Volume 1 Issue 5

StarNet
Independent Flooring Cooperative

starlog
Special Double Issue
A Series of Floorcovering Bulletins

UNDERSTANDING CONCRETE MOISTURE AND VAPOR EMISSION PROBLEMS

A Fluid Situation

Moisture in concrete substrates is a leading cause of flooring failure, costing billions of dollars annually in damage, downtime, repair and replacement. You might think this problem occurs primarily in humid climates, or in geographies with a high water table. But moisture problems are much more widespread–and the problem is growing.

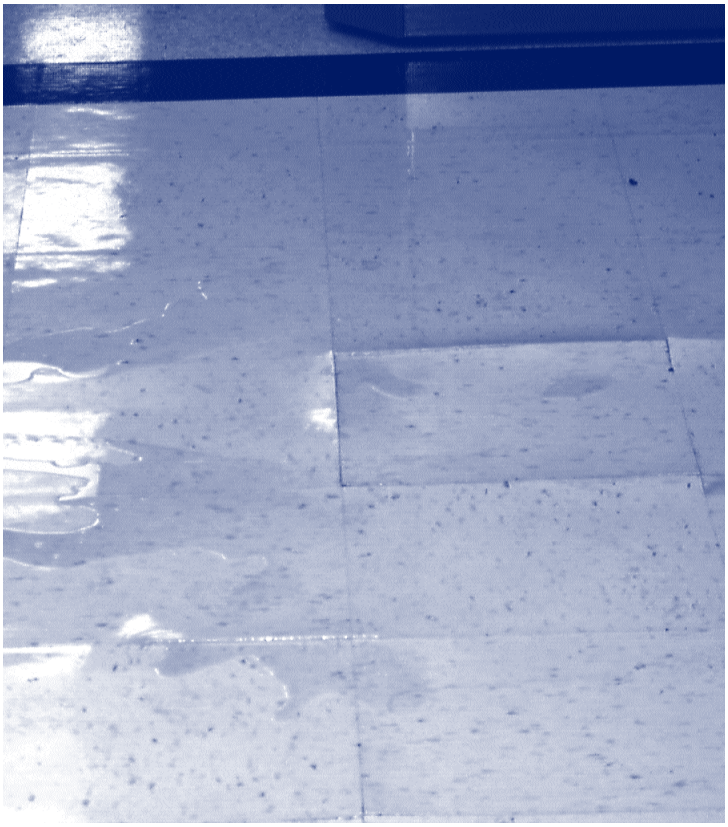
This important issue affects your building's serviceability and your facilities budget from initial construction and occupancy through the duration of the building's lifetime.

You can minimize your risk of moisture-related floor failure when you understand why this problem occurs and how to prevent it.

The High Price of H_2O

If you think bottled water is expensive, you'll appreciate the costs associated with the effects of too much moisture in concrete. Here's just the tip of the iceberg when calculating the impact on your building:

- **Delayed flooring installation for resilient, carpet, ceramic, terrazzo, hardwood and poured polymer floors.**
- **Adhesive bleeding and retarded setting, and inadequate short and long-term bond between floorcovering & substrate.**
- **Downtime to repair or replace concrete, floorcovering, fixtures, and wallcovering.**
- **Voided flooring warranty.**
- **Mold and mildew damage, toxic unsightly fungi and accelerated microorganism growth, alkali deposits and damage.**
- **Sick-building syndrome and indoor air quality issues.**
- **Lost worker time and productivity.**
- **Your reputation as a specifier or building manager, employee morale, tenant trust.**



Buckled resilient tile installation.

The Problem Hits Home...And Business

While about 90% of commercial flooring litigation cases focus on water related damages, only about 1.5% of the typical building budget is dedicated to waterproofing and related issues. And the problems are getting worse because of the realities of fast track construction, building on less-than-optimum terrain, cost-cutting, incompatible construction methods and floorcovering needs, contractor and subcontractor time issues and lack of understanding by all involved.

