Session VII-B: Roofs

Tuesday, December 7, 2004
3:30 p.m. to 5:00 p.m.
Grand Ballroom – Palm

Session Chair:
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3:30 p.m. to 3:40 p.m.	Introduction Dave Roodvoets
3:40 p.m. to 4:00 p.m.	*"Using a Heat and Moisture Transfer Simulation to Diagnose Moisture-Related Expansion/Contraction Problems in an Exterior Roof/Wall Assembly"* Larry Elkin
4:00 p.m. to 4:20 p.m.	*"The Pitfalls of Snow Retention on Metal Roofing"* Robert Haddock
4:20 p.m. to 4:40 p.m.	*"Saving Energy by Cleaning Reflective Thermoplastic Low-Slope Roofs"* David Roodvoets
4:40 p.m. to 5:00 p.m.	*"Effect of Solar Radiation Control on Electricity Demand Costs—An Addition to the DOE Cool Roof Calculator"* Tom Petrie
5:00 p.m. to 5:20 p.m.	*"Ice Damming: Case Study in Diagnosis and Remediation"* Mark Lucuik

Using a Heat and Moisture Transfer Simulation to Diagnose Moisture-Related Expansion/Contraction Problems in an Exterior Roof/Wall Assembly

J. Lawrence Elkin – *Campbell, Schneider & Associates, LLC*

A pyramid-shaped structure was constructed along the South Carolina coast in 1995. The structure was designed for use as a restaurant facility. Within months of completion, the exterior cladding began to exhibit deformations that suggested excessive expansion of the synthetic stone veneer panels. The panels were tested to determine if the hot and humid environmental conditions produced the excessive movements. Testing did not indicate that environmental exposure was the cause of the deformation. A review of the construction drawings revealed that the roof/wall assembly incorporated an additional layer of insulation not indicated by the veneer manufacture's literature. The designer specified a 3.5-inch-thick layer of EPS to be installed between a layer of structural steel panels and a plywood fastening surface. The roof/wall assembly was modeled using WUFI Pro to simulate heat and moisture transport through the assembly. The WUFI data were exported to a spreadsheet so that coefficients of thermal and moisture-related expansion/contraction could be applied to study movement of the wall components. The data revealed that unanticipated contraction of the plywood substrate, as a result of drying, caused the exterior panel deformations. The results from computer modeling correlate closely to field measurements and anecdotal evidence collected by several investigators throughout the history of the building.

The Pitfalls of Snow Retention on Metal Roofing

Robert M. Haddock – *Metal Roof Advisory Group, Ltd*

Metal roofs have long been considered a product of choice for snow areas because of their superior response and tolerance to many of the characteristics of such environments. The author has had extensive experience in designing and investigating metal roofs used in cold climates domestically and in Western Europe and Scandinavia and has recently been a lead author for Metal Roof Design for Cold Climates. This document presents useful perspectives on snow and ice dynamics as it relates to both metal roof design and the art and science of snow retention systems. It is not the purpose of this paper to address load requirements or the effects of drifting snow on structure design;, it is to assist the designer in making informed decisions through awareness of snowmelt phenomena and snow guard styles and types. Concepts presented here are founded on conventional science harmonized with domestic and North European trade practice of more than 500 years.

An aspect of metal roof design in cold climates that is commonly neglected has to do with snow retention. When snow blankets a roof, an adhesive bond occurs between the snow bank and the metal panels. The vertical load of snow is translated to a vector load parallel to the panels' surface. When the temperature-sensitive bond between roof surface and snow bank is broken, this force propels a blanket of snow from the roof in avalanche fashion. This can be a nuisance and a hazard. Snow guards have been used for a thousand years to mitigate these issues.

Popular "standing seam" products are designed with "floating" attachments that enable the panels to respond freely to thermal stress. These panel designs involve a singular point of positive attachment. The vector loads from a snow blanket on the roof's surface accumulate to that single point. Attachment at that single point must be adequate to resist the loads that are accumulated. Contrary to popular myth, the use of snow guards does not increase these loads except under rare circumstances. Any snow retention system must, however, be designed site-specifically to withstand these forces.

