polyurethane. Below the wood flooring strips was a layer of #15 building felt. The floor sheathing substrate consisted of 3/4-inch tongue and groove plywood. The floor structure included engineered wood floor joists. Kraft paper-faced fiberglass batt insulation (R-19) was installed between the joists with the paper correctly facing the floor sheathing.

By April 2000, the wet floor insulation had been removed. The bottom of the floor sheathing exhibited areas of moisture staining and low severity fungal growth. The floor assembly needed to dry before repairs could be performed. The area below the home was large, and the warm, humid season had begun; it would have been difficult and expensive to create a dehumidified enclosure below the home. Consequently, the decision was made to leave the insulation out of the floor until February 2001. The exposed flooring remained slightly warmer throughout the summer, which resulted in less condensation. When the cooler and drier fall and winter arrived, temperature and vapor pressure gradients changed to reduce the moisture content in the floor assembly. Once the moisture content of the floor deck and joists was around 12 per-



**Figure 2**
**Edisto Beach Temperature Conditions**




cent, the floor insulation could be reinstalled.

The Edisto Beach house originally included several "toe-space" HVAC supply grilles. This arrangement routes supply duct outlets below cabinets. An opening is cut into the vertical face of the cabinet base to allow supply air to discharge horizontally into the room. A metal grill is fastened over the opening. These are popular because they diminish the visual impact created by the mechanical system. The down side is that the air supplied by the grilles tends to wash over the floor. In addition, the spaces below the cabinets are charged with cold air. Typically, cooled supply air is around 55˚F. A conventionally insulated floor assembly exposed to such cold jets of air is particularly susceptible to condensation problems.

Part of the repair at the Edisto Beach house included relocating the HVAC supplies to floor-mounted grilles that blow upward and mix with the interior air. This would eliminate cold spots on the floor. However, rather than capping the toe-space vents at the floor deck, it was decided to use these openings as part of a passive venting system for the floor assembly to the interior of the home. This complies with Exception 1 of the crawl space ventilation requirements in the building code that allows venting to the interior of the home.

The individual toe-space vents would only provide venting for the joist cavity directly below each vent opening. The joist cavities needed to be interconnected to allow passive venting for all of the joists' cavities. Fortunately, the original home construction included a horizontal chase dropped below, and perpendicular to, the floor joists to enclose an HVAC trunk duct. The chase could be used to interconnect the joist cavities. Foil-faced HVAC duct board was fastened to the bottom, side, and end faces of the chase. The joints were sealed with tape and mastic.

Foil-faced, R-19, fiberglass batt insulation was installed in the remaining joist cavities with the foil facing downward. The foil tabs along each side of the insulation batts were spread across the bottom edges of the joists and stapled in place. The laps were sealed with foil tape. The foil vapor retarder facing was sealed to the duct board along the mechanical chase and to the perimeter of the floor framing. Mechanical, electrical, and plumbing penetrations were sealed with tape and mastic. The result is a foil vapor retarder and air barrier that extends fully across the bottom of the floor assembly. This complies with climate-related exceptions to the building code requirements for moisture vapor retarders.

## Post-Repair Monitoring

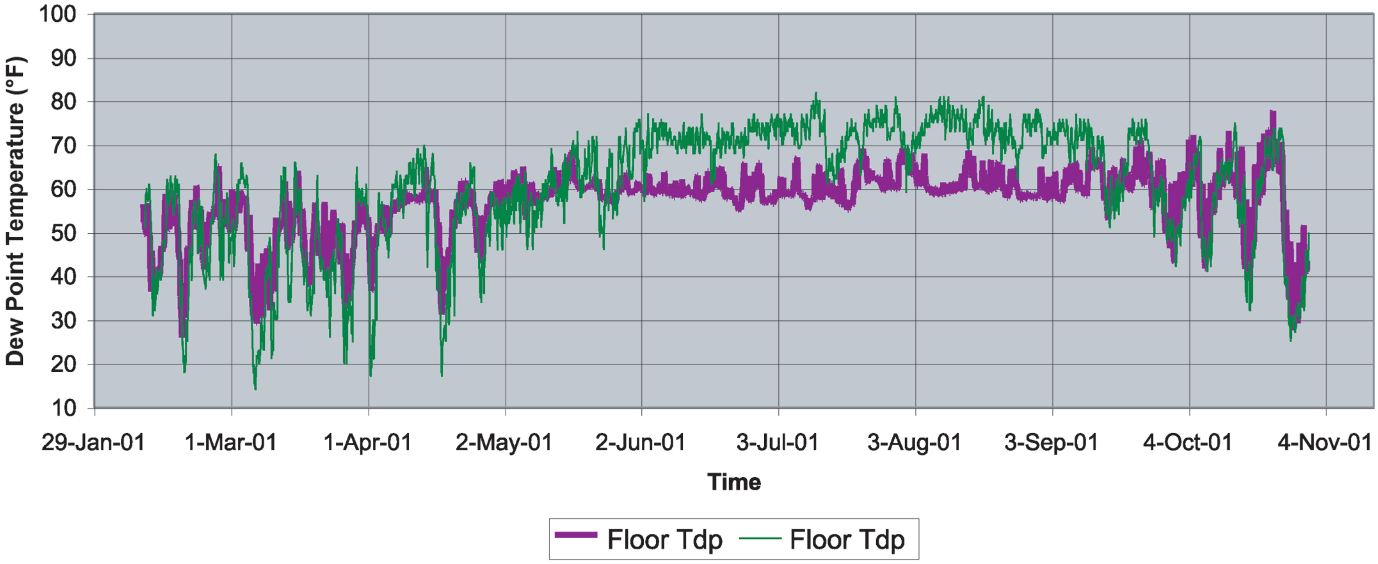
Prior to the insulation installation, a Sealed Units Parts Company, SUPCO Model DLTH temperature-humidity data logger was installed against the bottom of the floor deck in February 2001. The data logger was programmed to acquire data once an hour. It was located approximately 15 feet from the nearest floor vent opening. For comparison purposes, hourly exterior temperature and humidity data for Charleston, South Carolina, during the same time period were obtained from the National Climatic Data Center (NCDC). The data logger was retrieved at the end of October 2001.

