# [ ANOTHER BENEFIT FROM ABOVE-SHEATHING VENTILATION ! ]

## Moisture Removal Benefits with Above-Sheathing Ventilation on Steep-Slope Metal Roofs

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Providing an air space above the sheathing of a roof deck offers thermal benefits for stone-coated or standing seam metal roofs that yield energy savings in the summer and winter while also helping to remove unwanted moisture. The natural ventilation above the sheathing improves the durability of the underlying structure of the roof.

Metal roofs are sometimes offset mounted from the roof deck using a double-batten (counter-batten) construction. The design provides an air space between the exterior face of the roof sheathing and the underside of the roof cover so that a clear, albeit complex, air pathway exists beneath the roof cover. Solar irradiance absorbed at the roof's surface is conducted through the metal roof and heats the air space. The warmer and therefore more buoyant air moves up the inclined air passage. The ventilation scheme helps remove unwanted heat but it also removes unwanted moisture from the roof deck, thereby improving the roof's thermal performance as well as its durability. The thermally induced airflow occurring in this air space is termed above-sheathing ventilation (ASV).

Figure 1: Batten and counter-batten system used to mount stone-coated metal roofs.

Field studies were conducted on several attic assemblies having stone-coated metal shake roofs with and without cool color (infrared reflective) pigments and with and without above-sheathing ventilation. Stone-coated metal roofs are often offset mounted from the roof deck using a batten and counter-batten system. Here counter-battens made of nominal dimension wood strips (1 by 4's) are nailed to the roof deck from soffit to ridge, and battens (2 × 2's) are placed above the counter-battens and nailed to the deck (Fig 1).

### MOISTURE REMOVAL BENEFIT

A moisture engineering analysis was performed on the roof system depicted in Figure 1 using the MOISTURE-EXPERT model (Karagiozis 2001) that has shown good agreement in ventilated wall systems. The intent was to show the potential for reducing moisture-related problems in the roofing systems using ASV.

The following modes of heat and moisture transport were included:

- Vapor diffusion through all porous roof construction materials
- Liquid transport through all porous roof construction materials
- Air convection transport for both thermal and moisture components
- Moisture storage in all roof construction materials
- Radiative transport with nighttime sky conditions
- Radiative transport within the air gap provided by the stone coated metal roof
- Condensation and evaporation processes and freeze and thawing processes with the associated latent heat exchanges

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In the simulation analysis, the exterior and interior environmental loads were assumed for the climatic conditions of Knoxville, Tennessee. The proposed ASHRAE SPC 160P, "Design Criteria for Moisture Control," was employed for both the exterior and interior hygrothermal loading conditions. All simulations were initiated using double the equilibrium moisture content (EMC) at 80% relative humidity. Both the ventilated and non ventilated cases were simulated for a period of 2 years.

A snapshot of the moisture content in the sheathing board {oriented strand board (OSB)} is given in Figure 2. The simulation period started October 1, 2005, one of the more difficult periods of

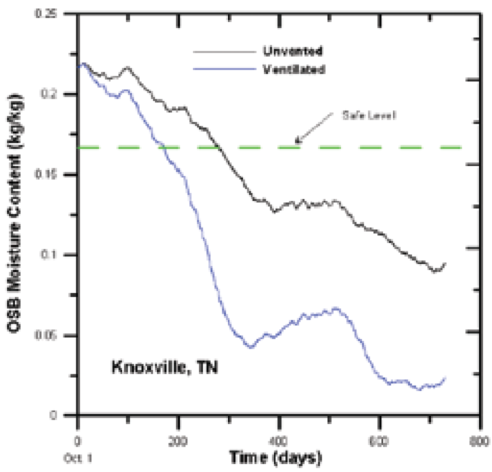
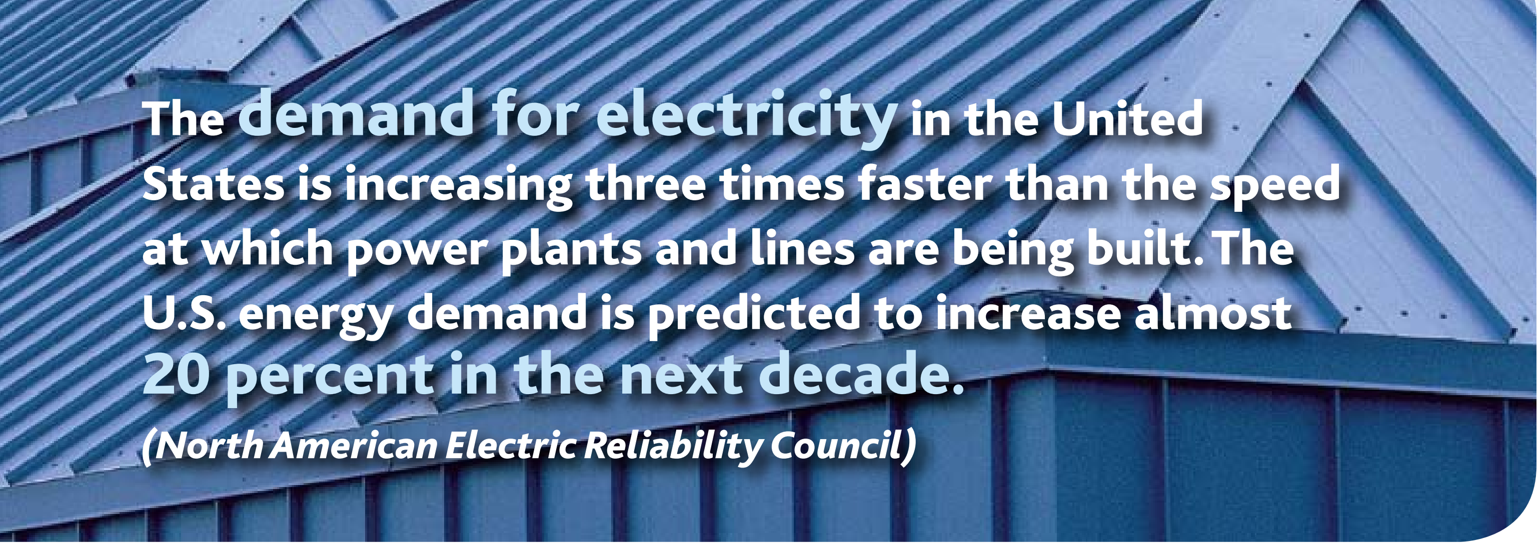



