



Moisture-Resistant Wall Construction

BUILD A BETTER HOME





Wood: The Natural Choice

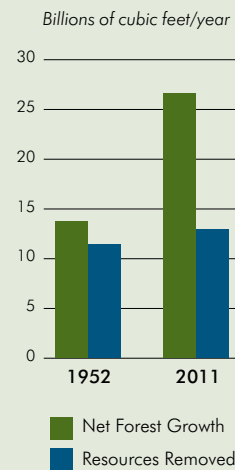
Engineered wood products are among the most beautiful and environmentally friendly building materials. In manufacture, they are produced efficiently from a renewable resource. In construction, the fact that engineered wood products are available in a wide variety of sizes and dimensions means there is less jobsite waste and lower disposal costs. In completed buildings, engineered wood products are carbon storehouses that deliver decades of strong, dependable structural performance. Plus, wood's natural properties, combined with highly efficient wood-frame construction systems, make it a top choice in energy conservation.

A few facts about wood:

We're growing more wood every day. For the past 100 years, the amount of forestland in the United States has remained stable at a level of about 751 million acres.¹ Forests and wooded lands cover over 40 percent of North America's land mass.² Net growth of forests has exceeded net removal since 1952³; in 2011, net forest growth was measured at double the amount of resources removed.⁴ American landowners plant more than two-and-a-half billion new trees every year.⁵ In addition, millions of trees seed naturally.

Manufacturing wood is energy efficient. Over 50 percent of the energy consumed in manufacturing wood products comes from bioenergy such as tree bark, sawdust, and other harvesting by-products.⁶ Very little of the energy used to manufacture engineered wood comes from fossil fuels. Plus, modern methods allow manufacturers to get more out of each log, ensuring that very little of the forest resource is wasted.

U.S. Forest Growth and All Forest Product Removals



Source: USDA—Forest Service

Life Cycle Assessment measures the long-term green value of wood. Studies by CORRIM (Consortium for Research on Renewable Industrial Materials) give scientific validation to the strength of wood as a green building product. In examining building products' life cycles—from extraction of the raw material to demolition of the building at the end of its long lifespan—CORRIM found that wood had a more positive impact on the environment than steel or concrete in terms of embodied energy, global warming potential, air emissions, water emissions and solid waste production. For the complete details of the report, visit www.CORRIM.org.

Wood adds environmental value throughout the life of a structure. When the goal is energy-efficient construction, wood's low thermal conductivity makes it a superior material.

As an insulator, wood is six times more efficient than an equivalent thickness of brick, 105 times more efficient than concrete, and 400 times more efficient than steel.⁷

Good news for a healthy planet. For every ton of wood grown, a young forest produces 1.07 tons of oxygen and absorbs 1.47 tons of carbon dioxide.

Wood is the natural choice for the environment, for design, and for strong, resilient construction.

1. United States Department of Agriculture, U.S. Forest Service, FS-979, June 2011; 2. FAO, UN-ECE (1996) North American Timber Trends Study. ECE/TIM/SP/9. Geneva; Smith et al. (1994), Forest Statistics of the United States, 1992. Gen. Tech. Rep. NC-168; 3. United States Department of Agriculture, U.S. Forest Service; FS-801 Revised September 2009; 4. U.S. Department of Agriculture, U.S. Forest Service, August 2014; 5. Forest Landowners Association, 2011; 6. U.S. Environmental Protection Agency, March 2007; 7. Produced for the Commonwealth of Australia by the Institute for Sustainable Futures, University of Technology, Sydney, 2010.

Built-In Protection from Moisture Intrusion

The Build a Better Home program from APA provides builders and homeowners with construction guidelines that protect homes against damaging moisture infiltration. Preventing moisture from getting trapped inside the building envelope is key to constructing long-lasting homes that stay dry and comfortable.

Walls are an integral part of this weather-resistive system. Designing and constructing wall details correctly, particularly around window and door openings, can prevent harmful moisture build-up whether the moisture originates from outside or inside the building.

This publication outlines the two primary sources of moisture in wood wall construction and methods to prevent its accumulation. Other design factors not covered in this publication include insulation options and other energy considerations and design recommendations for buildings within flood zones. Check with your local building department for these and other requirements specific to your location.



AVOIDING MOISTURE ACCUMULATION IN WALLS

Water can accumulate in walls from two sources: water leaks and vapor-laden air that penetrates the wall to produce condensation. Water from leaks presents the greatest threat of water accumulation in walls. Since water can leak directly into the wall, it can quickly accumulate to levels that will degrade the wood components as well as other products in the wall. Moisture vapor from air penetration and vapor diffusion are important, but they represent much smaller amounts of water accumulation.

HOW WATER LEAKS INTO WOOD WALL CONSTRUCTION

Water leaking through the envelope of a structure is the largest contributor to building damage. Leaks are caused by a number of factors, including:

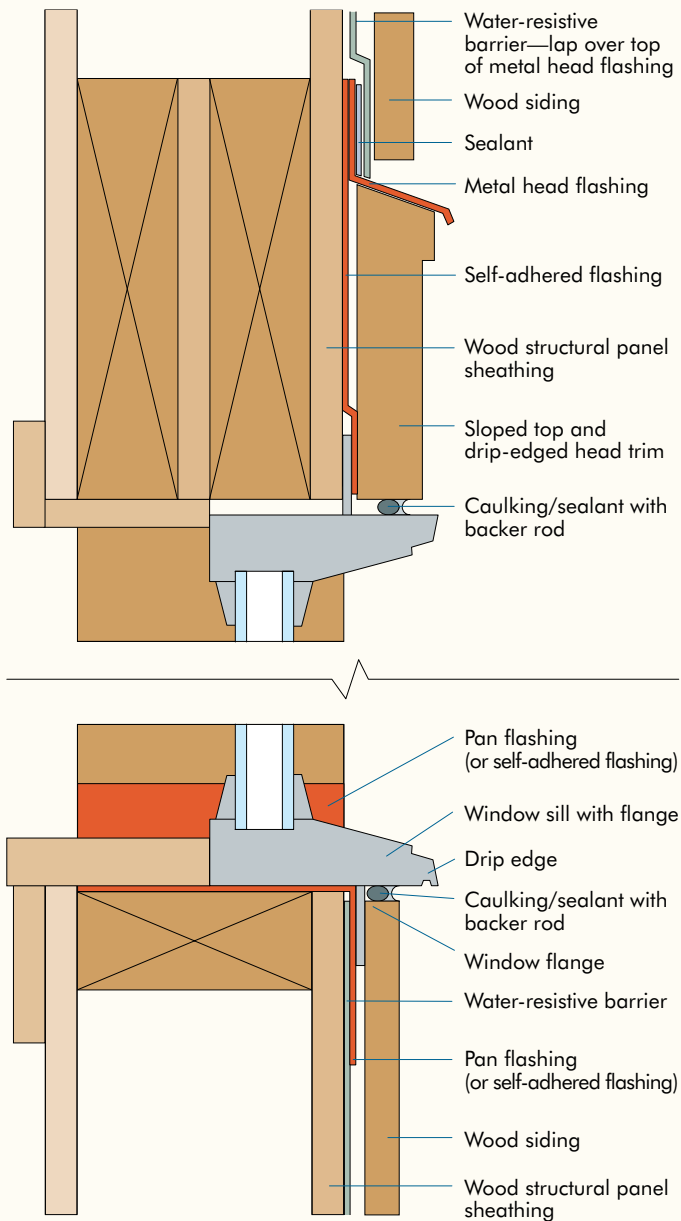
- Improper or missing flashing
- Improper installation of water-resistive barriers
- Poorly designed or executed wall intersections and penetrations

Wood structures have the ability to absorb, distribute and dissipate small amounts of water, especially from intermittent sources. Problems arise when there are design or construction errors that allow water into wall cavities at a rate that exceeds the structure's ability to absorb and dissipate the water by evaporation. Wood construction will perform indefinitely if done properly, but it is subject to failure if exposed to prolonged wetting where the wood moisture content exceeds 19 percent.

