Chapter

5

Insulation Applications and Comparisons

Applications

The primary purpose of thermal insulation is to control heat transfer through the exterior assemblies of a house. The *thermal envelope* of the home is considered to be the exterior perimeter where an energy breach may occur. This last line of defense, where heat gain or heat loss can occur, is not to be taken for granted. In fact, to guarantee the comfort of the occupants and the energy efficiency and durability of the home, the thermal barrier, or insulation, and the air barrier should form a continuous envelope around the house. All components of the air and thermal barriers must be in physical contact with each other to prevent any inferior or omitted element from getting within the envelope. Improperly installed materials, inferior-quality materials, or omitted areas will compromise the efficiency of a homeowner's heating and cooling system.

Locations

Insulation is not just for attics and outside walls. Many areas of a home that are often overlooked include ceilings with unheated spaces above (including dormer ceilings), knee walls of attic spaces finished as living areas, sloped walls and ceilings of attics finished as living areas, cathedral or vaulted ceilings, perimeters around slabs, floors above vented crawl spaces, floors over unheated or open spaces such as over garages or porches, basement walls, band and header joists, floors over unconditioned basements, soffits below cantilevered second-floor rooms, knee walls of closets in “bonus” rooms, and even areas where acoustical dampening is required such as laundry rooms or bathrooms.

Gaps and voids are areas where insulation should be installed but is omitted, thereby causing conductive and convective heat loss. A *gap* is a place where the insulation does not come all the way to the edge of the space to be insulated. A *void* is a hole in the envelope of the building. Examples include plumbing chases, wiring penetrations, fireplace cavities, dropped ceilings, soffits, and venting.

Foundations

In certain climates, an uninsulated foundation may account for up to 50 percent of the heat lost from an otherwise tightly sealed, well-insulated house.[1] Proper installation of foundation insulation material is necessary to avoid moisture condensation, material damage, and structural decay caused by the differences in temperature between the house interior and the adjacent earth. Poor design and installation also may aggravate radon infiltration and insect infestation. It is best to research common methods and local guidelines depending on the specific climate, soil type, and design conditions.

Although considerable savings in heating costs can be achieved by insulating a foundation, installation costs are often high, particularly for retrofit projects. The materials used, the location of the application, and the extent and timing of the work all affect the overall cost. While savings are accrued through energy-use reductions, “energy savers” financing packages, and home improvement savings programs, simple payback is typically the most popular analysis method. The payback period can range from 6 months for a simple do-it-yourself installation to 20 years for more involved work.[1]

Basement Walls

Installing insulation on the exterior of a basement wall (exterior insulation) is usually good practice. Exterior insulation can minimize thermal bridging and subsequently reduce heat loss through the foundation, can protect waterproofing, and can help serve as a capillary break to moisture intrusion, and can help prevent any freeze-thaw cycle damage to the foundation. Some exterior insulation materials are susceptible to insect infestation, so material selection is paramount to good performance. Foam insulation impregnated with insecticidal boric acid has yielded some success in discouraging termite infestations. Although termites avoid it, boric acid slowly leaches out of most materials exposed to moisture. Installation of a good gravel or manufactured "rain screen" drainage element outside the insulation can reduce moisture problems significantly and structurally protect the insulation.

More comprehensive analysis is needed to better identify appropriate protective coatings, address insulation moisture absorption, and understand long-term insulation R-value degradation. One study conducted by the Minnesota Department of Public Service, Office of Energy Conservation, surveyed 59 houses in the Minneapolis–St. Paul area from April to June of 1988. The study sampled foundation insulation specimens and soil specimens to determine long-term performance.