*Figure 2* shows a graph of the dry bulb temperatures for the exterior and floor conditions. Overall, the data show that the floor temperature was warmer than the exterior in the winter and cooler than the exterior in the summer. The floor's daily temperature range is larger in the spring and fall as compared to the summer. An examination of the spring and fall data shows that the daily peaks occurred between 3:00 p.m. and 4:00 p.m. The data logger had been installed several feet in from the west wall. The west wall above this location has several windows. It seems that the angle of the sun and the seasonal absence of tree foliage allowed the interior floor surface to warm during the spring and fall. The floor temperatures for several days at the beginning of the sampling period were logged prior to the installation of the floor insulation.

*Figure 3* shows the dew point temperature data for the exterior and floor conditions. The floor's dew point conditions in the spring and fall appear to closely follow the exterior conditions. However, the exterior range is slightly larger than the floor's range. This may be attributable to open windows and doors during the more temperate seasons. The interior and exterior moisture conditions

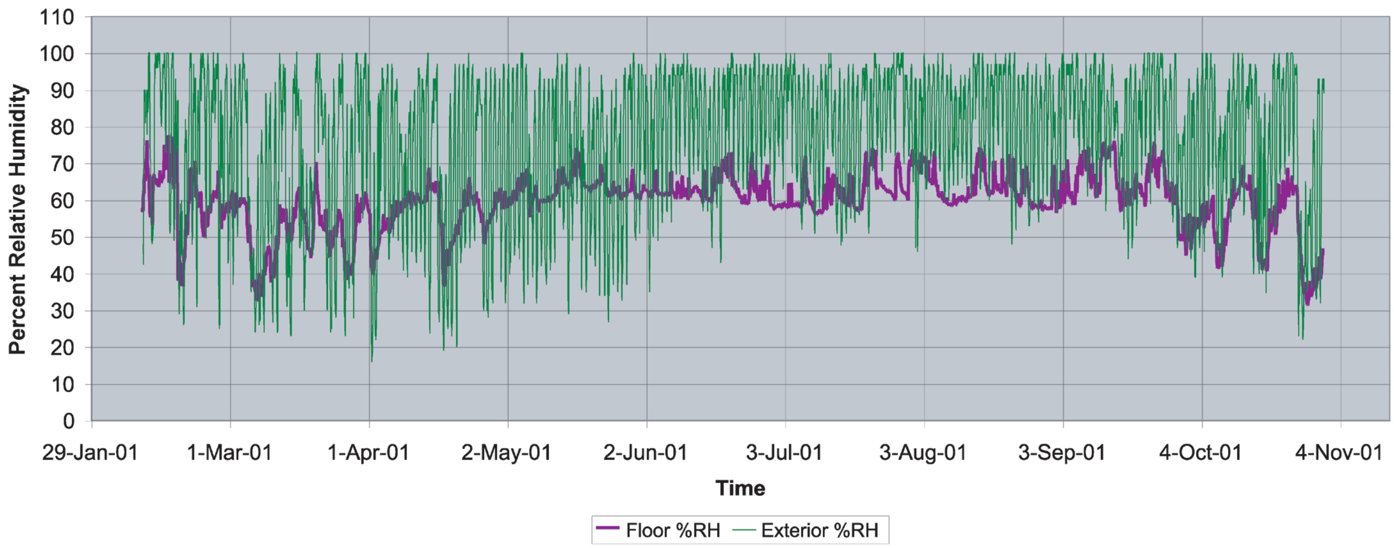
**Figure 3**
**Edisto Beach Dew Point Conditions**




would tend to equalize as a result of the communication between the interior and exterior. The floor's dew point is approximately 12 to 15 degrees less than the exterior dew point throughout the cooling season (June to September). Occasional cool fronts provided brief exceptions to this trend. This indicates that the floor assembly is effectively isolated from the warm and humid exterior air.