The control of water leaks into walls involves proper design, construction and maintenance. Design features such as roof overhangs can provide moisture protection. Proper construction incorporates products like flashing, water-resistant barriers, and caulks with the structural and architectural components in such a way that water is deflected or drained down and away from the wall. Proper maintenance of caulks and paint is necessary for long-term moisture performance of walls.

FIGURE 1

CROSS-SECTION OF WINDOW OPENING SHOWING INTEGRATION OF STRUCTURE'S WATER-RESISTIVE SYSTEM IN A WALL WITH WOOD SIDING

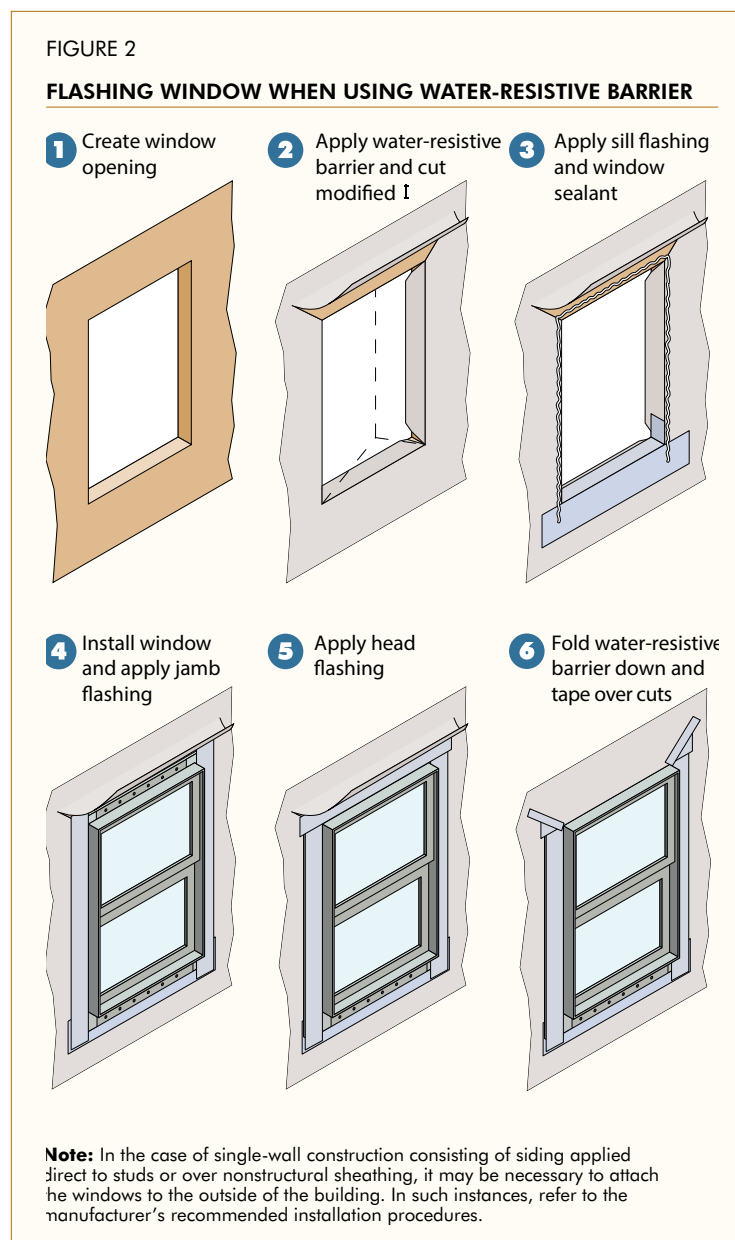


PREVENTING LEAKS WITH FLASHING

Flashing is used to deflect water and thus prevent leaks around wall intersections, window and door openings, and penetrations. Flashing can be made from galvanized steel, copper, aluminum, lead, vinyl, cut strips of water-resistive barrier materials, or various self-adhered membrane flashing products. At small wall penetrations, such as exhaust vents, custom flashing is used in lieu of conventional flashing because of the irregular shapes.

Flashing directs water flow down and away from the interior of the structure to the outside of the wall covering. In every example shown here, the water-resistive barrier laps over the top edge of the flashing. In such a manner, the flashing is part of a whole water-resistive system that is continuously redirecting water flow down and away from the interior of the structure.

Figures 1 through 16 illustrate examples of typical flashing details for wood-framed walls with various exterior finishes.



WATER-RESISTIVE BARRIERS

Long-term durability of wood-framed walls depends largely on keeping water out of the wall cavity. In order to accomplish this, a protective weather- or water-resistive barrier (i.e., building paper), or an approved alternative, such as “house wrap” that also sheds water is needed. (In this publication, weather-resistive barriers and house wrap are generally referred to as water-resistive barriers.)

Water-resistive barrier materials provide a line of defense for the building envelope against the intrusion of water. The materials and labor costs associated with these products provide inexpensive protection for structural components and reduce the risk of moisture accumulation and damage to moisture-sensitive materials such as wood sheathing and studs. The barriers must be installed properly, however, to prevent water leaks into the wall cavity. Proper installation at corners and intersections and incorporation of flashing are particularly important.

The basic principle behind water-resistive barrier materials is to provide a continuous drainage plane that sheds moisture down and away from the plane of the structural wall surface. This is accomplished by overlapping successive layers of water-resistive barrier behind the exterior finish and over the structural sheathing. In conjunction with properly applied flashing, water-resistive

barriers direct leakage away from the wood structural panel sheathing. This principle also extends to wall penetrations, such as windows and doors, plumbing hose bibs, electrical boxes, wall-mounted air conditioners and vents for appliances, and at junctures with horizontal surfaces such as exterior decks and cantilevered balconies, or sloping roof-to-wall surfaces. It is especially important in these cases to ensure that water leaks are not directed down the sheathing onto structural elements below, or into the wall cavity.

