Wind-Smart Design

In a blowing rain, it's the details that count

by Gordon Tully

Attention to wind should be a central focus of any coastal design. A smart design in a high-wind zone guides wind around the house as smoothly as possible. Effective features include hipped roofs with a medium slope, short overhangs, and few turbulence-producing obstructions, such as dormers and open porches. And because wind pressure increases with height, a wind-smart design stays low to the ground.
In short, good coastal design should be streamlined — the polar opposite of the boxy modernist style and the tall, gable- and porch-encrusted neo-Victorian style. Yet both these styles are immensely popular along the coast, resulting in a head-on collision between design and science.

Wind-smart design involves more than the shape of the house, however. Materials matter, too. To survive strong winds, the building envelope must remain continuous and intact. In a flying debris test, a 2x4 traveling 90 mph goes through a stud wall as if through butter, so you are taking a risk building wood-framed walls in high-wind areas. Instead, consider building in concrete or using reinforced masonry. But above all, include these essential features to keep the basic structure intact:

- windows with special frames and laminated glass
- properly reinforced garage doors
- roof structure with plywood sheathing and engineered fastenings
- firmly nailed roofing (no staples)

Keeping the building dry in the face of wind-driven rains will require much more, however.

FIGURE 1. The key to wind-smart detailing begins with a continuous air barrier. While ordinary housewrap might work, a self-adhesive membrane applied to continuous sheathing is more durable and less likely to leak once installed. In heating climates especially, it's important to use a specially formulated membrane (or comparable spray-on liquid) that will not create an exterior vapor barrier.

PRIMARY AIR-PRESSURE RETARDER

The key to wind-smart detailing begins with a continuous air barrier. In a wood-framed wall without a dedicated air barrier, various solid layers — drywall, sheathing, and cladding — share the job of preventing airflow through the wall. But even with a good air barrier, *some* of the barrier work will occur in the other layers, because "good" does not mean "perfect." It is the same with vapor retarders: every layer has a perm rating, but the vapor retarder has the *highest* perm rating.

Rapid variations in air pressure from gusting will try to flex the air barrier. For housewrap or building paper to act as an air barrier, it must be continuously held tight against a stiff sheathing. In northern climates, a poly or paper vapor retarder (which typically acts as the primary air barrier) will belly and tear, so a good substitute is the "airtight drywall approach" (ADA) from Canada. This method relies on gaskets and sealants to stop air at the drywall plane. Rigid insulation outside the studs works in any climate. A self-adhesive membrane applied to the sheathing works well, as does a fluid-applied membrane, assuming it is reinforced at gaps in the substrate and does not form an exterior vapor retarder. One example is Grace's Perm-A-Barrier (**Figure 1**), which is available in both liquid and membrane formulas (www.na.graceconstruction.com).

PRESSURE-EQUALIZED RAIN SCREEN

Imagine a brick cavity wall in which the brick is made porous by screened vents placed on a 4-foot grid, and with a good air barrier on the inside of the cavity. This creates a *pressure-equalized rain screen*, and here is how it works: The pressure within the cavity will be nearly the same as the outside because of the vents and the air barrier. The brick absorbs the pressure of the wind-driven rain so that any rain that passes through the vents or mortar joints runs down the inside face of the rain screen, where it can drain back out at flashings. There will be no suction through the wall to induce leakage at capillary joints. The air barrier stops any residual water that gets through the rain screen.

ORDINARY RAIN SCREEN

In a typical cavity wall, the outer layer has few vents and becomes a partial air barrier, creating a pressure drop between the outside and the cavity. Although some water will be sucked into the wall on the windward side, this kind of construction is still quite effective (providing, as always, that you can drain the cavity at the bottom!). Venting the cavity at the top makes it a better rain screen and helps to dry out the cavity.

