Article

CertainTeed SAINT-GOBAIN

Creating Energy-Efficient Building Envelopes

Design Strategies for Maximizing Thermal Control

Temperature changes from season to season have a significant impact on a building's energy use and occupant comfort. This makes the concept of thermal control a very important part of the design process, with the goal of having a more thermally efficient building. Understanding heat transfer and how certain building materials can be used to impede it is the first step in meeting this objective.

HEAT TRANSFER

Incoming and outgoing heat flow is a prominent factor in determining a building's comfort level and operating cost. Heat has a natural tendency to flow from an area of high temperature to one of lower temperature. The greater the temperature difference, the more the heat flows through an assembly. For example, a heated building will lose heat to its colder exterior in the winter. And, during the summer, an air-conditioned building will draw heat from its very warm exterior.

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The rate of heat transfer through the wall depends on two things — the temperature difference between interior and exterior and the makeup of the wall materials. Some materials — such as glass, concrete and all metals — transfer heat very well and are called conductors. Other materials, such as fiber glass and foam sheathing, are referred to as insulators with a high resistance to heat flow.

There are three different ways through which heat transfers in and out of a building — conduction, convection and radiation. In a building, these modes of heat transfer all occur at the same time and play an important role in the heat balance of a building.

Conduction is probably the best known and the easiest to understand heat transfer mode. It takes place when a material separates an area of high temperature from an area of low temperature, such as a wall. **Convection**, the second most common heat transfer mode, occurs as a result of liquid or gas moving over a surface, such as wind blowing against a building. There are two types of convection — forced and natural. Natural convection occurs when the movement of liquid or gas is caused by density differences, and in forced convection, the movement of the liquid or gas is caused by outside forces. **Radiation** involves the transfer of invisible electromagnetic heat waves from one object of higher temperature, such as the sun, to another of lower temperature, such as a human body.

To make a building more energy efficient and comfortable, building and design professionals need to impede these modes of heat transfer. Though it is impossible to stop these processes entirely, it is possible to significantly slow them down by placing obstacles in their path. This is referred to as "breaking the thermal bridging."

FEATURED PRODUCTS

Unfaced and FSK faced CertaPro™ commercial batt

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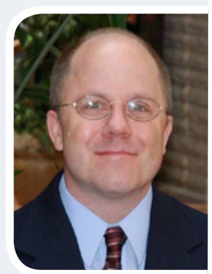

Stan Gatland

Manager of Building Science Technology

Stanley D. Gatland is responsible for generating and providing technical information on the system performance of new and existing building envelope materials to architects, engineers, builders, trade contractors, building envelope consultants, building scientists and building code officials. He also provides training in the principles of building science to these industry professionals.

CertainTeed CertaPro™ unfaced fiber glass batt insulation provides New Jersey's Waterfront Technology Center at Camden superior thermal protection and energy efficiency as well as acoustic control for improved working conditions within the building. The unfaced light-density batt is designed for steel stud construction and easy friction-fit installation.

BREAKING THERMAL BRIDGING

Thermal bridging is the path that offers smooth travel for heat transfer in poorly insulated buildings, usually built from concrete and metal with insufficient heat flow resistance between the outside and the exterior walls. The best way to slow down heat transfer is to put insulators between the conductors. Commercial insulation consists of cavity insulation, which occupies space inside the wall cavity, and insulating sheathing, which is installed over the exterior walls. There are a variety of materials that can be used to manufacture cavity insulation, including fiber glass, mineral wool, cellulose, open- and closed-cell foam plastics, reflective insulation and radiant barriers. Sheathing, however, is usually made from expanded polystyrene, extruded polystyrene, polyisocyanurate (ISO board) or fiber glass board. Before selecting insulation materials, it's best to check the ratings of their thermal properties.

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RATING INSULATION THERMAL PROPERTIES

As mentioned earlier, insulation materials and building envelope systems are characterized by their resistance to heat flow. Material performance can be rated according to thermal conductivity (k), thermal conductance (C) and thermal resistance (R-value).

When measuring the thermal properties of building materials, the standard is ASTM C518, where a heat flow apparatus measures heat transfer through homogeneous materials, such as insulation. Several material properties, including thermal resistance, conductance and conductivity, can be determined from temperature, heat flux, area and thickness data. Another standard, ASTM C1363 Hot Box, measures the thermal performance of building envelope assemblies. Measurements include the effects of thermal bridging due to structural components, as well as insulated cavities.