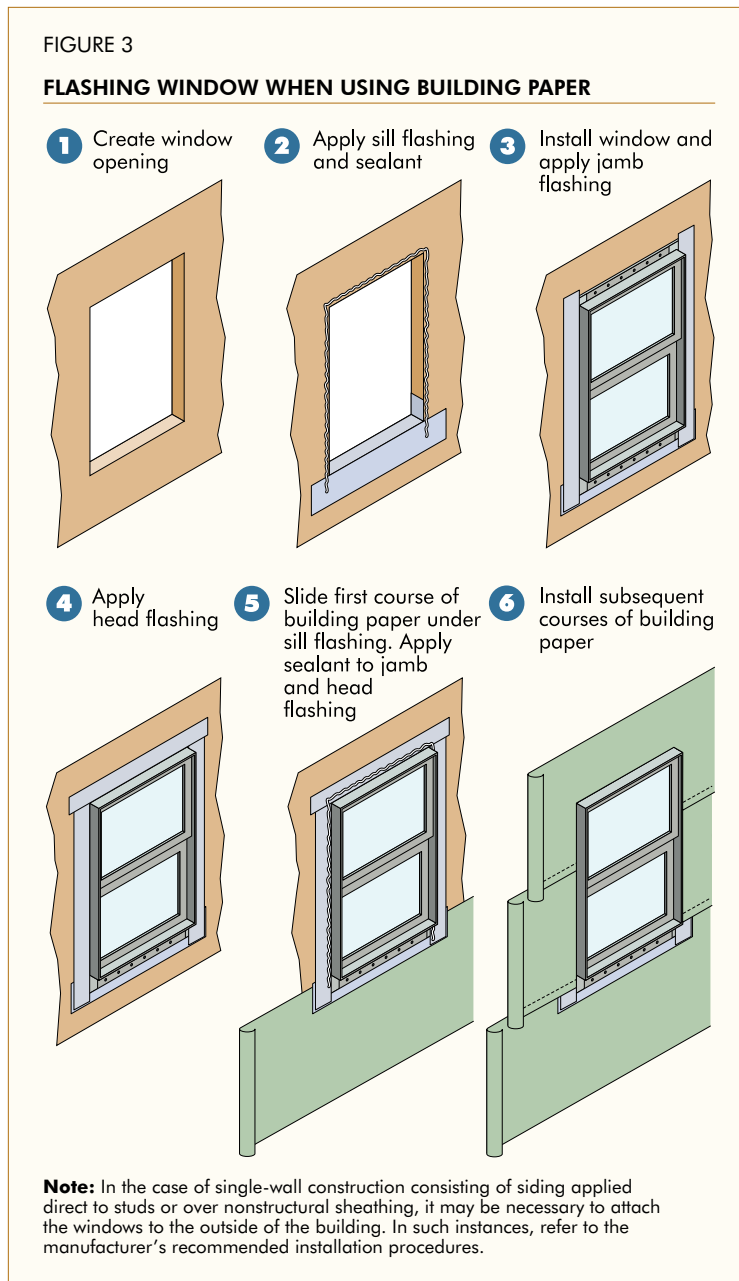
Figures 1 through 16 illustrate how the water-resistant barrier materials and flashing work together to channel any water running down the outside face of the barrier over the flashing and outside of the envelope.

Wall Intersections and Penetrations

There are many types of penetrations, including dryer vents, bathroom exhaust fans, exterior electrical outlets, exterior lights, and gas lines. The unique construction detailing around these penetrations requires special attention, including details around the following:

- Deck to wall intersections
- Wall to roof intersections
- Gutter to roof or wall intersections
- Skylight installation

Figures 10 and 11 illustrate typical wall intersection details. Figures 12 and 13 show a common wall penetration detail using a water-resistant barrier. Figure 14 shows a common wall penetration detail using flashing and building paper. Figure 15 is an example of the detailing required at the intersection of an outside deck and an exterior wall. Figure 16 shows the flashing and use of building paper around a door opening.



CAULKING AS A WATERPROOFING COMPONENT

Elastomeric exterior sealants, known as caulks, are a popular component of the waterproofing system used in modern structures. Used to seal the cracks between individual elements of the building's exterior finish, caulks help keep wind and water from penetrating the skin of the structure. Caulks are never perfect, even when carefully installed. However, caulks can be used as a secondary or tertiary part of the water-protective system.

Caulks are not permanent. They have a limited lifetime and must be replaced on a periodic basis. As a result, a caulked joint cannot be the sole form of waterproofing at a given location. Intelligent building design, the use of back-up methods of waterproofing such as building paper or "house wrap," and proper placement of flashing should always be used in conjunction with caulked joints.

FIGURE 4

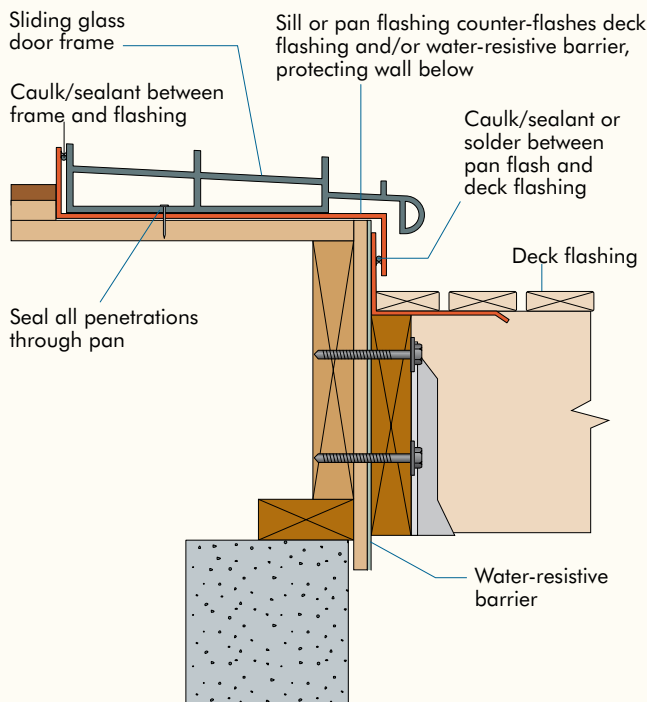
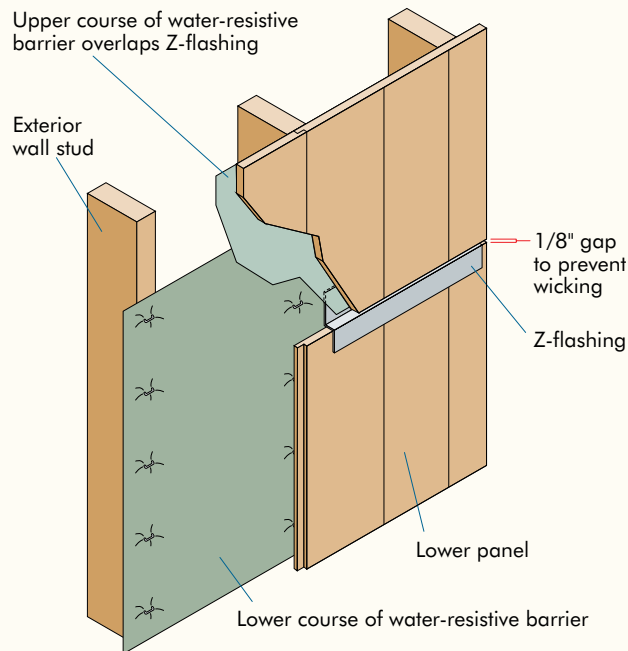
SILL FLASHING AT SLIDING GLASS DOOR

FIGURE 5

PROPER INSTALLATION OF Z-FLASHING IN A SINGLE WALL SYSTEM WITH APA RATED SIDING

A caulked joint is ineffective if it is not properly applied to a clean surface. A well-caulked joint should maximize the surface area between the caulk and the application surface. It should also have a smaller cross-section between the contact surface than it has at the mating surface. Figure 17, on page 13, illustrates this. A smaller cross-section in the middle of the caulked joint allows differential movement within the caulked joint, alleviating concentration at the mating surface between the caulk and the surface to which it is applied. While the caulk is flexible, the joint between the caulk and the mating surface is not. If stress is concentrated at the joint, it will cause premature failure of the joint.