The survey's results showed that the durability and performance of exterior foundations are due to installation quality and above-grade protective coatings rather than the type of insulation material used. Most coatings help to minimize moisture absorption and foster R-value retention. However, almost 60 percent of the bitumen coatings (commonly used to protect spray urethane insulation) sampled showed flaking, gouging, or other damage that could reduce effectiveness.[1]

The U.S. Department of Energy is working with regulatory groups to help establish appropriate guidelines that provide cost-effective thermal protection for buildings. Building scientists theorize that the best way to build a dry basement is to insulate the outside of exterior walls with a rigid, fibrous, insulating drainage layer, such as fiberglass or rock wool, and omit the common application of exterior damp-proof coating or interior vapor retarder.[1] Conventional damp proofing should be applied from 6" below grade down to 3' below grade. The fibrous insulation acts as a capillary break that keeps bulk water out even during floods. The concrete will always dry to the exterior because of the vapor pressure differentials. This construction resists summer wall condensation and potentially can act as a passive dehumidifier for the basement. In winter, water vapor will diffuse inward whenever the relative humidity of the basement air is below 33 percent.

Cavity foundation materials, such as concrete block, potentially lend themselves to both retrofit and new construction installations of foamed-in, blown-in, and poured-in insulations. The most commonly used materials include foamed-in insulations or poured-in polystyrene beads and granular materials such as vermiculite.

Concrete block is also available with insulating inserts for new construction. These materials reduce convection within the cells (the hollow cavity), but significant levels of heat can still conduct through the webs of the masonry. Some concrete block manufacturers attempt to increase the thermal resistance of their product by adding materials such as polystyrene or wood chips to the concrete mix.

Insulation also may be applied to the interior of a foundation or basement wall. This method is especially suited for renovation or remodeling projects without excavation. Material analysis is essential for proper placement, as well as for ensuring the safety and structural integrity of the home. For example, some types of insulation require separation from habitable spaces by a fire-rated material because they are extremely flammable and release toxic gases when ignited. Interior insulation applications fail to protect the waterproofing or structure as well as exterior insulation. Proper installation of sealants and vapor retarders is important for adequate performance of interior insulation.

Slab-on-grade foundations

Floor heat loss generally comprises about 10 percent of the total heat loss of a house.[2] This may sound minimal, but from a comfort standpoint, cold floors are usually not very desirable. Slab-on-grade foundations, or foundations for homes that have no basements, may require the insulation to be placed vertically on the exterior or the interior of the foundation wall or horizontally above or below the floor slab. Continuous vertical exterior insulation placed outside the foundation wall reduces heat loss from both the foundation and the slab. To reduce heat flow from the slab floor to the ground outside, extend the insulation below grade to the footing. Insulate any exposed slab edge above grade.

A homebuilder also can install insulation vertically on the interior side of the foundation before pouring the slab. R-10 perimeter insulation around the edge of a slab is probably the most common type. If the highest known water table of a site is 2' or more below outside grade, perimeter insulation may be placed in a vertical or horizontal position. If the highest known water table is less than 2' below the outside grade, perimeter insulation may be placed in a horizontal or L-shaped position.[2] Special consideration always must be given to the potential for insect or vermin infestation when using exterior or interior foundation insulation products.

Walls

As will be discussed in the next chapter, energy or building codes will prescribe the insulation values of exterior walls. Research seems to indicate that a total wall R-value of R-19, using batts, blankets, blown-in insulation, or sheathings, is typically recommended. Cracks around windows and doors should be addressed, whereas loose insulation or foam should be used in spaces around the rough framing and around the heads, jambs, and sills. Insulated doors are available, some with a thermal resistance value of R-5.

Insulated window units have airspaces between double or triple panes of glass that slow heat loss. To be truly effective, the units actually should contain an inert gas in the airspace; however, such windows are a little more expensive.

