BY TED CUSHMAN

A Passive House in Wildfire Country

Ramona, California, situated in the dry hills near San Diego, gets barely 16 inches of rain in a typical year. Almost all of it falls in a few torrential downpours during the brief winter rainy season; of the 15.18-inch precipitation total for 2016, 12 inches fell on a handful of days in January and December. In mid-summer, the sun-baked hills are bone dry. Last June, for example, the Ramona airport weather station received precisely zero inches of rain.

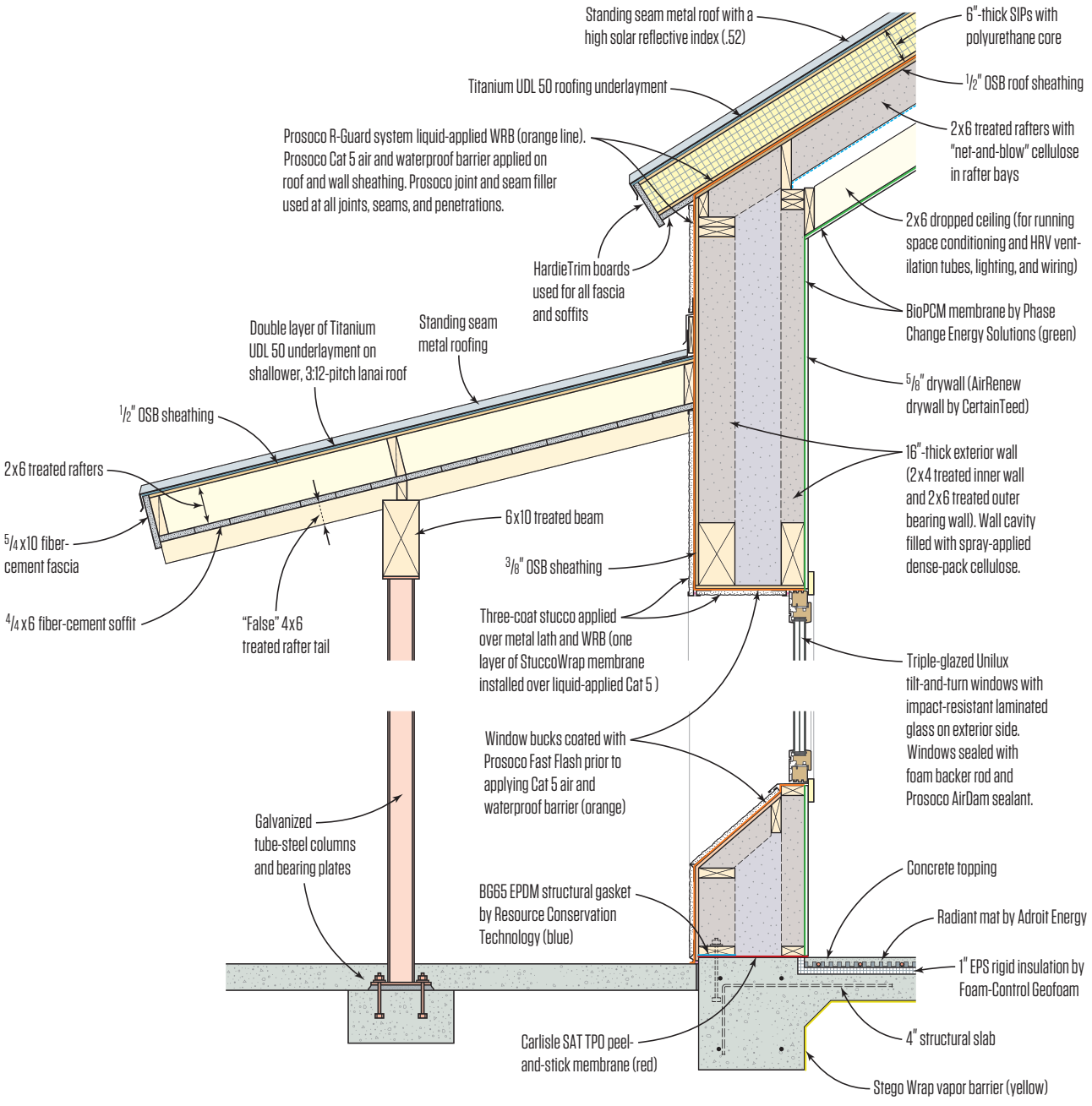
As it happened, when I drove up the canyon the week after Christmas to meet builder Jeff Adams of Alliance Green Builders and to tour San Diego County's first Passive House, it rained all day.