MOISTURE FROM AIR INFILTRATION AND WATER VAPOR TRANSMISSION

Condensation of vapor is a source of moisture intrusion. Condensation occurs if there is a significant drop in the air's temperature as it passes through an insulated wall such that the air temperature falls below the dew point. The dew point is the temperature at which moisture vapor in the air condenses. If it happens to be within the wall cavity, the building materials absorb this moisture, and thus the moisture content of the building materials increases. The moist air can enter from the inside or the outside, depending on the vapor pressure differential across the wall. In a hot, moist climate with air-conditioned buildings, there could be infiltration from the outside to the inside. In cold, dry climates, the inside air leaking out could cause the problem.

Air Infiltration in Wood Wall Construction

Condensation in wall systems may be caused by air infiltration. Even relatively small differential pressures across a given wall can cause a large volume of moisture-laden air to leak into or out of a structure, thereby increasing the risk of condensation within the wall.

FIGURE 6

CROSS-SECTION OF WINDOW SHOWING INTEGRATION OF STRUCTURE'S WATER-RESISTIVE SYSTEM IN A WALL WITH BRICK VENEER

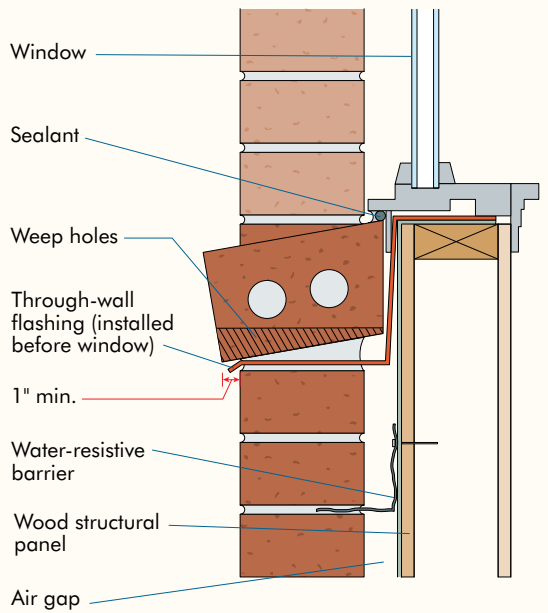
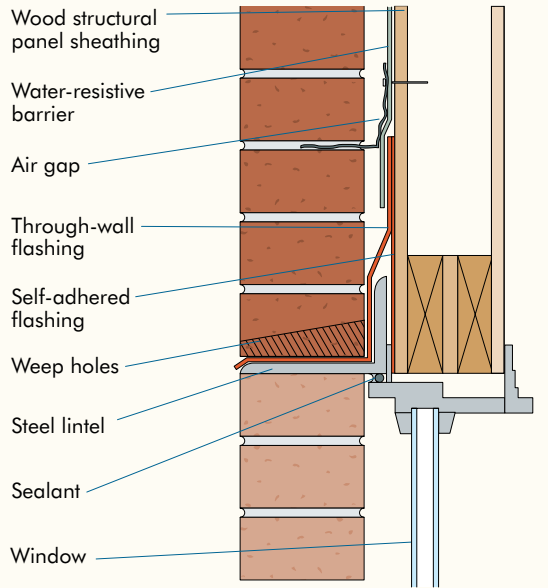


FIGURE 7

CROSS-SECTION OF WINDOW SHOWING INTEGRATION OF STRUCTURE'S WATER-RESISTIVE SYSTEM IN A WALL WITH PORTLAND CEMENT STUCCO EXTERIOR WALL COVERING

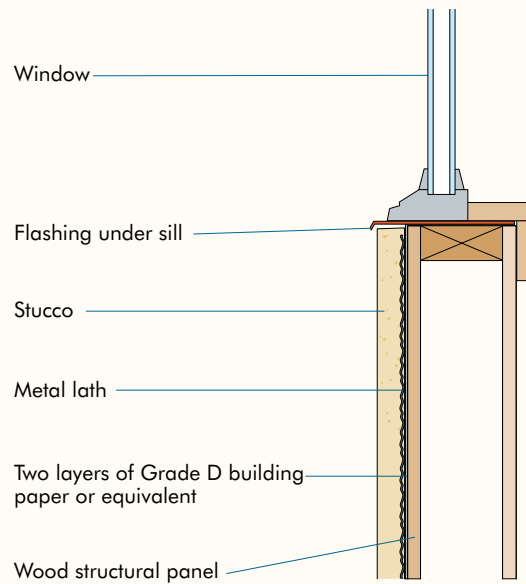
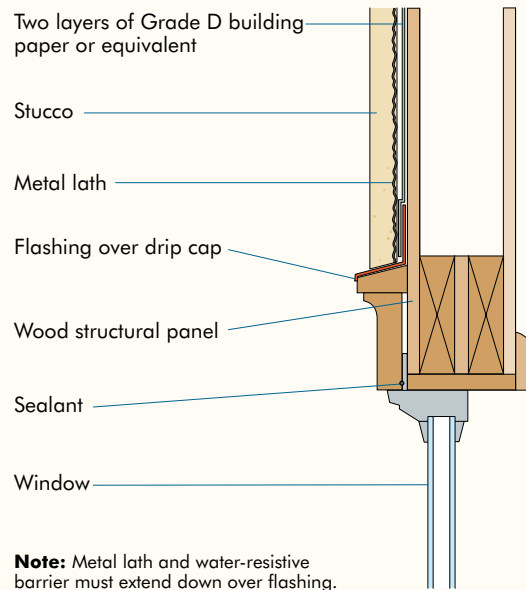
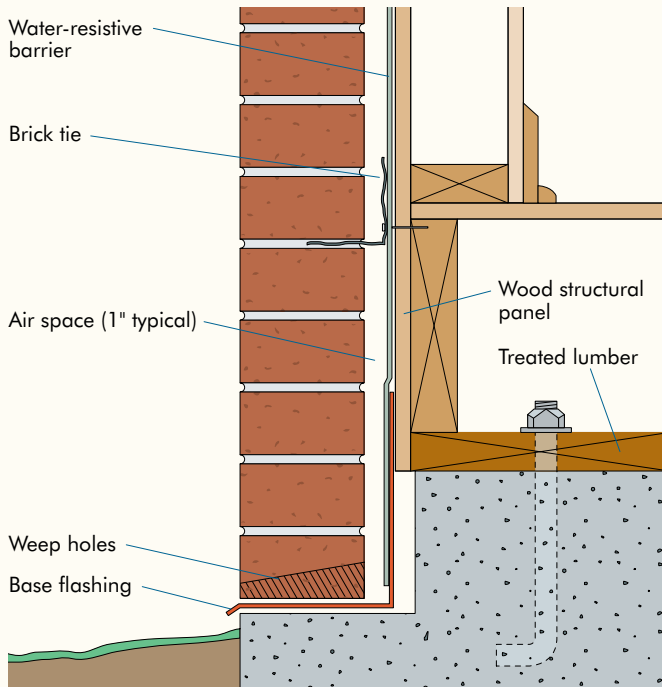