Figure 2. Comparison of moisture content of OSB layer as a function of ventilation strategy (ventilated vs. non vented) for a 2-year period.




the year for the sheathing to dry out. ASV accelerated the removal of unwanted moisture and reduced the moisture content of the OSB sheathing well below that of the OSB in a closed cavity (Figure 2). Ventilating the roof deck dried the OSB within 200 days to safe moisture limits in which fungal growth would not typically occur. In comparison, the closed roof deck required an additional 100 days to reach safe moisture content.

The number of air exchanges occurring within the ventilated cavity (Figure 3) tells the story. The occurrence of air exchange rates are displayed for the assumed air changes per hour (ACH), which are dependent on both temperature and wind pressure

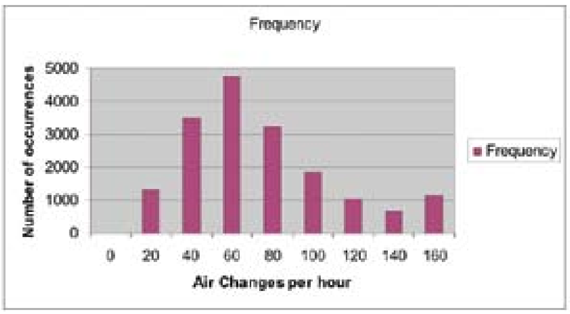



Figure 3. Period of time during 2-year simulation for cavity air changes per hour (wind- and temperature-dependent).

flows acting along the roof ventilation cavity. Roughly 20-100 ACH are prevalent about 80% of the time during the 2-year simulation runs. The 60 ACH was the maximum incident air exchange rate observed occurring about 25% of the time. Therefore, the potential moisture removal benefits afforded by ASV are evident from the vented compared to the non vented simulations.

As a check, Miller (2006) made field measurements of the airflow underneath stone-coated metal shake roofs (Figure 1) by monitoring the decay rate of the tracer gas $CO_2$ with time and deducing the flow rate from a continuity balance for the concentration of $CO_2$. The $CO_2$ gas was injected into the vent gap of the soffit to saturate the cavity. After a substantial buildup of concentration registered on a monitor, the gas injection was stopped, and the concentration was recorded at timed intervals. All measurements were made around solar noon, when the roofs were at their highest temperatures. Computed airflows were about 18 cfm, which for the volume of the air space yields about 80 air changes per hour. Therefore, the measured data is well within reason of the results from the hygrothermal simulations.

## Summary

Moisture is a prevalent issue in all aspects of building design. Metal roofs employing above-sheathing ventilation show superior hygrothermal performance when compared with a non vented roof system. Above-sheathing ventilation therefore adds yet another feature to this ecologically sound building material. Providing the ventilation above the sheathing improves the durability of the underlying structure of the roof. As a result, the expected performance of metal roofing in high winds and hail storms is further enhanced because of the improved hygrothermal performance afforded by a metal roof system using above-sheathing ventilation.

Future articles will address: (1) does above sheathing ventilation reduce attic air temperatures and in turn reduce heat losses from ducts installed in attics; (2) does increased spacing of the air gap improve thermal performance; (3) what are the seasonal benefits of above sheathing ventilation; and, (4) does above sheathing ventilation help retard ice damming.

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