Chapter 4: SIP Building Science

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- Importance of building science
- Bulk water management
- Controlling water vapor
- Designing assemblies to dry
- Ventilation in airtight buildings

Introduction

Building science is the study of the interaction between a building, its systems, its components, the building occupants, and the surrounding environment. When applied properly, building science can improve a building's durability, occupant comfort, and energy efficiency.

The emergence of building science in residential construction over the last two decades can be traced to some of the unintended consequences of so many new construction technologies. The introduction of thermal insulation, airtight building enclosures and forced air heating systems have made houses more comfortable and energy-efficient, but failing to consider the interrelationships of these systems has caused moisture problems, uncomfortable houses, and dangerous indoor air quality.

SIP homes have very low levels of air infiltration and for this reason moisture accumulation can quickly lead to major problems if the assemblies are not given the capability to dry. By following a few simple rules presented in this section, SIP builders can assemble durable structures that also provide great energy efficiency for homeowners.

Many of the concepts discussed in this chapter are adopted from the *Builder's Guide to Structural Insulated Panels (SIPs)*, by Joseph Lstiburek. This guide gives a more thorough explanation of general building science principles and those specific to SIP construction. It is available for purchase at www.sips.org.

Definitions

Bulk water: Water in liquid form, such as that deposited on a building from rain, dew, or melting snow

Drainage plane: Collection of water repellent materials used to protect a building from bulk water, including weather-resistive barriers, flashing and

	exterior cladding materials
SIP tape:	Vapor impermeable peel-and-stick tape used to seal SIP joints
Thermal void:	Gap in the insulating foam core of a SIP that is the result of penetrations, poorly installed splines, or electrical work
Ventilated cladding:	Siding or other exterior finish material with a vented air space separating it from the building's weather-resistive barrier
Vented roofing or cool roof:	Roof assembly with a vented air space separating roofing material from the roof sheathing
Drainage mat:	Woven plastic mesh installed between the weather-resistant barrier and siding to create an air space
Stack effect:	Pressure differences in a home caused by the buoyancy of heated air

Preventing Water Damage

Water damage poses one of the biggest threats to building performance in all types of wood structures. Uncontrolled moisture can lead to rot, mold, indoor air quality issues and even structural failures. With any type of wood construction, builders need to employ strategies that protect against the intrusion of both water vapor and bulk water (rain, snow, sleet).

Bulk Water Management

Building scientist Joseph Lstiburek recommends a "3-D" approach to bulk water management:

- Drainage
- Deflection
- Drying

SIP homes need to be protected by layering materials that allow rain water to drain from a building and be directed away from the site (Figure 1). The collection of water repellent materials, including weather-resistive barriers, flashing and exterior cladding materials, is referred to as the building's drainage plane.

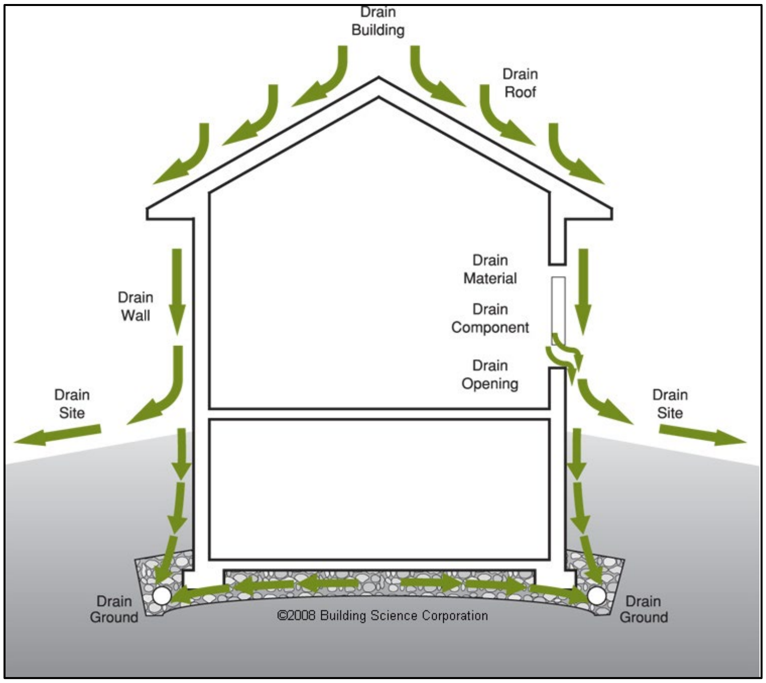

Figure 1: Bulk water management strategy

The most important principle in bulk water management for SIP construction is to create assemblies with a method of drying in the event that bulk water penetrates the drainage plane. It is generally accepted in the building industry that over the life of a structure wall assemblies will be exposed to moisture during service. In many cases they may even start out wet due to exposure during the construction. To ensure building durability and prevent moisture-related problems such as mold and rot, it is crucial that assemblies be designed with the capability to dry.