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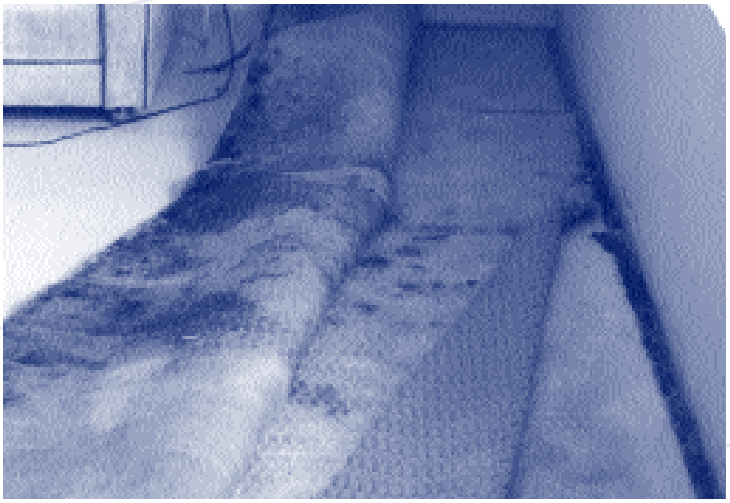


Mold-infested carpet and backing.

This very expensive problem has a notorious nationwide rap sheet, disrupting building operations in residential and commercial facilities:

- **A major retail chain removed and replaced curled VCT in a round-the-clock operation that cost hundreds of thousands of dollars.**
- **A large California general hospital experienced a total flooring failure and lost over one million dollars in downtime and material damages.**
- **A townhouse development saved .30/square foot in vapor barrier construction, only to spend several million dollars to redo the job and replace damaged carpeting and vinyl.**
- **A major sports arena had damages in excess of 50 million dollars as the result of an improperly treated slab.**

Moisture and Vapor Sources

Environmental

"Natural" moisture results from weather phenomena and soil capillary action. Water, water vapor, and deposits that come with it including alkali may permeate through concrete slabs from overwatered or poorly designed landscape beds, sloping hillsides, failed plumbing, inadequate drainage systems and faulty trenches. Water takes the path of least resistance and may migrate to a concrete slab from broken pipes, leaking sewers and run-off from neighboring buildings.

Construction

Compounding the moisture problem is fast track construction, the lack of perfect places to build, cost cutting and today's construction methods.

Construction crews may add too much water to the concrete mix to make it more workable, making the concrete slab the major culprit for contributing to moisture-related flooring failures.

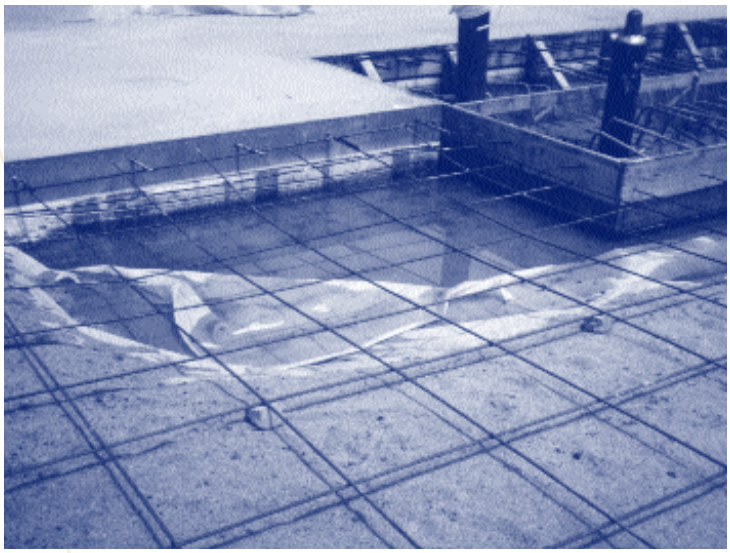
Occasionally, products used on the slab may make moisture problems worse. Resilient and carpet products with waterproof backings, for example, can be too effective at creating total moisture barricades. Water and/or water vapor must have some means of escaping from the concrete over time.