*Figure 4* illustrates the relative humidity conditions for the exterior and the floor. Overall, the floor relative humidity (RH) has a smaller annual swing, and the summer RH is consistently lower than the exterior RH. The floor's RH data show only brief spikes above 70% RH and no periods above 80% RH. According to Hugo Hens in "Minimizing Fungal Defacement," the critical threshold for

**Figure 4**
**Edisto Beach Relative Humidity Conditions**




fungal growth on building materials is an average relative humidity above 80%. While some fungi can develop at RHs as low as 65%, the elevated RH must be sustained for a long enough time for the fungi to germinate. The floor's RH remained above 70% for more than 24 hours only for short periods during mid-September. This may be a result of venting the floor to the interior of the home.

This author has observed that the period from mid September to mid October creates difficulties for residential heating, ventilating, and air conditioning (HVAC) systems in warm, humid climates. The latent loads remain quite high while the sensible loads drop from the summer levels. Many HVAC systems use only thermostats as controls. During the fall conditions, the thermostat does not experience high temperatures frequently enough to energize the HVAC system to provide adequate dehumidification. Also, milder temperatures encourage homeowners to open doors and windows for ventilation. Consequently, interior humidity levels increase. As the floor assembly is vented to the interior, the floor's humidity level increases.

## Conclusions and Recommendations for Future Studies

The current state of residential building codes can allow for the construction of durable crawl spaces in warm, humid climates. However, the codes do not clearly explain why alternate techniques are required for these climates nor do the codes define what alternate techniques are acceptable. While current research, such as that being performed at Advanced Energy Corporation (*see Part I in the October 2003 issue of* Interface), shows that the Sealed Crawl Space Technique (SCST) can solve crawl space moisture problems, the SCST may not be practical for implementation in circumstances where construction occurs in flood zones. The sealed floor technique (SFT) is an attractive alternative to the SCST in these cases.

Current research and this case study do not support the belief that ventilation can resolve floor moisture problems. Rather, this case study supports other studies indicating that uncontrolled ventilation can exacerbate moisture problems. A foil vapor retarder installed across the bottom of the Edisto Beach house's floor resulted in decreased moisture within the floor assembly. Passive venting may allow incidental levels of moisture to migrate to the home's interior where it can be removed by the HVAC system. However, interior moisture that transfers through the floor vents can increase the floor's relative humidity during fall conditions.

One concern surrounding the SFT is the difficulty associated with pest control inspections of an encapsulated floor. In future installations, it is possible to install access doors beneath rooms that have plumbing fixtures or water appliances to facilitate inspections. Resealable, polyethylene doors used for asbestos and mold abatement containment areas could provide such access. Unfaced insulation could be placed in the floors above the door panels. The surrounding foil vapor retarder would then be sealed to the perimeter of the door panels.

Future studies could provide additional insight into the benefits and performance of the SFT system. A more detailed study could monitor interior, exterior, and floor assembly temperature, dew point, and relative humidity conditions. This could be used to determine the extent that these three zones communicate heat and moisture. Corresponding wood moisture content data for the joists, floor sheathing, and interior wood flooring could provide insight regarding the significance of brief periods where the floor's relative humidity was above 70%. ■

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## About the Author

**J. Lawrence Elkin, PE**

**J. Lawrence Elkin, PE,** received his B.S. and M.S. degrees in Mechanical Engineering from Rose-Hulman Institute of Technology. Afterward, he spent several years designing nuclear magnetic resonance and magnetic resonance imaging equipment. For the last seven years, Elkin has performed forensic evaluations of building failures. Elkin's expertise is primarily in the physics of thermodynamics and fluid dynamics as they apply to building envelope systems. Currently employed at Campbell, Schneider and Associates, LLC, Elkin utilizes the latest techniques to evaluate difficult moisture problems. These techniques include computer-based numeric simulations, electronic data acquisition, and many other advanced field investigation strategies. Elkin's research has resulted in wall, floor, and roof designs specifically developed for use in warm and humid climates. He also provides expert testimony to help resolve construction-related litigation. Elkin is an active member of the Building Environment and Thermal Envelope Council (BETEC) of the National Institute of Building Science (NIBS) and the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE).

## SMALL BUSINESS LONGEVITY

According to the Center for the Study of Taxation, 70% of family businesses don't make it to a second generation and 87% don't survive to a third generation. The center's study determined that if gift, estate, and generation-skipping taxes had been repealed in 1971, by the year 1991, there would have been 262,000 more jobs, $47.3 billion more in GDP, and $398.6 billion more in capital.

***— FMI Construction Outlook***



  