Construction-Generated Moisture:

LIMITING ITS EFFECTS ON LOW-SLOPE ROOFING SYSTEMS

By SPRI

Roofing system assemblies are typically designed to accommodate occupancy-generated moisture based on building usage and function. Buildings with relatively small amounts of occupancy-generated moisture (office buildings, retail structures, etc.) can be designed differently from buildings with large amounts of occupancy-generated moisture (swimming pools, paper mills, etc.).

Moisture generated during the construction phase of a building, however, is rarely recognized and seldom addressed by roof designers. In moderate climate regions (ASHRAE zones 1-3), construction-generated moisture may go unnoticed until musty air is detected or mold growth is discovered.

In colder climate regions, construction-generated moisture may be detected in the form of drips inside the building after the first freeze/thaw cycle. These drips are often misinterpreted as roof leaks. For this reason, it is vitally important that projects with elevated levels of construction-generated moisture be engineered to accommodate, dissipate, or avoid this moisture load.

Sources of Construction-Generated Moisture

Moisture associated with construction can be generated by various trades. According to *The Manual of Low-Slope Roofing Systems* (Griffin and Fricklas, p. 112):

- A 4-in-thick concrete floor slab poured in an enclosed building generates one ton of water per 1,000 sq ft of concrete.
- The use of propane heaters (to provide more comfortable working conditions or to help "dry" the construction) also generates large quantities of moisture. For each 200-lb tank of propane burned, 30 gallons of water is produced.
- Oil-burning heaters produce 1 gallon of water for every 1 gallon of oil burned.
- Paint, plaster, drywall, and other water-based construction materials also contribute to construction-generated moisture and potential accumulation in the roofing system assembly.

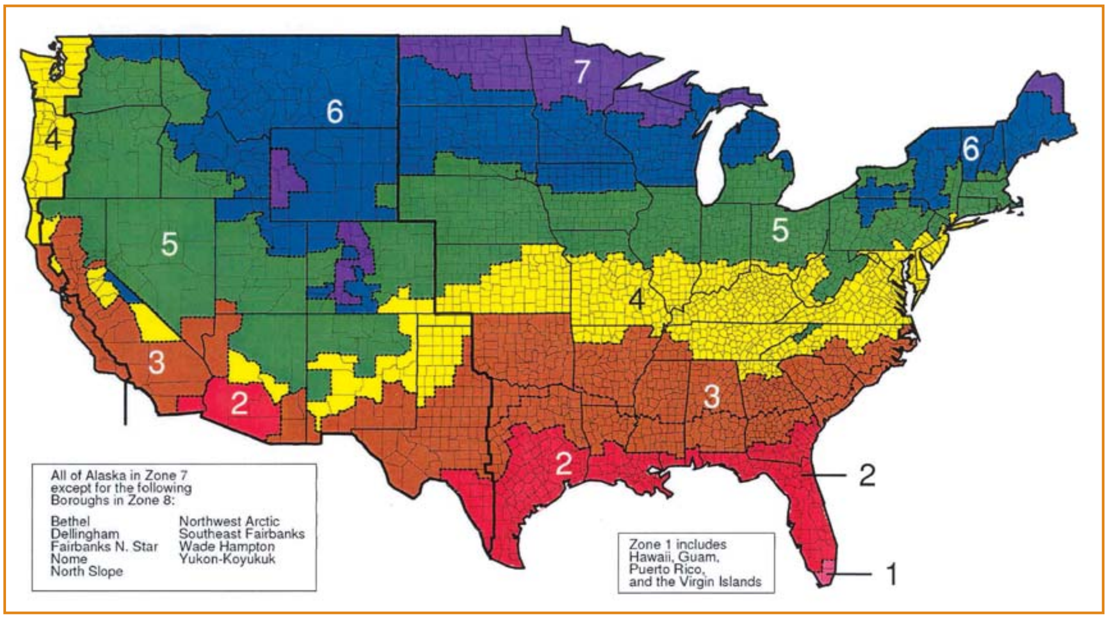

Chart 1 – In moderate climate regions (ASHRAE Zones 1-3), construction-generated moisture may go unnoticed until musty air is detected or mold growth is discovered. (Illustration courtesy of SPRI and ASHRAE.)