Floors

In most climates, insulation with a minimum thermal resistance value of R-19 should be installed beneath the floors of heated rooms located over unheated areas such as basements, beneath stairwells and stair landings between heated and unheated areas, and above garages, porches, or areas with an overhang subject to outside temperatures. Insulation can be omitted from floors over heated basements or heated crawl space areas if the foundation walls are fully insulated. Foundation walls of heated basements typically do not need to be insulated, except where 50 percent of the wall is exposed to outside air or if the basement contains a habitable room.[2]

Ceilings

Ceiling insulation should extend over the top of interior wall partitions and over the top of the plate at the outside wall. The insulation, however, should not block eave ventilation.

Attics

Attic areas typically should be filled with loose-fill or blanket insulation between and over ceiling joists in order to achieve a thermal resistance value of R-38. Cathedral ceilings and slanted ceiling areas are especially problematic due to the restricted space for insulation installation. As a minimal requirement for most climates, a total value of R-30 in any combination of building materials and insulation should be achieved with preferably 2" of clearance between the insulation and the underside of the roof sheathing. Standard framing practices typically allow for only 1" of clearance. This should be considered the absolute minimum for proper ventilation.

As mentioned earlier, finished attic areas with knee walls should not be overlooked. Each of these assemblies is analogous to those already mentioned, with the walls receiving a total wall value of R-19 in the knee walls, R-30 between the sloped roof joists, and R-38 between the horizontal ceiling joists (Fig. 5.1).

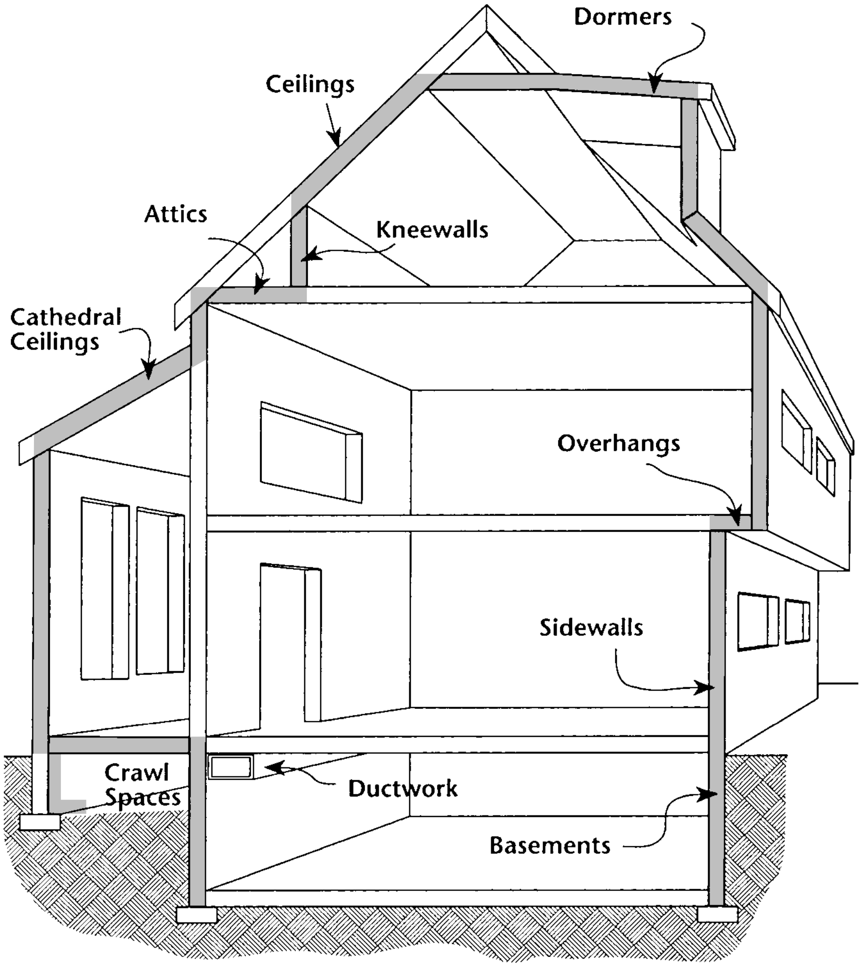

Figure 5.1 Areas to insulate. (*NAIMA*)