FIGURE 8

FLASHING AND WATER-RESISTIVE BARRIER INSTALLATION AT BRICK LEDGE



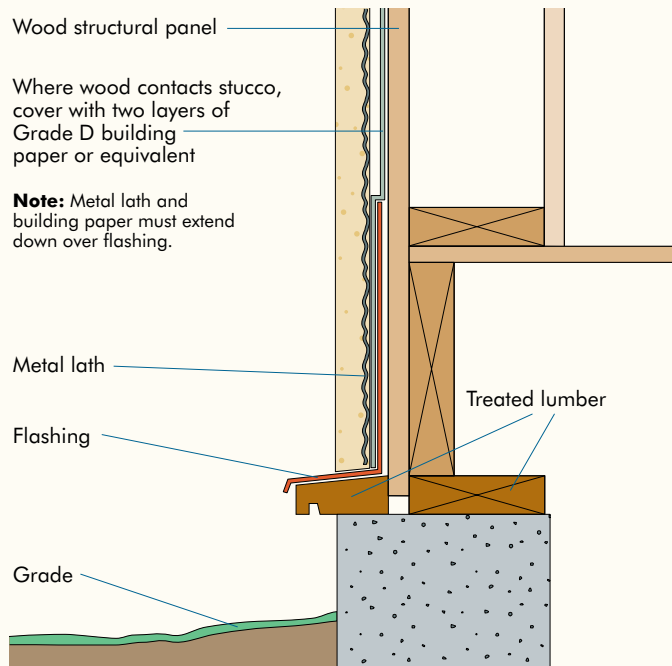
Air Infiltration Barriers

Differential air pressures across the wall assembly can cause air infiltration. This differential air pressure can be caused by an unbalanced ventilation system, the stack effect caused by hot air rising within the structure, the use of unvented heating appliances, or wind. The actual differential pressure does not have to be very large to cause a significant amount of air leakage in one direction or another. If the moisture-laden airflow persists for a significant length of time, condensation buildup can cause moisture damage to the structure and degrade the living conditions therein.

An air infiltration barrier such as house wrap can reduce the flow of moisture-laden air into the wall cavity if installed properly. The air barrier can be placed on the inside or outside surface of the wall. In a cold climate that requires a warm-side vapor retarder, the vapor retarder may act as the air barrier as well, if properly applied and sealed.

FIGURE 9

FLASHING INSTALLATION AT TERMINATION OF PORTLAND CEMENT STUCCO EXTERIOR WALL COVERING



Because the major model building codes allow air barriers to be used in lieu of building paper for most applications, the use of these products is on the rise. To get the full benefits of an air barrier, it must be sealed as described below to ensure that it is airtight.

Air barriers are available in rolls up to 9 feet wide, allowing the builder to wrap the barrier all the way around the house during construction. This is the origin of the term "house wrap." The large size speeds up installation and minimizes the number of seam seals. When the wrap is used as an air barrier, all of the splits, seams, penetrations and damaged areas must be repaired using a special adhesive-backed seam tape.

Figure 18, on page 13, shows general installation techniques for proper application of an air barrier.

FIGURE 10

FLASHING INSTALLATION AT BRICK VENEER-TO-ROOF INTERSECTION

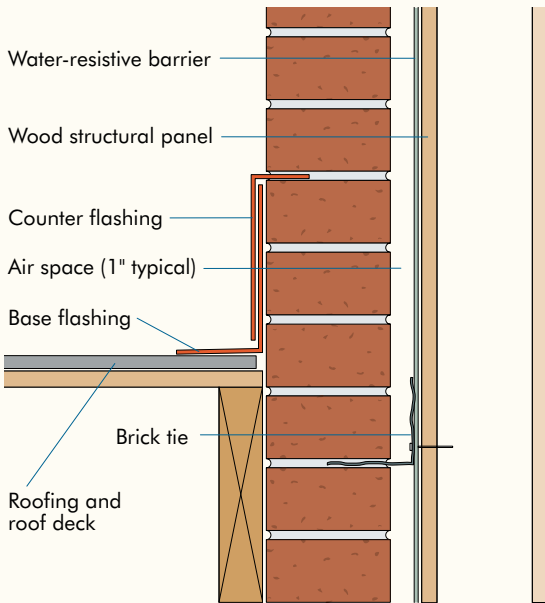
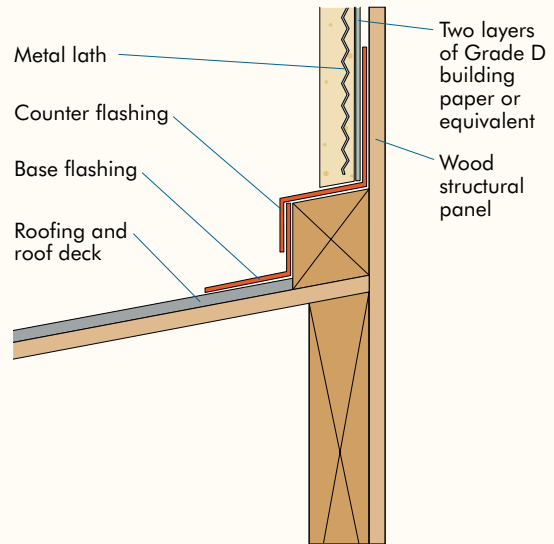


FIGURE 11

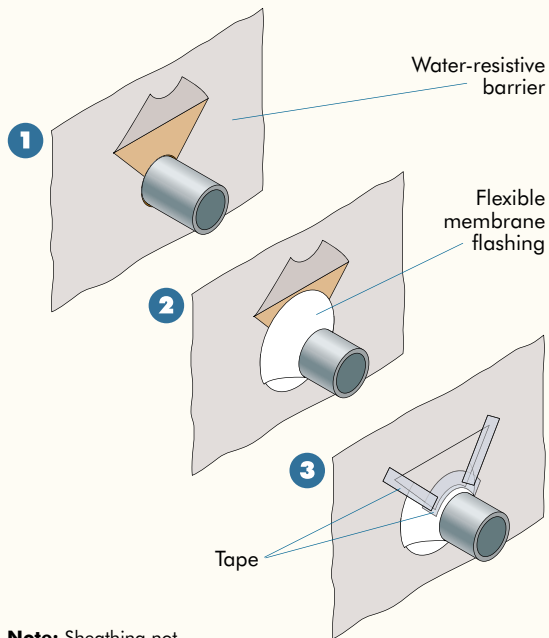
FLASHING INSTALLATION AT PORTLAND CEMENT STUCCO-TO-ROOF INTERSECTION



Note: Metal lath and weather-resistive barrier must extend down over flashing.

FIGURE 12

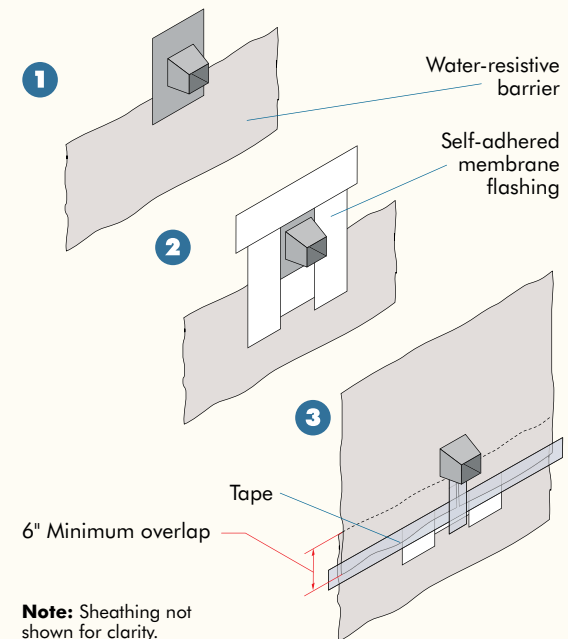
INTEGRATION OF STRUCTURE'S WATER-RESISTIVE SYSTEM AT A TYPICAL WALL PENETRATION



Note: Sheathing not shown for clarity.