Minimizing Concrete Moisture Problems

The three actions that have the greatest impact on minimizing moisture problems throughout a building's lifetime are:

1. **Construction location and site preparation.**
2. **The water/cement ratio of the slab mix.**
3. **Slab curing methods and drying times before floorcovering installation.**

Understanding these factors goes a long way in helping you prevent problems in new construction from ever occurring. Once the problem exists, in new or old buildings, it is an expensive proposition to bring in professional companies to help resolve the issue.



Ineffective vapor barrier. Barriers must be intact and strong enough to withstand construction traffic.

Site Preparation

The single most important consideration affecting floorcovering installations on concrete in contact with the earth is the proper preparation of the construction site. Buildings are being constructed on less than ideal locations, but there are still many procedures that can be employed before pouring the slab. Consider obtaining a geotechnical survey to determine water table levels, and review historical data for your area's flooding situations. Hold preconstruction meetings with excavation and construction crews to discuss potential water and water vapor problems.

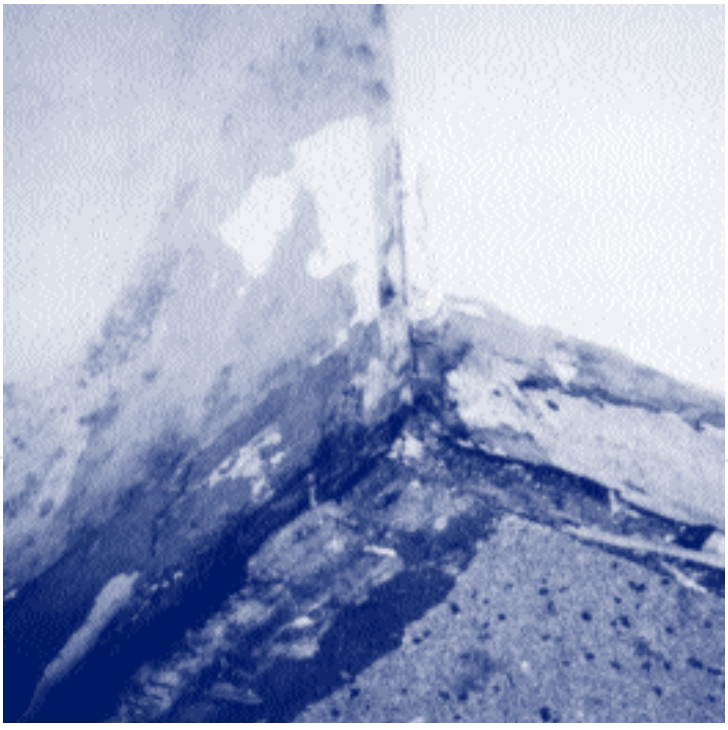
Water vapor, which is a mixture of air and water, can go places liquid water cannot. The differential of temperature and humidity between the moisture source and the building interior causes vapor to be drawn out of the slab surface into the building.

If the vapor is trapped under a flooring material, the moisture will condense at the slab surface and cause floorcovering failure. Adequate, intact vapor retarders as well as capillary breaks used during construction can be very effective in preventing ground moisture transmission up through the slab.

A Well Engineered Slab

Ironically, water is both friend and foe for concrete. In fact, concrete actually gets stronger with age as long as it stays moist throughout its life. The goal is to have a concrete slab made with a low water/cement ratio since that creates a stronger slab with less porosity. This goes a long way in minimizing any initial construction and ongoing moisture-related problems.

The water/cement ratio controls many of the concrete characteristics. If only enough water to hydrate is put into the mix, the concrete is not "workable" and cannot be poured into a slab. If too much water is added, the high water/cement ratio takes a long time to dry and decreases compressive strength. Ideally, the concrete slab has a low enough water/cement ratio to allow it to dry much faster and have a tight cement particle structure that is stronger and more durable with a higher compressive strength.