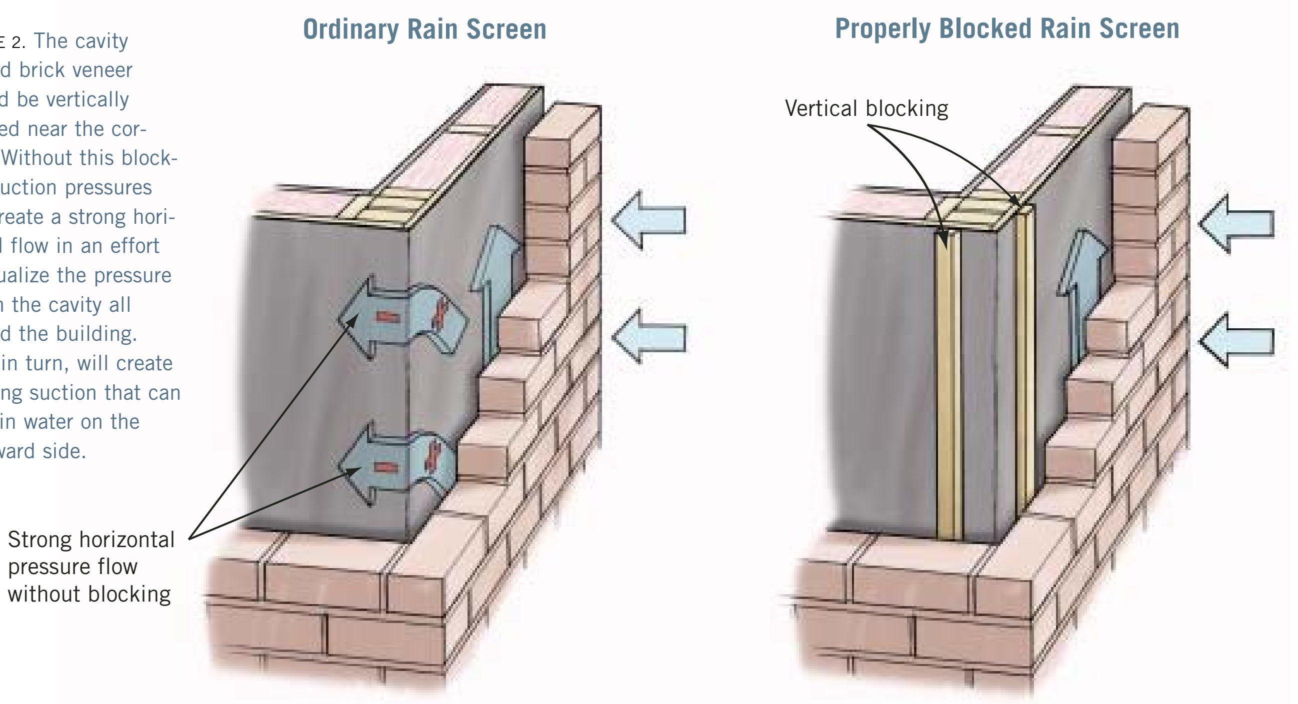
It is important to block any continuous cavity from horizontal air movement at corners (**Figure 2**). On the windward side, there will be strong positive pressure in the cavity, while just around the corner will be strong negative pressure. If you don't block the corners, there will be a strong horizontal flow to equalize pressure within the cavity all around the building, sucking water into the cavity on the windward side. This barrier will be under more than twice the normal wind pressure, so it should be sturdy. [For more information, refer to the Canada Mortgage and Housing Corporation (CMHC) "Best Practices Guides," www.cmhc-schl.gc.ca/en/inpr/bude/himu/himu_001.cfm.]

DRAINAGE PLANE

Shrinking the cavity until it is just a gap between adjacent materials results in a *drainage plane* design. Drainage planes can be created by anything that creates drainage channels, such as Benjamin Obdyke's Home Slicker (www.benjaminobdyke.com) or grooved rigid insulation. Under stucco, one layer of building paper or DuPont's Tyvek StuccoWrap (www2.dupont.com/Tyvek_Construction/en_US) may not keep the stucco separated from the sheathing, so you need to add a second layer of building paper. Under wood or composition cladding, building paper, insulated sheathing, or housewrap will create an adequate drainage plane.

If you omit the drainage plane entirely in wood-frame construction, as when EIFS is applied directly to sheathing, the result will be a crapshoot. In this case, the EIFS must act as both a water barrier and an air barrier, so all the joints around windows and doors are potential routes for water to reach the framing via suction-enhanced capillary joints. You will probably get away with it in dry climates, but not in wet ones, as evidenced by the huge class-action lawsuits in British Columbia and North Carolina, in which leakage through EIFS caused major structural damage in hundreds of homes.

FIGURE 2. The cavity behind brick veneer should be vertically blocked near the corners. Without this blocking, suction pressures will create a strong horizontal flow in an effort to equalize the pressure within the cavity all around the building. This, in turn, will create a strong suction that can draw in water on the windward side.



LITTLE DETAILS THAT COUNT

Almost no one in the home-building industry understands how sealant works. Caulk is treated as magic stuff that makes problems go away. Unless it is also an adhesive that holds the surfaces together, sealant cannot be expected to work if it is simply buttered on or squeezed into a joint (**Figure 3**). Here are the critical details to making a sealant joint work:

- ***Width.*** Most joints get bigger and smaller, and when they do, so does the sealant. But a sealant bead can compress and expand only by a percentage of its width: 25% for good sealants and up to 50% or more for super sealants. So, if a joint is likely to get 1/16 inch bigger than when you build it, the bead needs to be 1/8 inch to 1/4 inch wide. The cheaper the sealant, the bigger the joint.
- ***Bonding.*** Sealants only work if they bond permanently to both sides of the joint. Every sealant bonds to certain materials and not to others, so you must pick one that works for *both* materials. When a bead loses its bond, it invites water in by capillary action, which is made worse by wind-driven suction. In some cases, you need to prime the material to create a bond.
- ***Backing.*** A sealant bead needs to be about square, and must not bond to the back of the joint.