FIGURE 13

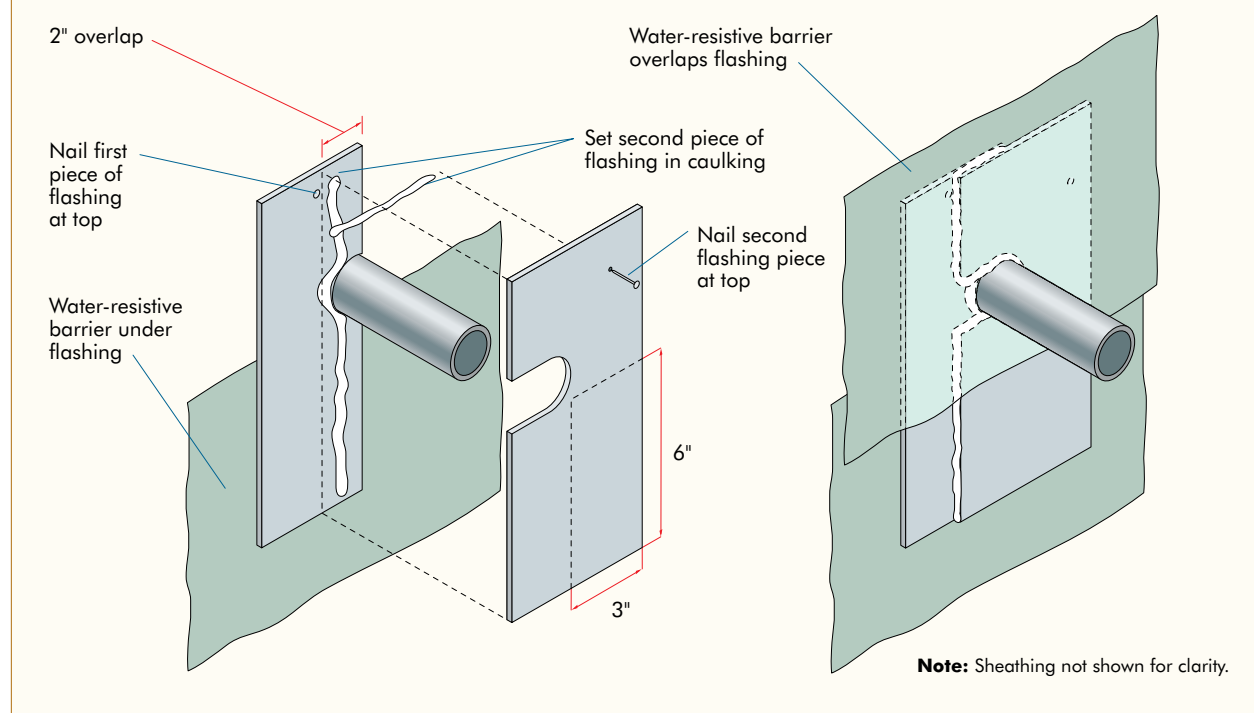
INTEGRATION OF STRUCTURE'S WATER-RESISTIVE SYSTEM AT A TYPICAL WALL PENETRATION WITH PRODUCTS THAT HAVE FLANGES



Note: Sheathing not shown for clarity.

Note: Seal the water-resistive barrier around all electrical, HVAC, and plumbing penetrations. Start taping or flashing at bottom of penetrations, shingling upper tape over bottom tape.

FIGURE 14

INTEGRATION OF STRUCTURE'S WEATHER-RESISTIVE SYSTEM AT A TYPICAL WALL PENETRATION**Vapor Transmission in Wood Wall Construction**

Vapor transmission is the molecular passage of water through the components of a building. A differential water vapor pressure across the wall causes this movement. In cold weather, vapor from the interior of the structure can permeate through the interior wall finish and condense on cooler framing and sheathing surfaces in the wall cavity if there are surfaces colder than the dew point temperature. To prevent this, an effective interior (“warm side”) vapor retarder installed beneath the interior wall finish or insulated sheathing is recommended by codes for most cold climate regions.

The “warm side” vapor retarder in exterior walls may be omitted in regions with moderate temperatures, such as the southern and southeastern United States. In warm, humid regions close to the Gulf of Mexico, in Hawaii, and in the Caribbean regions where air conditioning is prevalent, the vapor retarder should be installed on the exterior side of the wall behind the sheathing. This will prevent humid air from penetrating into the wall cavity and causing increased condensation on the cooler interior wall surface.

Selection and Installation of Vapor Retarder

When the warm side is determined to be the inside wall, the vapor retarder can be kraft paper or foil/kraft paper facing on the wall insulation. The effectiveness of this vapor retarder depends on how carefully the insulation is installed. The most effective installation technique is to cut the insulation batt length slightly oversize so it can be friction-fit to avoid gaps at the top and bottom wall plates. Also, the installation tabs of the insulation facing should be lapped and stapled onto the nailing surface of the studs instead of the sides of the studs to “seal” the insulation facing against air and moisture leakage and to minimize gaps between the insulation and studs.