Microorganism growth that began under the flooring, now rising up a wall.

Slab Permeability-Less is Better

The impact of a too-high water/cement ratio is a key cause of vapor emission-caused flooring failures. This is because the excess water leaves voids inside the slab, like the pores of a sponge. Increases in the water/cement ratio create exponential increases in slab porosity and permeability. The highly permeable slab allows a greater volume of water vapor and alkali to pass from the concrete to floorcoverings, causing bond and floor product damage, and high humidity for fungus and mold growth.

Slab Curing

Improper curing is the root of many concrete slab evils that allow high moisture emission levels and create subfloor preparation problems for flooring contractors. Curing, often confused with drying, involves maintaining a satisfactory moisture content and temperature in new concrete in order for the desired properties to develop. The goal is to keep concrete as saturated as possible for the first few days of curing until it reaches 70% hydration and the designed compressive strength at the end of the full 28 day curing time.

Various methods including covering the newly poured slab with polyethylene sheeting, waterproof paper, or a sprayed or rolled-on curing agent are used to facilitate curing. Curing agents have a timesaving advantage because they retard the evaporation of the original mix water so that curing takes place during the construction process. But, curing compound residue left on the slab may cause flooring adhesive bond problems later.

"Wet curing" uses methods such as ponding, sprinkling, fogging or covering with wet burlap. Wet cured concrete is less permeable than concrete cured with curing agents. In fact, the Portland Cement Association did testing that showed concrete wet cured for seven days is four times less permeable than concrete cured using compounds.

Slab Drying

Concrete needs to dry to an acceptable level before applying coatings or installing floorcoverings. Ideally, it takes one month of drying time for each inch of slab thickness. This time is in addition to curing. Variables that affect drying time include total slab thickness, how much water is in the concrete mix, the type of aggregate in the concrete, if there is a vapor retarder under the slab, if curing agents are used, if steel deck construction is employed and if the slab is on grade or suspended. Natural and man-made environmental influences also impact drying time, including temperature, humidity, seasonal changes, HVAC systems, wind and air blowers.

The best way to determine if the concrete is dry enough is to conduct moisture testing. Most flooring manufacturers recommend moisture tests be conducted before installing their products, and many flooring warranties may be voided if the tests are not conducted.

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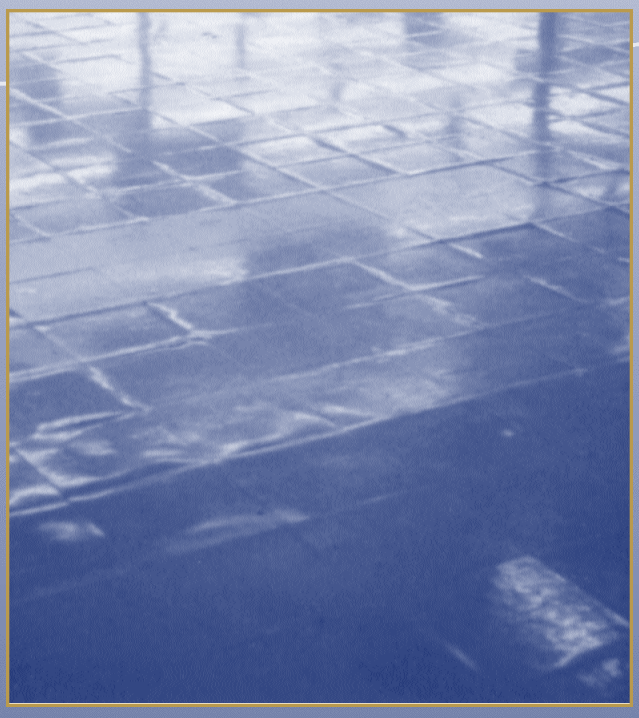
Moisture-Related Problems

Alkali

Fresh, wet concrete is high in alkalinity, with a pH measuring between 12 and 13. It is not uncommon for alkali to rise with water to the "green" concrete surface and remain as a white residue after the water evaporates. This can be cleaned with clear water, and may even disappear as the concrete dries. Do not use low pH acids to neutralize the concrete, as they may dissolve concrete aggregate or leave a residue that is as harmful to flooring installations as the alkali.