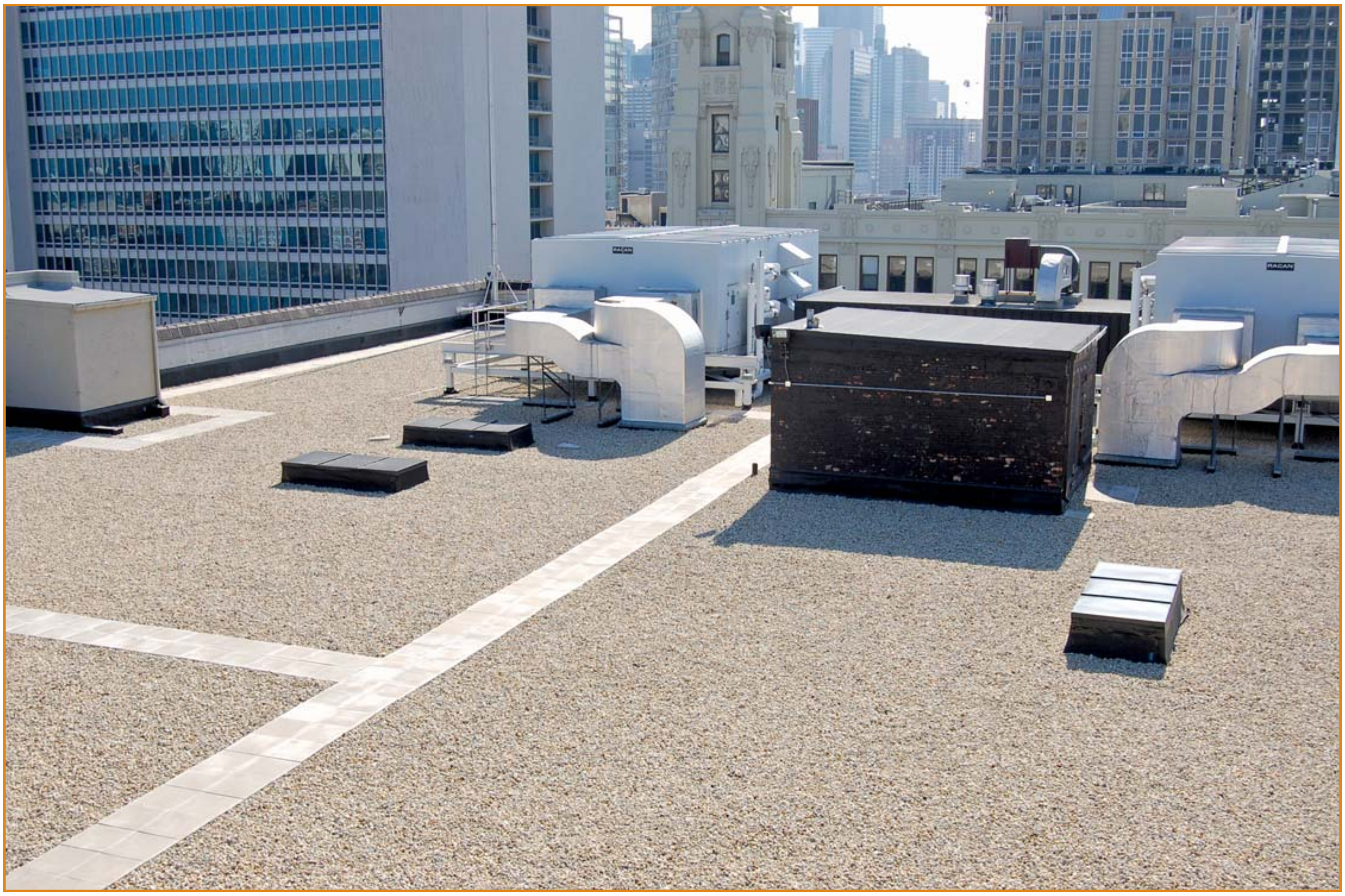

Photo 1 – In colder climate regions, such as Chicago, IL, construction-generated moisture may be detected in the form of drips inside the building after the first freeze/thaw cycle. These drips are sometimes misinterpreted as roof leaks. The ballasted EPDM roof shown here at 600 West in Chicago did not experience any moisture-related problems after construction. (Photo courtesy of Tom Hutchinson, Hutchinson Design Group Ltd., Chicago, IL.)

When proper measures are not taken, construction-generated moisture can contribute to high levels of relative humidity inside the structure. When the outside temperature drops, condensation can begin to form.

This condensation can appear on any cold surface (with a temperature at or below the dew point), including the underside of skylight domes, uninsulated portions of decks, roof insulation, or the underside of the roofing membrane.

Warm, moisture-laden air migrating upward can infiltrate or "intrude" into the roofing system assembly through deck-to-wall joints, gaps around penetrations, or voids in the deck. The intruded air is then trapped within the roofing system because of the air-impermeable roof cover.