Dubbed "Casa Águila" (after the golden eagles that visit the area) by homeowners Amy McQuillan and Pete Beauregard, the hilltop home is a unique showcase for green technology. As required by the Passive House standard, the house is airtight and superinsulated. But construction also had to comply with California's strict Wildland Urban Interface (WUI) code for ignition resistance in a wildfire-prone area. In this case, the fire risk is by no means theoretical: Casa Águila is a replacement for an earlier dwelling, once located on the same lot. That previous building burned to the ground, along with a thousand other homes in the area, during the 2007 Witch Creek wildfire.

Photo: Alliance Green Builders

Above, a drone photo captures the panoramic view at the site of "Casa Águila," a Passive House in California's Wildland Urban Interface zone near San Diego. Solar panels in the foreground track the sun, extending the system's daily output from early morning to late afternoon. The helical wind generator at rear supplements the PV system's production, and roof-mounted panels heat the home's water.

Fire-Resistant Passive House Shell



"Casa Águila" achieves wildfire resistance with noncombustible exterior siding, roofing, and trim. Framing and wood trim are treated with fire-retardant sodium borate. The home's landscape is detailed as "defensible space," with stone patios and gravel beds. Deeply recessed triple-glazed windows have impact-resistant outer glass to defend against the risk of wind-blown debris in a firestorm. Double stud walls are insulated with dense-packed borate-treated cellulose.

Illustration: Tim Healey

But fire resistance and Passive House compliance aren't the building's only advanced features; it's also self-sufficient for water. Despite the dry location, the building gets all its domestic water from its rain catchment roof. Surplus water from the heavy winter rains is collected and stored in 10,000-gallon tanks: four to store roof runoff for use as domestic water and four to store ground runoff for irrigation, plus a fire-suppression tank that's required by the local fire department. Water is heated by a rooftop solar system with a heat-pump backup. Wastewater is recovered for food production: All the building's blackwater and greywater are treated on site (another first for San Diego County) and used—along with stored stormwater—to irrigate a terraced "food forest" orchard and garden.

And although the home was certified by Passive House based on energy conservation alone, there's also active power production on the site. Ground-mounted sun-tracking solar panels, along with a vertical-axis helical windmill generator, create a power surplus that makes the dwelling net energy positive. Some of the surplus is exported to the grid, but a deep-cycle backup battery system stores some of it in case of a power outage. (Power outages are frequent during wildfire season, when the local utility shuts off power lines in the dry hills to prevent downed lines from sparking more wildfires—like the catastrophic 2007 fire, which was started by a blown-down power line.)

And yes—they do have a pool.

PASSIVE HOUSE FEATURES

Passive House is a performance standard, not a prescriptive rule; buildings have to meet objective criteria for energy use, but how they achieve that goal is up to the discretion of the designers and builders. Ramona has only about 2,900 heating degree days, and about 1,600 cooling degree days—but as Adams' partner, Rich Williams, points out, summer heat is extreme, winter can bring frost, and daily swings are large. To limit solar gain, Adams and Williams installed a reflective metal roof over a superinsulated roof deck (dense-blown cellulose capped with 6-inch polyurethane structural insulated panels (SIPs). Windows are triple-glazed Unilux tilt-and-turn units with high solar reflectance. Architect Andrew Wilt's design called for shading to shelter the windows from the summer sun.