If alkali comes back, or the pH continues to measure 9 or above, the excessive residue can be very harmful to the concrete, adhesives and floor covering. It can leave unsightly deposits and, if not removed, can actually corrode the floorcovering.

The best way to prevent excessive and continued alkali deposits from ruining your flooring installation is to keep concrete slabs as free as possible from excess water under and in the slab.



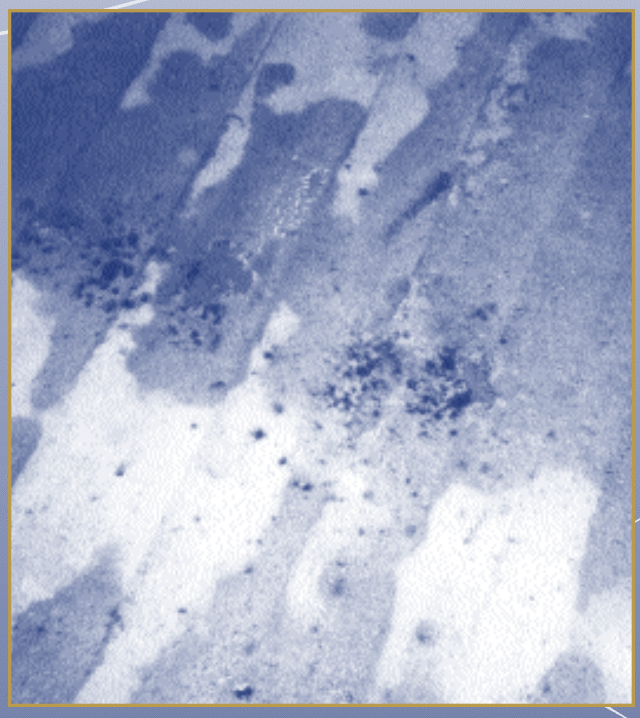
Alkaline salts can be carried with moisture to a floorcovering's surface, which can damage the floor and create a walking hazard.

Mold

Mold spores are present in virtually all buildings. They consume organic food sources found in construction products and enjoy the same living temperatures as people. Mold can grow to toxic levels if too much moisture or humidity is available.

Human reaction to mold can range from watery eyes, runny nose, headache, fever, upper and lower respiratory problems and asthma attacks to more subtle reactions including concentration difficulties and chronic fatigue syndrome. Your nose is a sensitive, if not subjective, mold locator. If you smell a musty or damp odor coming from the floorcovering, especially carpet, then you can bet that mold is thriving. In fact, moisture from concrete slabs can create mold colonies that can sicken people long before the mold can be seen or smelled.

Removing a floorcovering that may be harboring mold exposes the building and its occupants to dangerous toxins, so professionals should always be contracted to perform this service.



Mold growth is unsightly and unhealthy.

Providing good drainage under and around the building, using an adequate capillary break, installing an effective vapor retarder beneath the slab, pouring a well-engineered concrete slab, and allowing for optimum slab curing and drying times may add some time and up to $1 per square foot to your construction project. But if these measures aren't taken, it may cost up to $35 per square foot to correct.

Moisture Testing

Although concrete may appear dry, water is constantly moving to the surface and evaporating. All concrete is permeable and allows the passage of water vapor. Problems begin when this moisture is excessive, which occurs if there is no vapor retarder and the water is being carried up from the ground, or because the concrete is still drying. Moisture testing is well worth the 60 to 72 hours it takes to get results in order to properly measure the installation conditions. If the moisture test fails, and you seal off the means for water to escape by installing a floorcovering, it is a virtual set up for flooring failure.