Materials like the OSB sheathing used in SIPs have the ability to accumulate and store moisture without degrading their performance or service life. Moisture problems occur when the rate of moisture accumulation exceeds the rate of drying, driving moisture levels beyond the safe storage capacity of the material (Figure 2).

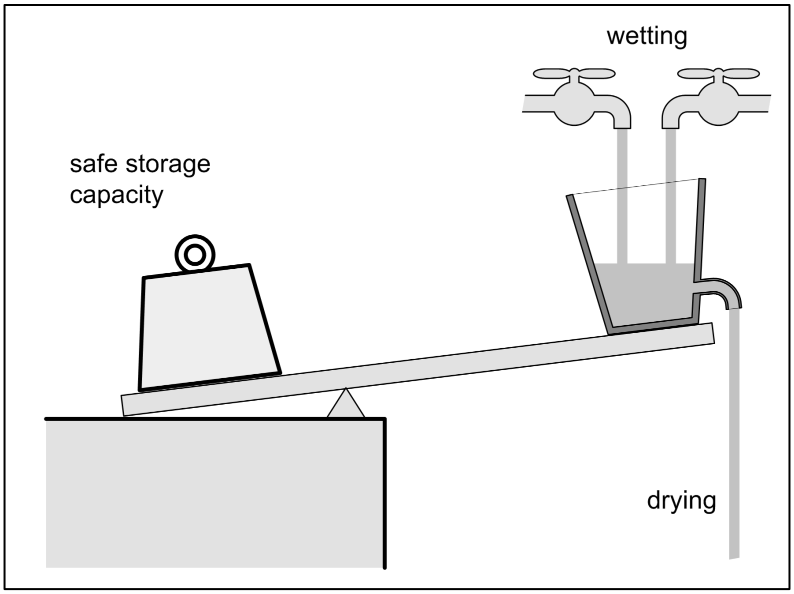

Figure 2: Moisture storage capacity of building materials

Controlling Water Vapor

In addition to controlling water in its solid state, it is equally as important to control water in its gaseous state. Water vapor has the potential to transfer through gaps in the building enclosure, condense into water, and cause major moisture-related problems.

Water vapor can transfer through building materials in two ways: air transport and vapor diffusion. In the case of air transport, pressure differences within a building, or between the interior of the building and the outside, will force air through any gaps or leaks in the building enclosure. Along with the air comes water vapor.

Vapor diffusion is the transfer of water vapor through a solid material due to vapor pressure difference or temperature difference. The rate of diffusion depends on the permeability of the material it is moving through, but because of the relatively low permeability of SIPs, air movement is of much greater concern for SIP building enclosures, as shown in Figure 3.