FIGURE 15

WATER-RESISTIVE SYSTEM AT AN EXTERIOR DECK

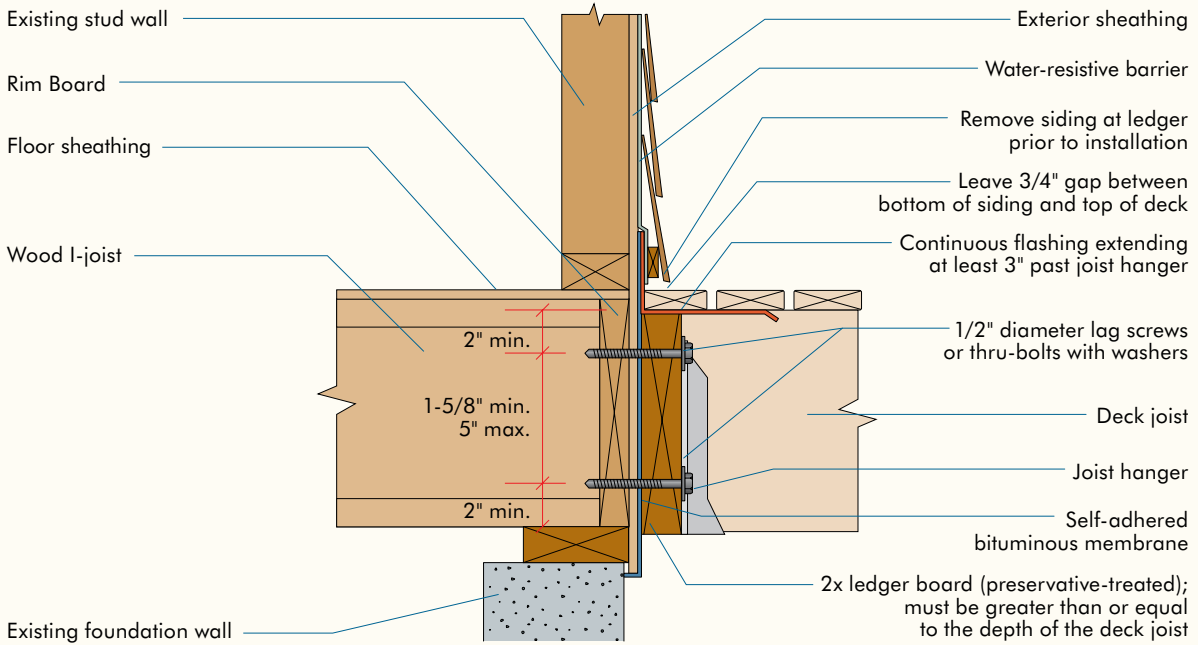
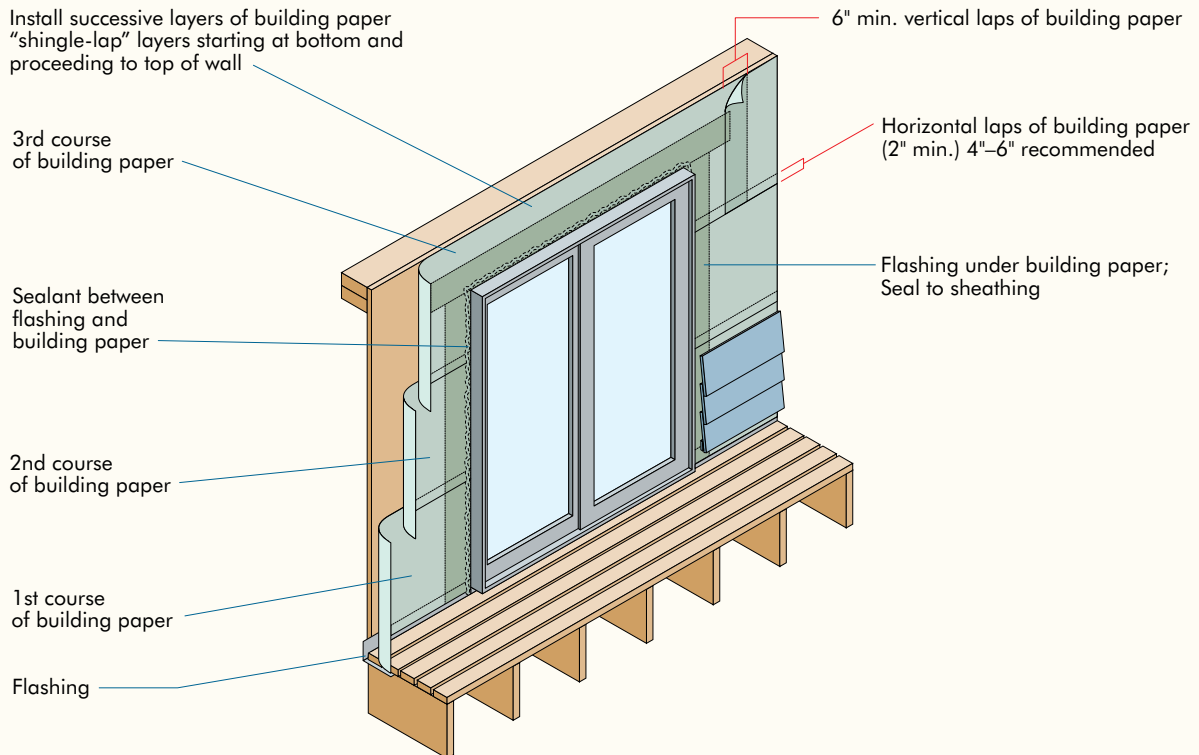
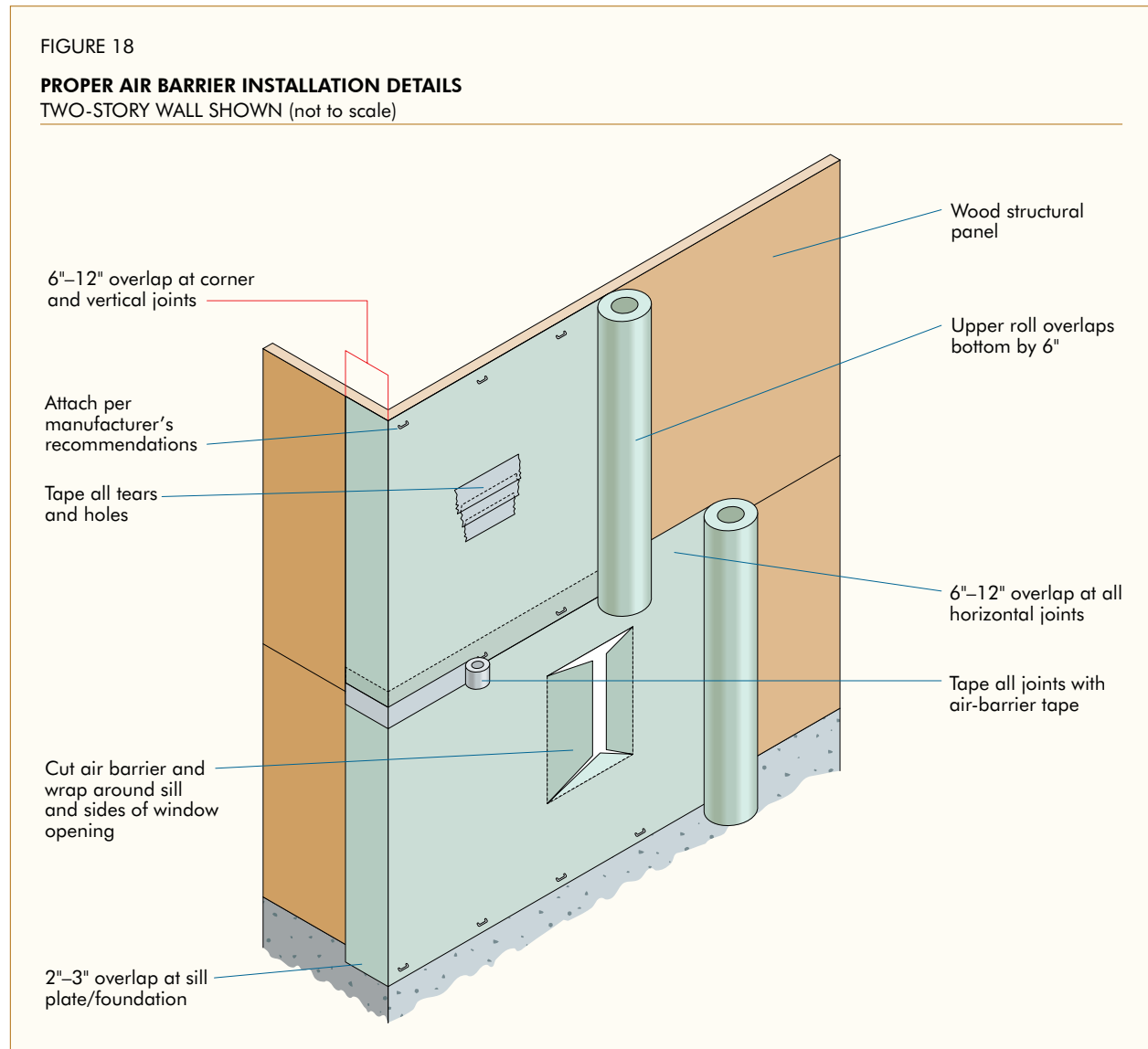
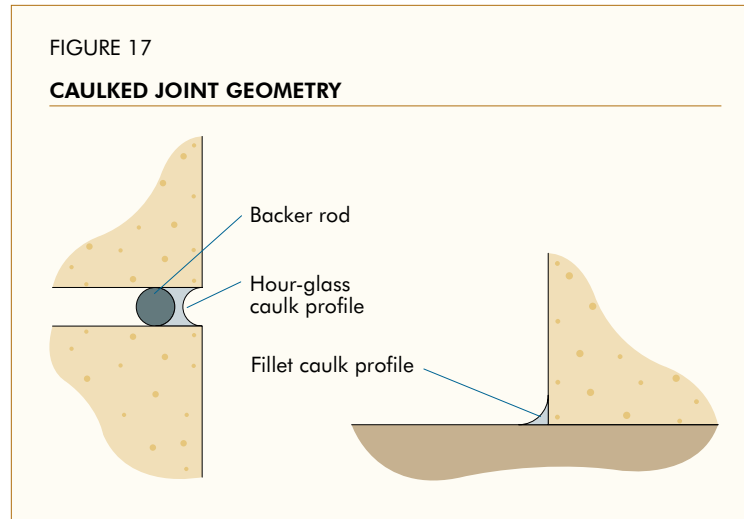