Traditionally, moisture testing was recommended for on-and-below grade installation over concrete. But, with fast track construction and the use of curing compounds over lightweight aggregate concrete on steel deck construction, testing is now recommended for all grade levels. Many contractors do not run objective testing for a number of reasons including lack of time, substituting visual "subjective" analysis instead, cost-cutting, or assuming an older slab for a renovation project does not need testing. Concrete slab age is irrelevant. All concrete surfaces emit moisture in the form of vapor, regardless of age or grade level.

The Calcium Chloride Test

A practical, well-established and widely accepted test for dynamic moisture is the Calcium Chloride Test. This test has reflected industry-wide standards for concrete moisture vapor emission levels for decades.

This test measures a change in the weight of moisture-absorbing anhydrous calcium chloride and represents the amount of moisture transmitting out of a large concrete surface area. The value is expressed in pounds–a pound being the equivalent weight of the water that is emitted from a 1,000 square foot concrete slab surface during a 24-hour period of time. The number of tests needed to determine if a substrate meets the requirements for a successful floorcovering installation is a minimum of three tests for the first 1,000 square feet, and one additional test for each additional 1,000 square feet.

Follow the procedure detailed in ASTM F 1869, which outlines the standard method for measuring vapor emission rates on concrete subfloors using the Calcium Chloride Test. Conduct the test in an environment similar to what the finished flooring will be maintained in. And it's important to note that the test measures the amount of moisture at the time of testing, but it cannot predict moisture that may occur in the future. So, it's a good idea to conduct this test every time you install a new floorcovering or when the building environment experiences moisture changes from natural and man-made conditions.

The test is not difficult or complicated to conduct. If you are interested in learning more about test procedures, or about the specifics of ASTM F 1869, "Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloors Using Anhydrous Calcium Chloride", contact the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA, 19428. (610-832-9500.)

Calcium Chloride Test being retrieved after 64 hours of moisture testing.

pH Testing

In addition to the Calcium Chloride Test, a concrete pH test must be conducted to check for high pH levels, which can give rise to problems ranging from adhesive and floorcovering incompatibility to alkali deposits and damage. Fresh concrete is naturally alkaline, and as the slab dries, the pH usually drops to an acceptable level to install floorcoverings. But, alkali is a highly destructive natural chemical that exists in some soils. If moisture dissolves the alkali and carries it to the slab surface, the pH level remains high and the concrete can be compromised. If the floorcovering is already installed, the alkali attacks the adhesive and flooring material, resulting in bumps, ridges and loosening of the floor. As the moisture evaporates around the floorcovering joints and seams, the alkali deposits that remain look like white, salt-like particles. This residue damages the floorcovering and creates walking safety issues.

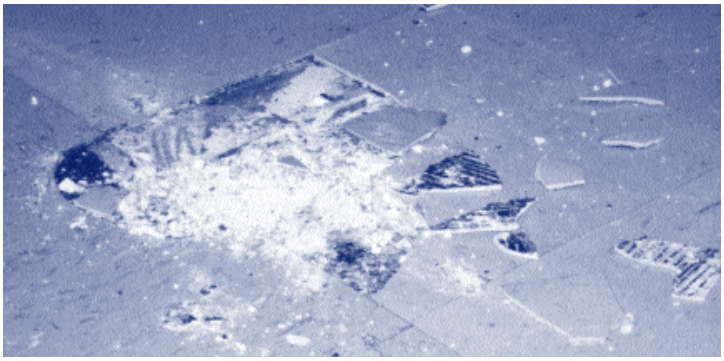
Calcium Chloride and pH tests/test kits are available from many scientific products manufacturers and distributors. Wide range pH tapes that measure acidity/alkalinity are included as part of most Calcium Chloride Test kits. If you are interested in obtaining this kit or learning how to conduct the test, contact your local StarNet Floorcovering Dealer.

Who's Responsible?

Determining who's responsible for conducting the tests can be complicated and frustrating, and there are varying schools of thought on that, let alone who is liable if a floorcovering experiences a moisture-related failure weeks, months or years after installation.