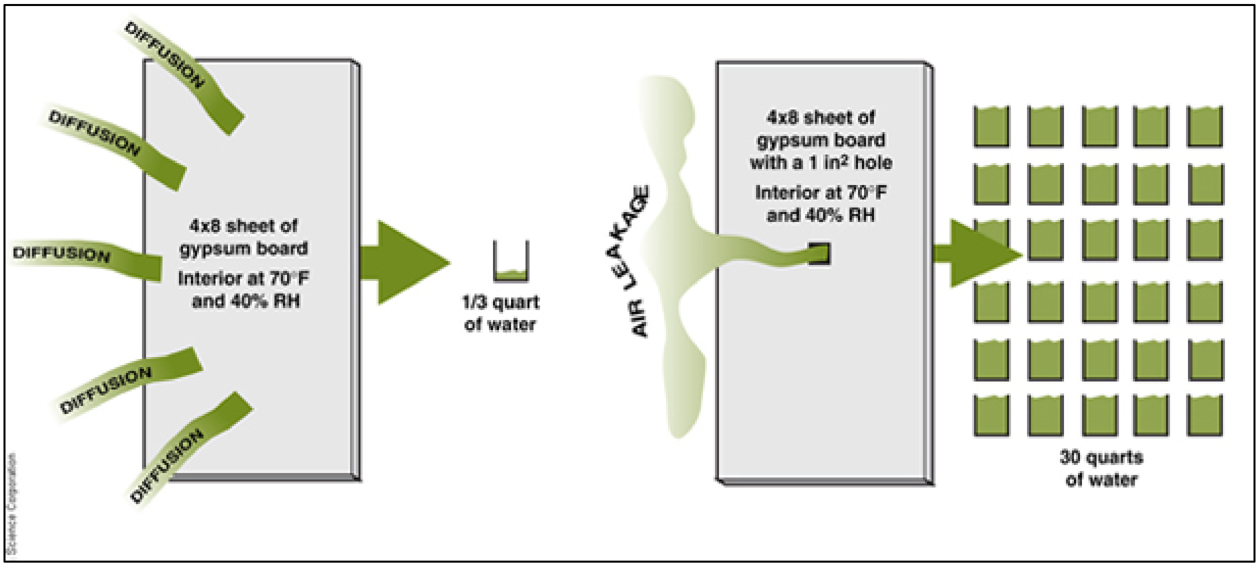

Figure 3: Vapor diffusion versus air transport

Air transport through the building enclosure has negative effects not only from a moisture perspective—it reduces energy efficiency and hampers efforts to control the temperature and humidity in the building.

Best Building Practices

Sealing

SIP homes typically have very low levels of air infiltration compared to traditional wood frame construction. This is because the OSB facings function as a code compliant air barrier and there are no wall cavities for air to move through (Figure 4). The only places where air can move through a SIP building enclosure is at the joints, windows, doors, and penetrations through the building envelope for plumbing, electrical and other needs.

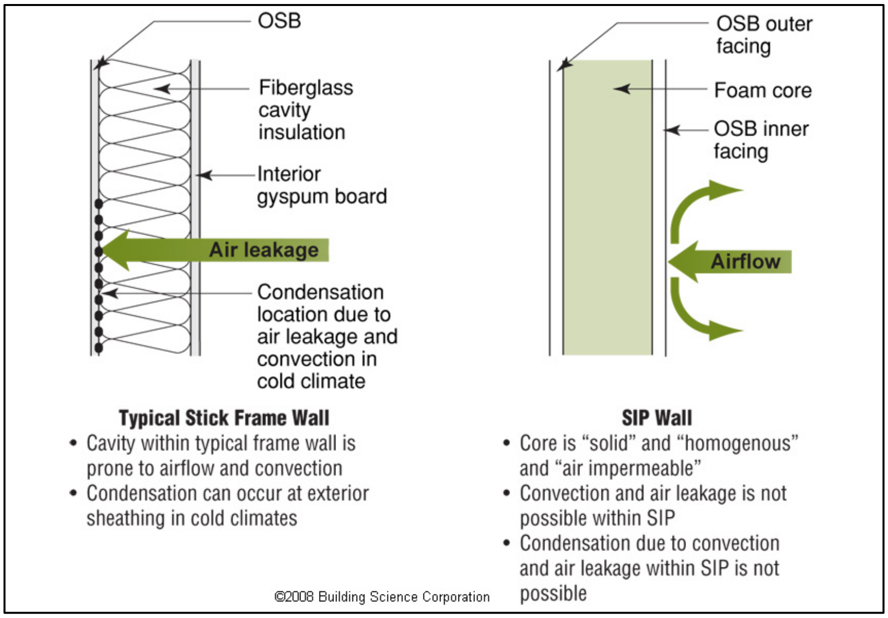

Figure 4: SIP wall as an air barrier

Properly sealing joints is the primary durability concern with SIP building enclosures. Water vapor that makes its way into the joint from either the inside or the outside will condense when it encounters colder temperatures. If not given the ability to dry, repeated condensation can lead to rotting at the SIP joint.

Always follow manufacturer recommendations for sealing panel connections and apply the appropriate sealant where noted in the construction details. It is also the builder's responsibility to inspect a SIP building after the subtrades have completed their work to make sure any penetrations through the building envelope have been properly sealed.

SIP Tape

Many SIP manufacturers recommend applying a peel-and-stick SIP tape to panel joints to provide an additional layer of protection against moisture intrusion.

As a general rule, SIP tape is applied to the "warm side in winter." For cold and mixed climates, this is the interior. In hot humid climates it is the exterior. The joint retains the ability to dry in the opposite direction.

Never apply a vapor barrier on each side of the SIP joint—an example would be SIP tape on the interior of roof joints in a cold climate and a fully adhered roofing membrane on the exterior of the SIP roof panel. If at any point either of the vapor barriers failed, or the materials got wet during construction, the moisture would be trapped in between two materials that prevent it from drying.

