The most common source of building enclosure failure is moisture and the consequences range from a visible, isolated water leak to widespread concealed deterioration, corrosion, and mold growth. Contemporary building enclosures are essentially an assembly of barriers that, in combination, control moisture migration and condensation. The enclosure’s performance in this regard depends on proper sequencing, detailing, and construction of essential barriers designed to control the flow of water, heat, air, and vapor.

**WATER BARRIER**

The water barrier is the most important deterrent against rainwater and groundwater penetrating the building enclosure and wetting, deteriorating, and contaminating interior surfaces. To maintain a watertight building enclosure, this barrier must be continuous and shingled in the direction of water flow. In drained wall systems, the exterior cladding protects the water barrier from direct exposure to weather and ultraviolet (UV) radiation. The proper design, placement and construction of integrated through-wall flashings is critical.

**THERMAL BARRIER**

The thermal barrier (i.e., insulation) is vital for occupant comfort and energy efficiency and its proper location within the enclosure is critical for the prevention of condensation within walls and roofs. Since thermal barriers control most of the heat loss, building codes require a minimum amount of thermal resistance for the building enclosure. As long as a temperature differential exists between the interior and exterior, some heat transfer will occur from one side of the wall or roofing system to the other, but the rate of heat transfer can be decreased if the assembly’s thermal resistance is increased. To avoid condensation within the enclosure, the thermal barrier needs to be continuous and placed in the appropriate location within the assembly and relative to the vapor retarder. The appropriate sequencing of materials varies by climate.

Windows, and doors in some instances, also play an important role in the wall assembly’s overall thermal resistance. Much of the heat loss through a wall occurs at, or around, windows. The thermal resistance of the window depends on several factors, including the following:

- Thermal conductivity of the frame material
- Exposed surface area of the interior window frame relative to the exterior
- Thermal conductivity and radiant energy transfer properties of the glazing
- Alignment of the window with the thermal barrier of the wall assembly
AIR AND VAPOR BARRIERS

Vapor migrates through a wall either by diffusion through the building materials or by air movement, primarily through gaps and holes in the wall assembly. Vapor diffusion is driven by vapor pressure differentials reflecting the tendency of moist, warm air to migrate to cooler, dryer conditions. This movement is controlled by a vapor barrier (usually a sheet membrane, such as polyethylene or aluminum foil), which is typically placed on the warm side (during winter conditions) of insulation so the vapor migration is arrested before it reaches colder surfaces. Vapor migrating across the wall and cooling as it comes into contact with colder surfaces has the chance of condensing.

A successful design also considers the vapor resistance of other wall components in addition to the interior vapor barrier. For example, waterproofing membranes can have extremely high water vapor resistance and can prevent the escape of water that bypasses the membrane or may have been trapped in the wall or roof during construction.

The air barrier is intended to restrict warm, moist air from migrating across the wall and reaching colder surfaces. Air infiltration or exfiltration is driven by air pressure differentials across the wall assembly created by a combination of stack (i.e., chimney) effect, mechanical pressurization, and wind. The location of the air barrier within the wall is usually not critical, but it must be rigid or applied to a structural backing to withstand the exerted air pressures. An effective air barrier system needs to be continuous at interfaces between wall components and joints in the building wall assemblies.

A wall assembly in a heating or cooling climate generally requires a vapor barrier and an air barrier. Some sheet materials normally used as vapor retarders, such as aluminum foil or polyethylene, are not normally effective as air barriers because they are neither sufficiently rigid nor easy to permanently seal to components penetrating the barrier, such as beams, ducts, and electrical outlets or conduits.

CONCLUSION

The design and detailing of enclosure assemblies should be approached as an integration of four barriers, one for each element. Although a single product or layer can perform the function of multiple barriers, the performance criteria for each barrier is different and must be assessed in its own right in terms of reliability, suitability, durability, and constructability. For all structures, careful consideration must be given to the design and construction of these four barriers to achieve a watertight, thermally efficient, and condensation-free building wall assembly.

Simpson Gumpertz & Heger (SGH) is a national engineering firm that designs, investigates, and rehabilitates structures, building enclosures, and materials. Our award-winning work encompasses building, energy, civil/infrastructure, and science/defense projects in the United States, Canada, and more than thirty additional countries.

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