Airtightness is a key Passive House requirement in any climate, and for their first Passive House, Adams and Williams sweated the details. Wall plates are gasketed to the slab foundation. Walls and roof are air-sealed with Prosoco fluid-applied membrane, which continues up the walls and onto the roof sheathing. The SIPs, applied over the sealed roof deck, create self-supporting overhangs; false rafter tails under the eaves are exterior-applied.

FIRE RESISTANCE

Landscaping is a main component of WUI codes. As required by the California code (and enforced by the local municipality), vegetation is kept to a minimum near the house. There's also "defensible space"—paving, driveways, and gravel beds surround the building. A hydrant, connected to the backup storage tank, stands near the top of the driveway.

Carpenters apply 6-inch SIPs to the roof frame (top). The roof sheathing under the SIPs has already been air-sealed with fluid-applied membrane. Above, roofers install steel roofing panels on top of synthetic roofing underlayment.

Photos: Alliance Green Builders

Builder Jeff Adams inspects an air filter for the Zehnder heat recovery ventilator serving the home (above left). A smoke detector tied into the Zehnder controls at the system's fresh-air intake port (above right) is wired to shut the fans down and close a damper if smoke from a wildfire begins to enter the system.

Keeping the building's exterior noncombustible was relatively simple. The roof is metal; the exterior cladding is cement stucco. Trim is mostly Hardie fiber cement. The exposed rafter tails (as well as the wall and roof framing) are treated with fire-retardant sodium borate (also effective against termites).

But windows turned out to be a critical factor. "As lay people," explains Rich Williams, "we think that the fire just burns along the ground to the house, burns up to the eaves, and sets the house on fire." But in fact, he says, wind-blown debris can play a major role. The location's hot, dry Santa Ana winds, which blow from California's inland deserts toward the coast during the peak wildfire season, "get whipped up by the fires to extremely high velocity," he says. "That kicks up rocks and debris, and they shatter windows. Once those windows are shattered, embers and flaming material enter the home, and the house catches fire from the inside out." In the Witch Creek fire, according to Pete Beauregard, a neighbor's weather station clocked the wind at 120 mph—the threshold that triggers a requirement for impact-resistant windows and storm shutters in coastal hurricane zones.

"Originally, we were going to put in external aluminum roller shades," says Williams. "But the cost was around $70,000. Also, they're 12 inches deep. Even with 16-inch-deep walls, they were hard to accommodate. And besides that, these things are not only thermal bypasses, but also air leakage points in the envelope." Instead, the team opted for triple-glazed Unilux windows with an outer pane of impact-resistant laminated glass. "The up-charge for the impact glazing was $30,000," says Williams. "So compared with the roller shades, we saved the project about $40,000."

As the team spec'd out a Zehnder heat recovery ventilator (HRV), a thought occurred to them: If a wildfire did burn over the area, the ventilation system might suck in smoke and spread it throughout the building, damaging furniture and finishes and contaminating the ducts. So Alliance added a hard-wired smoke detector at the Zehnder's air intake, to shut down the HRV's fans and close an airtight damper if smoke starts to enter.

Wildfire risk is also a driver for the building's deep-cycle battery backup system. During the dry, blustery autumn, homes in the area lose power occasionally because the local electric utility shuts off power lines when winds get too rough (hoping to avoid a repeat of the 2007 disaster). Casa Águila's batteries are designed to hold enough charge to get the house through those down times. But the system isn't designed for the continual charge and discharge cycles that would let the house operate without a grid connection. Instead, the grid acts as the battery to compensate for variable wind and solar production: When the home makes more power than it needs, the excess is fed to the grid for use by the neighbors. At night, or when the sun and winds are both weak, the home draws power from the utility grid.

The 3.2kW wind generator and 21kW PV array are optimized to extend the home's energy-positive hours. The ground-mounted solar arrays pivot to track the sun—and on cloudy days, the system can even point the array at the brightest spot in the cloudy sky. The builders are monitoring the home's energy production and consumption to learn the patterns. Eventually, the plan is to install short-cycle batteries that will allow the building to run independently from the grid.

Ted Cushman is a senior editor at JLC.

Photos: Ted Cushman