As the air cools, condensation occurs, and liquid moisture will collect on colder surfaces, turning to frost and ice at temperatures below freezing. The higher the level of interior relative humidity and the greater the temperature differential between the interior and the exterior of the building, the more moisture will collect.

In extreme cases, and especially with the use of a single layer of insulation, ice buildup, due to condensation, can be noticed by a "cracking" sound when one walks on the membrane. Also, heavy ice formation along insulation joints can generate expansion forces that push laterally, causing insulation joints to widen. Condensation within the roof insulation may cause permanent damage, loss of R-value, and loss of wind-uplift resistance.

As the outside temperature rises and the roofing system assembly warms up, frozen moisture begins to thaw, resulting in drips inside the building. The drips are not associated with rainfall or snow accumulation on the roof. In fact, drips are more likely to occur on sunny days when temperatures warm to above freezing.

The intensity of the drips is directly related to the amount of moisture that has has been stored within the roofing system assembly. The concentration of drips, however, is more likely to be seen around the perimeter and at deck end-laps.

Controlling Construction-Generated Moisture

Roofing professionals need to identify and plan for construction-generated moisture during the design process. In order to reduce the probability of condensation, buildings under construction should be adequately ventilated during concrete hydration and other high-moisture-related construction activities.

Temporary, high-volume ventilation systems are commercially available and should be used during construction. These high-volume air-handling systems include dehumidification that is essential to remove the large amounts of moisture from the air. HVAC systems designed for temperature control of finished buildings are not sufficient to remove construction-generated moisture.

Additional Cold-Climate Design Recommendations

In cold-climate regions (ASHRAE Zones 5-8, see *Chart 1*), the following design recommendations should be considered as a matter of general practice. These recommendations are intended to supplement the measures taken to control construction-generated moisture.

- Use a vapor retarder to prevent moisture accumulation caused by air intrusion. The vapor retarder must be positioned within the roofing system assembly so that its temperature is always warmer than the dewpoint temperature. This prevents the warm, moist air from reaching the dewpoint, thereby eliminating condensation. Consult a roofing design professional or the roofing materials manufacturer/supplier to ensure that the proper amount of insulation (R-value) is used to keep the vapor retarder "warm."
- Use multiple layers of insulation (minimum of two) with staggered joints to help retard warm, moist airflow from the interior of a building up into the roofing system.
- Seal deck-to-wall joints and gaps around roof penetrations (air barriers) to further limit air infiltration into the roofing system assembly.
- Avoid, where possible, the use of wet materials or materials with excessive moisture contents.

Remedies for Existing Conditions

In buildings where drips are frequently experienced, the interior relative humidity should be measured. If the interior humidity exceeds the outdoor humidity, a condensation problem may exist. It is also important to note that simply comparing relative humidities is not enough.

For example, a low outside temperature (20°F) with a high relative humidity (90%) would still allow condensation to form in a roof system when the interior temperature is 70°F. Even with a lower interior relative humidity of 40%, condensation can occur. The reason is that the interior vapor pressure is higher because of the greater capacity of the warme air inside to hold moisture—even though the exterior is more humid, relatively speaking.

Either way, these buildings should be adequately ventilated and dehumidified to remove excess moisture. Additionally, the following recommendations may help eliminate drips.

- Verify that the design operating temperature of the facility has not been exceeded. The warmer the air, the more moisture it can hold.
- Provide air circulation using mechanical or electrical fans during the winter months to mix warmer and colder air, preventing moisture-laden air from accumulating beneath the roof deck.
- Ensure that the deck-to-wall joints and joints between the deck and roof penetrations are sealed from the underside to prevent intrusion of warm air from the building interior.

Conclusion

All buildings should be designed to accommodate occupancy-generated moisture. In addition, construction-generated moisture must be controlled. Buildings under construction should be adequately ventilated during concrete hydration and other high-moisture-related construction activities.

All roofing system assemblies should be designed to accommodate the anticipated occupancy-generated moisture based on building usage and function. In a cold-climate area, the use of a vapor retarder should be considered as determined by a roofing design professional.

Eliminating moisture intrusion into the roofing system assembly will improve the performance and life expectancy of the assembly, which is a benefit to the entire building industry.

Photo 2 – Many roof designers are excited about the potential of vegetative and photovoltaic (PV) roofing systems. However, construction-related moisture problems are common to all types of roofs. (Photo courtesy of GAF Materials Corporation, Wayne, NJ.)

SPRI is a trade association representing sheet membrane and component suppliers to the commercial roofing industry. For more information about SPRI and its activities, visit the association's Web site at ***www.spri.org****.*