For calculating the heat flow of insulated building envelope assemblies, there are three different methods of varying complexity devised by the American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE). The first and most simple is the isothermal planes method. This is used when cross-sections have continuous, homogeneous layers. The second method, the parallel path flow method, is used when cross-sections have structural and cavity areas and when components have similar thermal resistance. The third method, the modified zone method, is used with steel-framed assemblies. These assemblies have cross-sections with both structural and cavity areas.

Calculating heat flow can be as easy as adding thermal resistance in a system with homogeneous layers, as with the isothermal planes method, or as complex and complicated as the modified zone method. Most building and design professionals can do their own calculations in the isothermal planes method, but with the complexity of the modified zone method, it's best to use the free online calculator provided by the Oak Ridge National Laboratory (www.ornl.gov/sci/roofs+walls/calculatores/modzone/index.html). This will help to ensure accuracy.

Structural components are highly conductive and create thermal bridges. For example, metals conduct 300 to 1,000 times more heat than most building materials. The thermal impact of a metal stud in a framed cavity is greater than the actual surface area of the stud, so metal has an exaggerated effect on heat transfer out of proportion to its physical size. Because of this, choosing the proper insulation assembly is crucial.

TYPES OF INSULATION ASSEMBLIES

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Matching insulation assemblies with applications depends on the material used for the external walls of the building. External walls are typically concrete block or tilt-up, metal, curtain walls (no cavities) or masonry facade (brick, block or concrete panels with insulatable cavities).

Concrete Block and Tilt-up Walls

Insulating sheathings can be installed either on the interior or on the exterior of concrete block and tilt-up walls. A common insulating material for this construction is foam plastic insulation board. The location of the sheathing depends on the climate and the type of sheathing material.

Interior non-load-bearing steel-framed assemblies can support cavity insulation. Since thick concrete has insulating value, many building codes have reduced insulation requirements due to the mass effect of the concrete. It's often advisable, though, to exceed code requirements to achieve the highest level of energy efficiency.

EIFS

EIFSs (Exterior Insulation and Finishing System) resemble traditional stucco. When installing an EIFS, it's important to follow the manufacturer's installation instructions, so moisture does not encroach behind the EIFS at window, door and other fenestrations, where it can be trapped.

Steel Stud Cavity Walls

The most common wall assembly is the steel stud cavity wall, which includes a masonry facade. To improve the thermal performance and increase cavity condensation control in cold climates, the designer can: specify exterior insulating sheathings, which increase cavity surface temperatures and improve energy efficiency as well; incorporate exterior air barriers, which also function as wind barriers to reduce air leakage; or specify interior air barriers, such as a "smart," breathable vapor retarder, to reduce the potential for convective loops and increase drying capability.

Water-resistive barriers, ventilation and a drainage space behind the masonry facade will reduce saturation of the substrate materials and promote drying. This exterior wall configuration is a cost-effective way to achieve thermal performance while managing moisture.

Metal Buildings

Metal buildings have their own set of installation and compliance recommendations. An authoritative publication covering ASHRAE 90.1 is available from NAIMA, the North American Insulation Manufacturers Association. It's available online at www.naima.org. NAIMA's reference for flexible fiber glass insulation used in metal buildings, Standard 202-96, provides information on thermal performance of metal building roof systems and wall systems. R-value and U-value data are listed for screw-down roofs and for sidewalls having varying cavity R-values and fastener spacing.

For more energy efficiency information, consult ASHRAE 90.1, "Energy Standard for Buildings Except Low-Rise Residential Buildings," which provides minimum insulation R-values and offers guidelines for overall building energy efficiency.

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Thermal Kraft, Foil, & FSK-25 Faced Batts

A SUSTAINABLE FUTURE

One of the primary goals of the sustainable building design movement is to produce more energy-efficient, healthy, long-lasting buildings. Such buildings will likely provide more pleasant working environments for their occupants and make operations more efficient and economical for building owners. Following these thermal control design guidelines is a significant step toward achieving this goal.

CertainTeed Corporation
P.O. Box 860
Valley Forge, PA 19482

Professional: 800-233-8990
Consumer: 800-782-8777
www.certainteed.com/insulation