Session XI-A: Thermal Performance II

Wednesday, December 8, 2004
3:30 p.m. to 5:00 p.m.
Grand Ballroom – Beach

Session Chair:

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3:30 p.m. to 3:40 p.m. Introduction
Chris Mathis

3:40 p.m. to 4:00 p.m. *"Thermal Conductivity of Moist Cellular Concrete—Experimental and Numerical Study"*
Dariusz Gawin

4:00 p.m. to 4:20 p.m. *"Long-Term Thermal Resistance of Polyisocyanurate Foam Insulation with Gas Barrier"*
Phalguni Mukhopadhyaya

4:20 p.m. to 4:40 p.m. *"Evaluating Overall Thermal Performance of Metal Curtain Walls Using Large-Scale Testing"*
Hua Ge

4:40 p.m. to 5:00 p.m. *"Component Modeling Methodology for Predicting Thermal Performance of Nonresidential Fenestration Systems"*
Charlie Curcija

Thermal Conductivity of Moist Cellular Concrete—Experimental and Numerical Study

Dariusz J. Gawin – *Technical University of Lodz*

Jan Kosny and Kenneth Wilkes – *Oak Ridge National Laboratory*

Hygrothermal phenomena in cellular concrete samples during the steady-state tests of thermal conductivity have been numerically simulated. It has been found that the most important factor for the accuracy of these tests is the initial moisture content of the test specimens. In the range of 70-85% RH the "heat pipe" mechanism is of importance, causing an additional latent heat transport, which increases apparent thermal conductivity. This phenomenon is strongly influenced by the material porosity and inner structure of pores, i.e., the shape of the sorption isotherms. Outside this range of relative humidity, errors caused by moisture transport and related heat effects are negligible. The error caused by moisture has been found for the cellular concrete with density of 600 kg/m3 to be smaller than for the 400 kg/m3 one. For smaller values of specimen thickness, the error is smaller. The smaller the temperature difference used between plates of the heat-flow-meter apparatus, the smaller is the moisture induced error observed. On the basis of the computer simulation results, graphs and tables with correction factors are developed to improve the accuracy of steady-state measurements of thermal conductivity for cellular concrete.

Some experimental results of steady-state measurements of thermal conductivity by use of the heat-flow-meter apparatus are presented. They concern three types of cellular concrete with densities of 400, 500, or 600 kg/m3 and additionally for two types of lightweight concrete, i.e., wood-concrete and EPS-concrete, at various moisture contents. These results qualitatively confirm the theoretical predictions presented in the first part of the paper.

Long-Term Thermal Resistance of Polyisocyanurate Foam Insulation with Gas Barrier

Phalguni Mukhopadhyaya, M. Kumar Kumaran, John Lackey, David van Reenen, and Nicole Normandin – *National Research Council Canada*

Mark T. Bomberg – *Concordia University*

Michel Drouin

Closed-cell polyisocyanurate (polyiso) foam insulation with gas barriers or impermeable facers is used in various building envelope applications. The impermeable gas barrier on both sides of polyiso foam insulation board is designed to maintain the long-term thermal resistance (LTTR) of the insulation at a higher level. Recently, researchers at the Institute for Research in Construction (IRC)/National Research Council (NRC) of Canada, in association with the Canadian Polyisocyanurate Council, have been working to develop a standard test methodology that would help to quantify the design LTTR value of polyiso foam insulation boards with impermeable facers. This paper presents selected results from laboratory tests, field observations, and numerical modeling. Comparisons among these results indicate that the extent of thermal aging of impermeably faced polyiso foam boards can vary in different products. A concept of combined lateral and normal diffusion has been introduced in the numerical modeling to help prediction of the long-term thermal behavior of impermeably faced polyiso products. However, comparisons between the experimental and numerical modeling results indicate that the ratio of lateral to normal (L/N) diffusion rate is not the same for full thickness boards as for thin slices.

Evaluating Overall Thermal Performance of Metal Curtain Walls Using Large-Scale Testing

Hua Ge – *British Columbia Institute of Technology*

Paul Fazio – *Concordia University*

A comprehensive research program was carried out to establish the overall performance of curtain walls including thermal, condensation, energy, and indoor thermal comfort using a holistic approach. The study aimed at evaluating the relative importance of design details in contributing to the overall performance of curtain walls, to provide recommendations on the improvement of product design for manufacturers and to quantify the benefits provided by advanced systems.

The research work included both laboratory testing and simulation analyses. This paper presents the experimental studies. A two-story full-size test specimen (3.8 m by 6.7 m) made up of two types of curtain wall designs was tested under a series of steady-state and periodic winter conditions in a large-scale environmental chamber. The testing carried out included (1) air leakage tests, (2) thermal performance tests, (3) measurement of the local convection film coefficient, and (4) measurement of local draft induced by cold curtain wall surfaces.

The experimental results indicate the effect of design details on the performance of curtain walls. For example, high-performance glazing unit provides 20% higher condensation resistance than standard double IGU, and the advanced frame system with larger thermal breaks provides 30% higher condensation resistance than the regular frame system. To carry out the experimental study effectively, a number of innovative test procedures were developed. The testing provided a valuable set of experimental data that may be used to validate current and future computer simulation programs.

Component Modeling Methodology for Predicting Thermal Performance of Nonresidential Fenestration Systems

D.C. Curcija – *University of Massachusetts*
M.S. Bhandari – *Carli, Inc.*
M. Manteghi – *TRACO Architectural Systems, Inc.*
B.V. Shah – *National Fenestration Rating Council*

Nonresidential fenestration systems have different characteristics from residential products and therefore require different treatment. A component modeling methodology has been developed and is presented in this paper to specifically address nonresidential fenestration products, from punched openings to site-built and assembled products. The basic premise of this methodology is that the manufacturer of each fenestration component (i.e., framing, glazing, and spacer manufacturer) is responsible for its own product, for which the performance is published in NFRC-certified product directory (CPD), while the overall performance of the fenestration system is determined using functions developed from a number of actual runs with real glazing and spacer systems. The methodology is based on four generic runs, incorporating the high and low end of performance (i.e., best/worst or B/W options). This methodology can be implemented in a software tool, which would pull component information from the CPD into its own database and would calculate thermal and solar-optical performance at the standard size as well as the actual product size. This way, not only responsibility for component performance is clearly defined, but also the input data about fenestration systems for building energy simulation is accurate and will lead to more precise prediction of peak loads and annual energy use. Implementation of this methodology within a nationally recognized rating program will allow for uniform and accurate representation of nonresidential fenestration systems, for both site-built and punched opening type of fenestration products, while still providing data for a prescriptive path in energy codes (e.g., performance at standard NFRC size).