Areas of Concern

Thermal Bridges and Voids

In addition to properly sealing the joints between panels and other interfaces, thermal bridges and thermal voids present another potential area for moisture problems.

Thermal bridges occur when dimensional lumber or metal is embedded inside a SIP. This is common with dimensional lumber or engineered splines that are often specified to meet certain structural demands. Sawn lumber has a much lower insulating value than the foam core of a SIP and creates a thermal bridge spanning between conditioned and unconditioned space.

During extreme temperature differences, the higher thermal conductivity of a thermal bridge can move the dew point inside the SIP wall. If the joint is not sealed correctly, water vapor can condense inside the wall.

Thermal voids are gaps in the insulating foam core that are the result of penetrations, poorly installed splines, or electrical work. The lack of insulation allows cold temperatures to extend into the panel and create a dew point where water vapor can condense. Special care should be taken to fill thermal voids with expanding foam and thoroughly seal around dimensional lumber that interfaces with SIPs.

The Stack Effect

Improperly sealed SIP joints, especially at the roof ridge, are a target for vapor intrusion driven by the stack effect. Warm air is more buoyant than cold air, and during the heating season it will rise to the top of a building. This creates a pressure difference that can cause warm air to leak out at the roof ridge and cold air to leak in on the ground floor. Any gaps in the air barrier will create a recipe for condensation, which can lead to rotting at the roof ridge or other roof joints if they are not properly sealed.

In climates with a cooling season, air conditioning can cause a reverse stack effect. Cool air inside the home has a higher density than the warm air outside. Dense, cold air sinks to the bottom of the building, and the resulting pressure difference can pull warm, moist air in through improperly sealed roof joints.

Roof and Wall Ventilation

Walls

To boost the drying capacity of SIP wall assemblies, *Builder's Guide to Structural Insulated Panels (SIPs)* by Joseph Lstiburek recommends that exterior cladding materials be ventilated in regions where annual rainfall exceeds 20 inches. Adding a vented air space behind the cladding system allows for any moisture that penetrates the exterior cladding or enters the wall assembly to dry out.

Details for creating a vented air space for different types of wall cladding systems are covered in Chapter 9.

Roofs

Similar to SIP wall assemblies, it is recommended that SIP roof assemblies be vented in wet climates where annual rainfall exceeds 20 inches. Vented roof systems are often referred to as a “cool roof” and should not be confused with a vented attic.

Traditional truss-framed roofs with the insulation at the ceiling line typically have vented attics, where air circulates in the unconditioned attic space. A SIP roof places the insulation at the roof line and encloses the attic as conditioned space, so it should not be vented under any circumstances. Conditioned attics have many advantages, such as extra living space and the added energy efficiency of locating duct work and/or air handlers in the conditioned space.

The term “cool roof” is somewhat of a misnomer when applied to SIP roof systems because the reason to add roof ventilation has little to do with temperature. Roof ventilation is used primarily to increase drying ability. Should moisture enter the SIP roof system through either a leaky roof or from water vapor making its way into improperly sealed joints, that moisture must have a way to dry or it could potentially cause rot in the SIPs themselves and undermine the structural integrity of the roof system.

Chapter 9 discusses cool roof systems and specifications in greater detail.

Ventilation

As previously discussed, SIP buildings are very airtight, making it necessary to provide mechanical ventilation. Limiting the amount of air leakage in a home allows incoming air to be controlled, filtered and dehumidified by mechanical systems, creating a better level of indoor air quality for occupants.

There are a variety of ways to provide mechanical ventilation in SIP homes. The types of HVAC systems used in SIP homes vary greatly by climate, so it is recommended that SIP builders work with a qualified HVAC professional. HVAC is discussed in greater detail in Chapter 8.

Summary

Understanding the principles of building science is important when dealing with airtight homes. Less air movement through wall and roof assemblies creates greater energy efficiency, but it also limits the assembly’s ability to dry. With SIP buildings, it is crucial to protect against bulk water and water vapor, while also detailing assemblies so they can dry if they get wet.

Another key aspect of SIP construction is joint sealing. Working with large panels means there are very few joints, but if these joints are not sealed they are a magnet for vapor intrusion and carry the potential of serious moisture problems after years of occupancy. By paying attention to sealing and detailing, builders can construct SIP buildings that are durable, energy efficient, and provide exceptional indoor air quality.