Protect yourself by insisting the general contractor or flooring subcontractor conduct the tests and prepare a written report. The report should be signed, dated and available to the GC, flooring subcontractor and, if appropriate, to the architect, interior designer, facility manager and building owner.

Architectural project specifications should also require that successful testing be conducted before the floorcovering is installed. This is an important liability issue--architects have been sued for improper or nonexistent specifications on moisture testing.



This gypsum-based floor patch swelled from too much moisture, causing the mechanical failure of the floor

Moisture Limits

Virtually all flooring manufacturers have moisture limits for the installation of their products. Most resilient flooring requires a maximum of 3 or 5 lbs. per 1000 square feet per 24 hours, depending upon whether the flooring is a sheet or tile, and the kind of backing it has. The Carpet and Rug Institute recommends a maximum of 3 lbs. unless the carpet is more breathable, in which case a maximum of 5 lbs. is recommended. Rubber, hardwood and ceramic flooring generally have a maximum of 3 or 5 lbs. as well. Always check with the manufacturer, or a professional floorcovering contractor for the allowable moisture limits.

Tackling Moisture and Vapor Emission Problems

If the test fails, your options include:

1. **Waiting additional time for the concrete to dry and/or using a desiccant drying system,**
2. **Altering the exterior drainage, gutters and downspouts.**
3. **Installing a suspended flooring system that is properly ventilated on the underside.**
4. **Controlling the vapor emission from the top side.**
5. **Removing and replacing the concrete and/or the vapor retarder, capillary break, and under-slab drainage.**

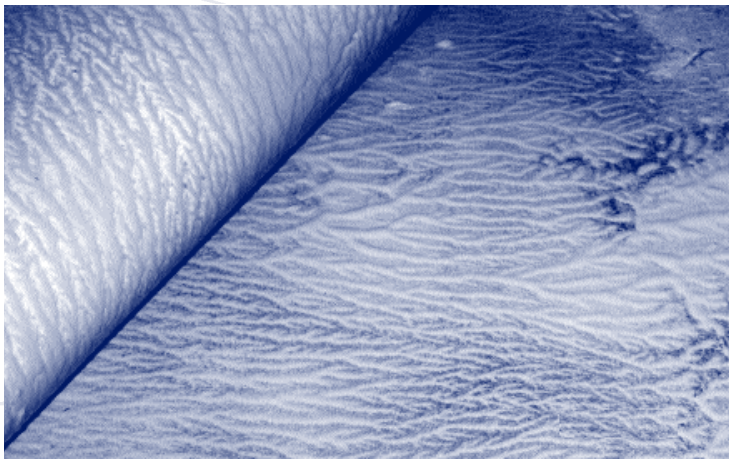
By all means you should refuse to install flooring until the test passes or until you can bring the problem under control. But, until you know what is causing the moisture problem, you can't fix it. Call in an expert, an engineering consultant who specializes in identifying moisture–related problems, to determine the cause and the best course of action.

Topical Control

If you choose to control the vapor emission topically, then work with professionals who manufacture and apply products designed exclusively to solve moisture-related problems.

There are three basic methods and materials:

1. **Penetrating liquids that enter into the concrete pores to stabilize humidity and immobilize mineral migration. Chemically reactive penetrants react with calcium hydroxide in the concrete to create a by-product that controls moisture. Mechanical penetrants control moisture without dependence on concrete chemistry.**
2. **Surface coatings coat the surface of the slab to suppress moisture vapor emission volume. These can have a wide range of permeability depending on the material and applied density.**
3. **Diffusive membranes establish physical space between the concrete and floorcovering or coating, creating a physical layer on the concrete surface to buffer the vapor pressure differential.**



Sheet floor failure from trapped water vapor.

