Session V-A: Below Grade

Tuesday, December 7, 2004
10:30 a.m. to 12 noon
Grand Ballroom – Beach

Session Chair:

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10:30 a.m. to 10:40 a.m. Introduction
Bill Healy

10:40 a.m. to 11:00 a.m. *"Interior Retrofit of Masonry Wall to Reduce Energy and Eliminate Moisture Damage: Comparison of Modeling and Field Performance"*
Peter Häupl

11:00 a.m. to 11:20 a.m. *"Determination of Long-Term Mechanical Properties for Thermal Insulation Under Foundations"*
Hogler Merkel

11:20 a.m. to 11:40 a.m. *"Frost Heave in Swedish Slab-on-Grade"*
Peter Roots

11:40 a.m. to 12:00 p.m. *"Heat Loss to Building Foundations: An Analysis Based on a Theory of Dynamic Thermal Networks"*
Eva-Lotta Wentzel

Interior Retrofit of Masonry Wall to Reduce Energy and Eliminate Moisture Damage: Comparison of Modeling and Field Performance

Peter Häupl, Heiko Fechner, and Hans Petzold – *Dresden University of Technology*

In middle and northern Europe many existing buildings have to be improved energetically by means of additional thermal insulation on the building envelope. For buildings with façades worthy to be preserved, only an inside insulation layer may be possible, but with inside insulation layers, moisture problems often arise.

Using a capillary active material, as has been done in this research, the amount of condensation water on the cold side of the inside insulation can be reduced. Also, a vapor retarder is not necessary and, therefore, the drying potential is not limited.

Based on the physical models for coupled heat, air, water vapor, capillary water, pollutant, and salt transport (CHAMPS) in porous building and insulating materials and the computer code DELPHIN developed at the Institut für Bauklimatik (Dresden, Germany), in continuation of the topic "capillary active inside insulation," further substances and substance combinations were investigated in order to develop safe wall constructions in connection with appropriate thermal insulation. That was done via a computational prognosis and, secondly, with practical application in six test houses in Germany. The latter were connected to measurements of all climatic boundary conditions, such as temperature, relative humidity, shortwave radiation, precipitation, wind velocity and direction, as well as hygrothermic properties, such as temperature and humidity, in the materials.

For numerical simulation, a set of storage and transport functions for the porous building materials is necessary. This paper describes the modeling and measurement of the moisture storage and moisture transport functions for the capillary active insulation material "calciumsilicate" used in the study.

A comparison of measured and calculated hygrothermic performance within the envelope in a renovated frame house near Hannover, Germany, shows good correspondence. Heat losses have been reduced to one-third, and condensation water does not exceed 0.5 kg/m² during winter. Moreover, a simplified computer code, COND, has been developed. It delivers about the same results and a sufficient assessment of the moisture distribution in the structure.

Determination of Long-Term Mechanical Properties for Thermal Insulation under Foundations

Holger Merkel – *DOW Deutschland GmbH&Co. OHG*

Thermal insulation is widely used in applications under sustained loading, such as insulated foundations of buildings. In this application, the impact of thermal insulation is twofold—frost protection and energy saving. In order to maintain the thermal protection of foundations over the lifetime of a building, it is absolutely necessary to predict the long-term mechanical performance of thermal insulation materials. Accordingly, requirements have been defined in the new harmonized European standards for factory-made insulation product.

This paper discusses the impact of these requirements on determination and design of properties for thermal insulation products, such as extruded polystyrene foam (XPS), typically used in this application. The key physical phenomena, which determine the long-term mechanical behavior, are described as well as a mathematical model for prediction of long-term performance. Based on experimental results and findings, conclusions are drawn for the design of thermal insulation layers under foundations.

Frost Heave in Swedish Slab-on-Grade

Peter Roots and Carl-Eric Hagentoft – *Chalmers University of Technology*

This paper discusses the risk for frost heave in modern Swedish slab-on-grade. Theoretical simulations are undertaken in order to model the frost front below the slab. Different designs of the slab-on-grade for a north (Luleå) and a south (Lund) location in Sweden are studied. For example, the insulation thickness below the slab is varied and frost protection insulation is applied with different thicknesses and widths.

The results show that there is a risk of frost heave. In a well-insulated slab-on-grade, the frost front will extend below the edge beam of the slab. However, with frost protection insulation, the depth of the frost front below the slab will be reduced significantly. Frost heave must be considered in the design process for a modern Swedish slab-on-grade.

Heat Loss to Building Foundations: An Analysis Based on a Theory of Dynamic Thermal Networks

Eva-Lotta Wentzel and Johan Claesson – *Chalmers University of Technology*

The calculation of heat flow in the ground, in particular the time-dependent heat loss through the foundation, poses particular problems due to three-dimensional flow and very long time scales. In this paper a new tool of analysis called “dynamic thermal networks” is presented briefly and used to analyze the time scales for the time-dependent heat loss for different types of foundations: a slab-on-ground, a cellar, and a split-level foundation.

The heat loss may be divided into a transmittive and an absorptive component. The transmittive and absorptive step-response fluxes and the corresponding weighting functions provide a precise description of the time scales of the heat flow to the ground. It is shown that the transmittive component has time scales of a decade and even more, while the absorptive component has a time scale of days only.