Saving Energy by Cleaning Reflective Thermoplastic Low-Slope Roofs

David Roodvoets – *SPRI, Inc.*

William A. Miller and André O. Desjariais – *Oak Ridge National Laboratory*

Temperature, heat flow, reflectance, and emittance field data have been electronically cataloged for a full three years for 18 different single-ply membrane roofs exposed to different climates across the U.S. Our results show that the surfaces of the white thermoplastic roof systems lost about 30% to 50% of their solar reflectance after three full years of field exposure. The field data were used to validate a computer code, and simulations were run to determine the trade-off in added insulation and the increase in the cost of building roof energy caused by soiling of the thermoplastic membranes. Simulations also showed what energy costs a building owner would incur before it is economically justifiable to wash a roof.

Washing a high-reflectance thermoplastic membrane roof in Phoenix is clearly justified for roof insulation as high as R-30. In fact, building owners can realize a net savings of about 6¢ per square foot if they wash the roof every other year for a roof with a white thermoplastic membrane and R-15 insulation. In the more moderate climate of Knoxville, the advantage for washing the roof is only about 1¢ per square foot after three years of exposure for a highly reflective thermoplastic membrane with R-15 insulation. Cooling-energy savings are offset by the heating-energy penalty, and it appears that the ratio of cooling degree-days to heating degree-days exceeding 0.4 may roughly represent the boundary for periodically washing cool roof membranes.

Effect of Solar Radiation Control on Electricity Demand Costs–- An Addition to the DOE Cool Roof Calculator

Tom Petrie, Kenneth E. Wilkes, and André O. Desjarlais – *Oak Ridge National Laboratory*

Two versions of the DOE Cool Roof Calculator are on the Internet to assist in the selection of an energy-saving surface for low-slope roofs. The CoolCalcEnergy version, for small and medium-sized commercial facilities, gives savings based on costs per unit of energy. This paper documents how the CoolCalcPeak version was added to include estimates of savings in demand charges that large facilities often incur for electricity. The database for the Cool Roof Calculator was reworked. Differences in peak deck heat fluxes with and without solar radiation control were obtained over the cooling season for varying locations (as characterized by average solar insolation), R-value of the low-slope roof, and solar reflectance and infrared emittance of the roof surface. Peak solar insolation is relatively constant over the U.S. Thus, lower demand charges save about the same amount of annual operating costs for a particular set of circumstances in all U.S. climates that have significant cooling requirements.

Ice Damming: Case Studies in Diagnosis and Remediation

Mark Lucuik and William C. Brown – *Morrison Hershfield Limited*

Ice damming is a problem that annually affects a large number of buildings in Canada. It is generally associated with interior leakage and with accompanying mold and rot and can also present a danger of falling ice. However, it can also affect the service life of roofing materials and components, even if leakage to the interior doesn't occur.

Ice damming is a building science issue that arises from differential melting and freezing of snow on a roof. The root causes of the melting are frequently far from the roof deck. As a consequence, methods to alleviate ice damming often treat the leakage without addressing the fundamental cause. Such methods can reduce or eliminate the leakage in the short term but, because they do not address the cause of the melting and freezing, they often do not provide a long-term solution. In addition, they frequently do not address the durability issues caused by ice buildup on the roofs. The best solution is to determine the causal factors and undertake appropriate remediation in order to solve the problem on a longer-term basis.

This paper will discuss the factors that contribute to ice damming through detailed case studies on three low-rise condominium complexes in Ottawa, Ontario, Canada. Each complex has suffered severe ice damming since its construction. To develop a remediation strategy, we performed a systematic diagnosis of the cause of the ice damming and the implementation of trial repairs at each site. These trial repairs were monitored (temperature and visual indicators), and it was found that the suggested repairs had some benefit on two sites and little benefit on the third.