These requirements can be met for most sealants by filling the joint behind the sealant bead with a "backer rod" made of polyethylene foam.

Horizontal butt joints left exposed to the weather require regular painting to keep water from invading via capillary action at the joint, or through holes created by toe-nails. A common example occurs in traditional wood railings where the baluster sits on the bottom rail (**Figure 4**).

Similarly, at the edge of a wet surface (like a windowsill or rail caps), there needs to be a kerf or vertical offset in the bottom surface to prevent water from flowing back into a joint or onto a wall surface. Drip moldings accomplish the same thing in a roof.

ROOFS

Lost in the discussion of rain screens and drainage planes is the roof, which can be the most vulnerable part of the envelope. Roofs have their own set of requirements, including finding some way to maintain the continuity of the air barrier at the eaves. They deserve a discussion of their own. — *Gordon Tully is an architect in Norwalk, Conn. He teaches a summer executive education course at the Harvard Graduate School of Design.*

Effective Sealant Bend

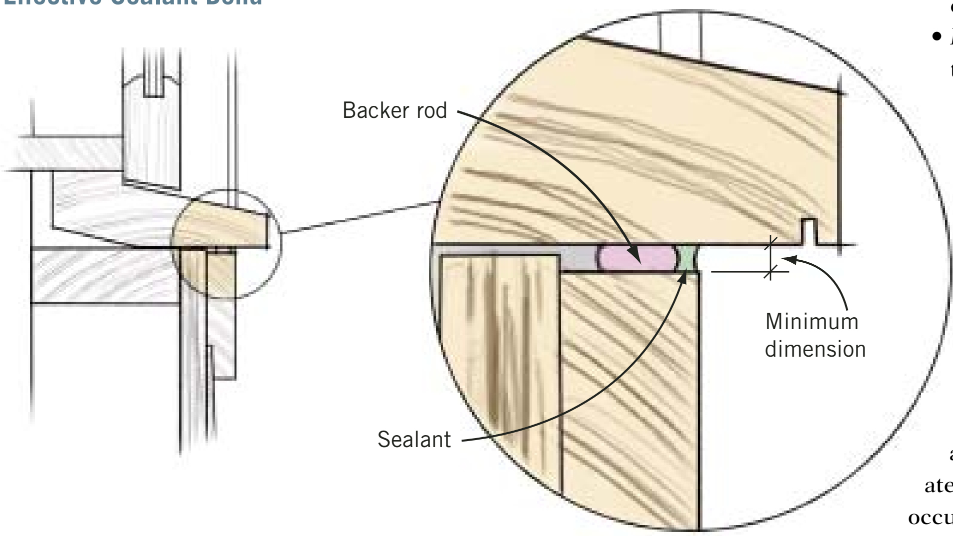


FIGURE 3. For a sophisticated plastic sealant like polyurethane caulk, a properly detailed joint will work, but it must be properly shaped so it can expand and contract as the joint moves. Most important, the bead should bond on only two sides. To prevent it from bonding on the back, a "bond breaker," such as a polyethylene backer rod, is required.

High-Maintenance Handrail / Low-Maintenance Handrail

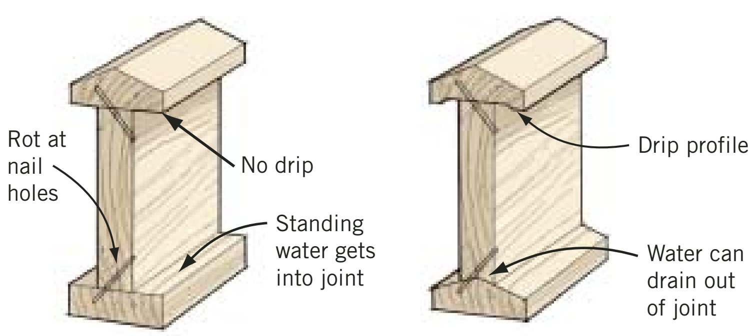


FIGURE 4. Handrails are particularly vulnerable to water penetration and rot out quickly in a coastal environment if detailed improperly (left). Applying the principles of good design (right), drip-edges and a drainable joint to flow water away will help reduce maintenance while still preserving a traditional look.