Superinsulation

Around 1980, a new approach to fuel and energy conservation came to the attention of architects and builders. Called *superinsulation,* this approach provided a high degree of comfort in winter and summer and reduced fuel consumption by 75 to 95 percent relative to conventional houses.[3] The method was announced and explained in talks at building construction conferences, in magazine articles, and in books. Enthusiasm spread rapidly, with the result that by 1987 there were several tens of thousands of superinsulated houses in routine use in the United States and Canada. The origins of superinsulated design actually date back to the 1940s, when a group of individuals at the University of Illinois began analyzing heat losses from houses.[3] In 1976, researchers were able to prove that superinsulated design concepts would need only as much as one-third as much auxiliary heat as the designs being promoted by the U.S. Department of Housing and Urban Development (HUD).[3] A new moniker for superinsulation being used today is the *airtight drywall approach* (ADA).

In some very cold regions, this new method now dominates home construction.[3] It is important to note that a universal standard is not possible because a design that is optimal for Boston will not be optimal for sunny Colorado, cloudy Rochester, or bitterly cold Anchorage. Because its main reliance is on heat conservation (excellent insulation, excellent retention of intrinsic heat) rather than on solar radiation, the superinsulated house is tolerant of less favorable sites and orientations. It is permissible to locate such a house in a moderately wooded area and to employ a far from south-facing direction (orientation).

The main distinguishing characteristic, or hallmark, of a superinsulated house is thick and widely applied insulation. An actual effective R-value of R-25 in all walls, ceilings, and floors is a minimum standard.[4] Even at the sills, headers, eaves, window frames, door frames, and electric outlet boxes, a moderate amount of insulation is provided. The construction must be airtight but still introduce a steady and controlled supply of fresh air. The occupants benefit from the absence of drafts, cold floors, and cold spots near windows. A superinsulated house, throughout most of the winter, is kept warm almost entirely by the modest amount of solar energy received through the windows and by intrinsic heat. Interior heat is generated by systems and appliances typically functioning within the home. These sources include stoves for cooking, domestic hot water systems, human bodies, clothes washers, clothes dryers, dish washers, electric lights, television and radio sets, refrigerators, and other electric appliances.

A conventional furnace typically is not used. Most homes rely on "borrowing" from the domestic hot water system, or on a minimal amount of electrical heating. A wood stove or portable electric space heaters may be used during extreme temperature dips to keep such a house comfortable. There is not a significant added expense for superinsulated housing mainly due to the elimination of a furnace or a big heat distribution system.[4] In fact, what little auxiliary heat is needed is less than 15 percent of that required for typical houses of comparable size built before 1974.[3] In summer, the house stays cool because south-facing heat gain has been minimized due to the reduction of window area as well as the use of roof eaves.[4]

The extra cost of superinsulating a house is usually only 3 to 6 percent of the total construction cost.[3] Experts suggest that the best insulations for superinsulated home design are those with highest R-value per inch, lowest cost per R-value, durability, and great resistance to settling. Fiberglass blanket products are especially popular owing to their low cost, ease of installation, and good fire resistance. Blown-in fiberglass when installed in dense quantities is gaining popularity and because of its ability to be installed in hard-to-reach places; however, settling can be problematic. Some insulation types are not recommended. These include vermiculite and perlite. Urea formaldehyde foam insulation (UFFI) is discouraged due to shrinkage problems and an errant controversy over formaldehyde emission. Balloon framing is preferred over platform framing because platform framing, although more popular, easier to construct, and less expensive, is inherently problematical from a thermal standpoint, owing to areas around floor joists, band joists, and headers that act as thermal bridges.[4]

References

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4. J. D. Nisson and Gautam Dutt, *The Superinsulated Home Book* (New York: John Wiley and Sons, 1985), p. 22.