FIGURE 16

PROPER INSTALLATION OF BUILDING PAPER—SHOWN AROUND A DOOR OPENING



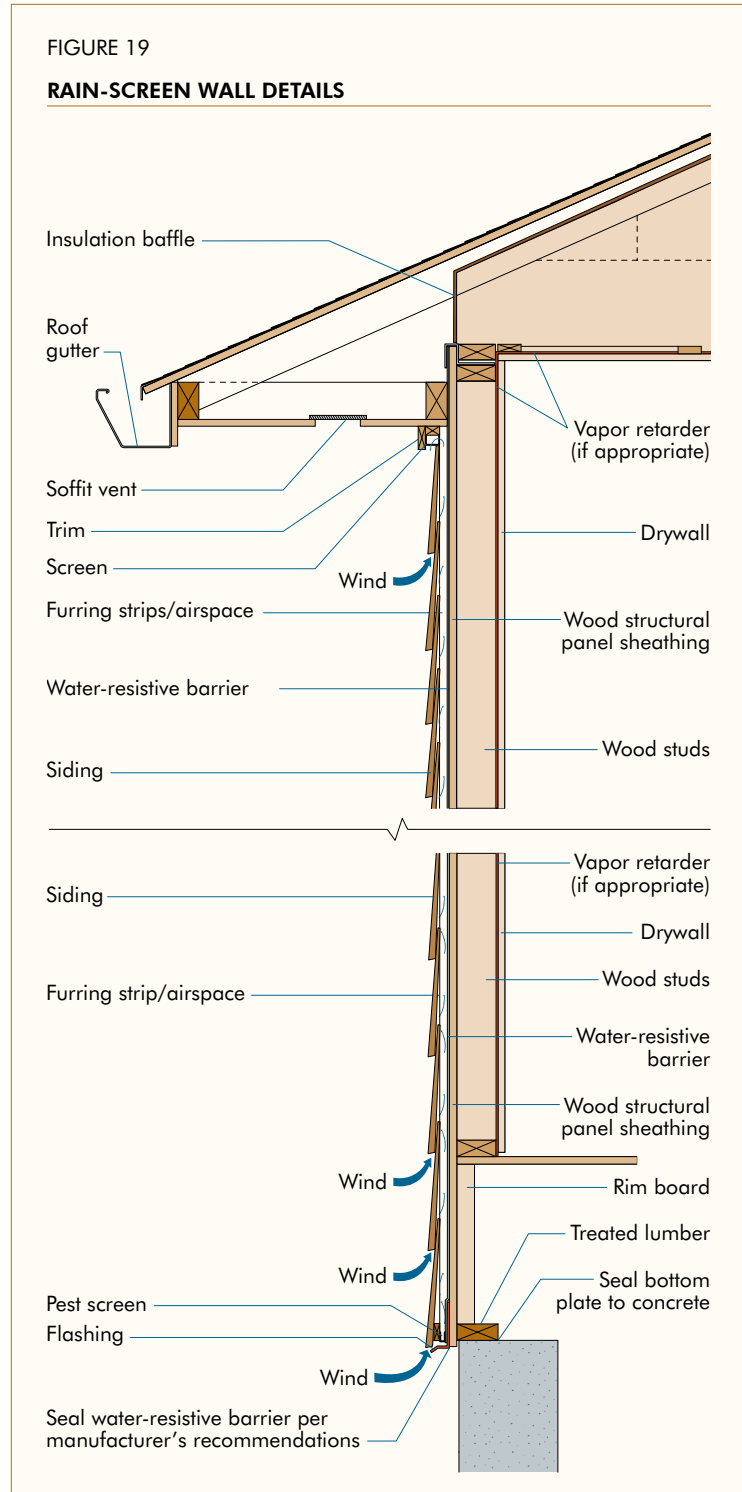
Alternatively, an effective continuous vapor retarder can be installed by using a separate layer of 4-mil polyethylene sheeting stapled over the interior side of the wall framing. In this case, unfaced insulation without an integral vapor retarder facing may be used and friction-fit to fill the stud cavities without gaps. While polyethylene sheeting makes a very good vapor retarder, it is relatively difficult to install. In most cases, the use of polyethylene is not necessary even in very cold regions. Ordinary interior latex paint applied over drywall can provide sufficient vapor retardant properties.



INSTALLING RAIN-SCREEN WALLS

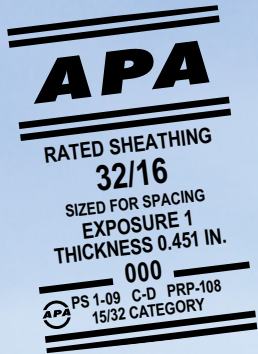
The entire exterior finish, weather-proofing, and flashing system in wood construction relies on gravity to keep bulk water out of the building envelope. Wind-driven rain can compromise these safeguards because the water is hitting the wall from a different angle. If wind-driven rain is an infrequent occurrence, the forgiving nature of wood construction can often account for the occasional influx of water into the building system. The moisture will be removed through capillary suction and evaporation and the entire building frame will dry.

In areas where wind-driven rain is frequent, the amount of water driven into the wall system could be more damaging. In these cases, a rain-screen wall is often used. Rain-screen wall construction creates an air space between the exterior finish system and the weather-resistive system. This separation is made with the use of pressure-treated lumber spacers that are installed vertically and carefully detailed around openings and penetrations to allow drainage of any water that makes it through the exterior finish. This space— $\frac{3}{4}$ to 1 inch—is open at the bottom to allow the air space to equalize with the exterior air pressure. The top is trimmed out to allow for air flow while preventing wind-driven rain from getting behind the screen. The openings at the top and bottom have pest screens. This system is often used with an interior air barrier to allow the air pressure in the interior of the wall to equalize with that in the air space behind the cladding. This will eliminate the driving force that causes water to leak into the wall.



About APA

APA is a nonprofit trade association whose member mills produce approximately 85 percent of the structural wood panel products manufactured in North America.



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APA's services go far beyond quality testing and inspection. Research and promotion programs play important roles in developing and improving panel and engineered wood systems, and in helping users and specifiers better understand and apply products.

More Information Online

Visit APA's website at apawood.org for more information on engineered wood products, wood design and construction, and technical issues and answers.

Online publication ordering is also available through the website.



Build a Better Home: Moisture-Resistant Wall Construction

We have field representatives in many major U.S. cities and in Canada who can help answer questions involving APA trademarked products. For additional assistance in specifying engineered wood products, contact us:

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REPRESENTING THE ENGINEERED WOOD INDUSTRY