Prevention is Key

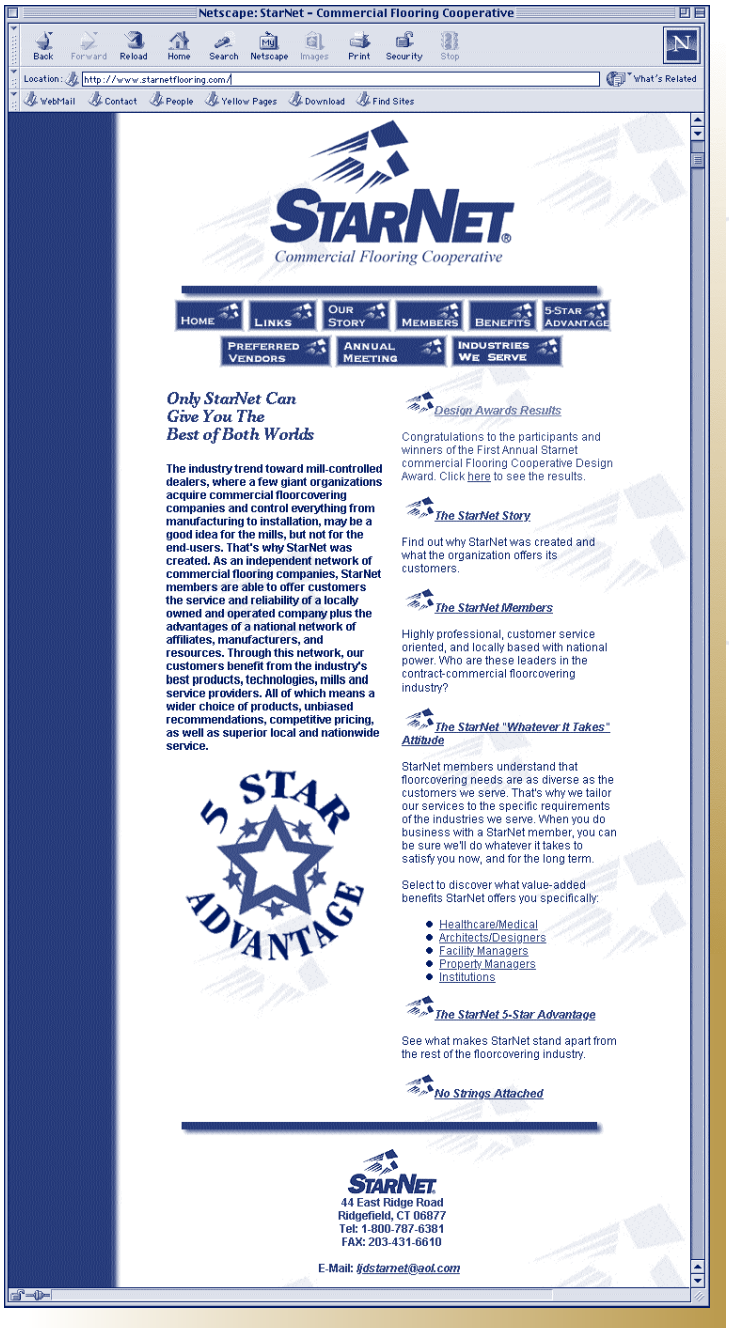
The floorcovering manufacturer or flooring subcontractor often gets the phone call when moisture damages the product. But, unless the flooring material was faulty to begin with, or installed incorrectly, they may not be to blame. The best policy to follow is prevention in the first place including:

- **A geotechnical survey before ground is broken, to identify environmental sources of water.**
- **Good under-concrete preparation including capillary breaks, moisture retarders and adequate drainage.**
- **Correctly written concrete specifications.**
- **A well-designed concrete slab with a low water/cement ratio, with adequate wet cure and slab drying times.**
- **Moisture testing and report filing prior to installing any floorcovering or coating.**

Finally, if a problem does surface, be sure to work with qualified experts in moisture identification and control that can help you manage the situation.

Information Sources:
Armstrong World Industries, Inc.
Carpet and Rug Institute
Floor Seal Technology
Resilient Floor Covering Institute
StarNet Flooring Cooperative Members

Check out our website for member information and more at: www.starnetflooring.com



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