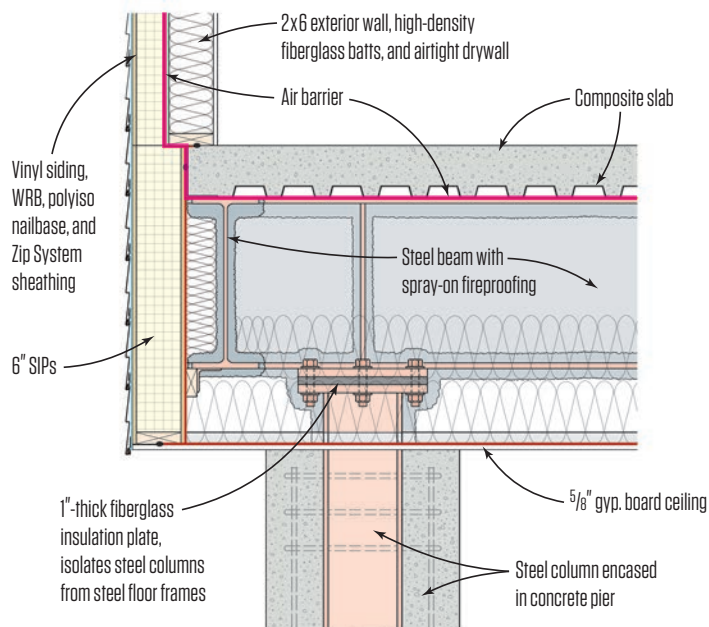


BY CHRIS WEST



To keep the steel frame and concrete slab for the first occupied floor thermally isolated from a cold garage below, the architect and the Passive House consultant devised an insulated enclosure under the floor structure. A 1-inch-thick fiberglass thermal isolation pad at the column-to-beam connection adds insulation value of R-2—not much but still significant compared with ordinary steel.

A Thermally Broken Steel Connection

I'm a Passive House consultant working in Vermont. Up until now, my work has been exclusively with single-family homes. But in 2015, architect Michael Wisniewski of Duncan Wisniewski Architecture, in Burlington, Vt., asked me to help with the design of “Elm Place,” a proposed 30-unit senior living facility to be owned and managed by Cathedral Square, a non-profit that operates more than 20 senior living facilities in Vermont. This was to be the first certified Passive House multifamily building in Vermont.

The size and shape of a large multifamily building make it very different from a house. The massing affects the ratios of volume to surface area, which can help a large project like Elm Place achieve Passive House performance without the extreme superinsulation required in a small dwelling.

But the multifamily world can also pose particular challenges. This building, for example, was designed with a ground-level parking garage beneath two upper stories of apartments. The first occupied story above the garage would rest on a concrete slab, poured on a corrugated steel deck supported by a steel floor frame, all held up by steel and concrete pillars. Because of some issues related to soil conditions on the site, the steel frame was quite beefy. And because steel conducts heat so readily, thermal bridging was a major consideration.

As a Passive House consultant, my first suggestion was to keep all that concrete and steel floor structure completely outside the thermal envelope, by insulating above the slab, and framing up from there. But Wisniewski shot that idea down: If a waste pipe broke under that kind of insulated floor, he pointed out, it would be hard to detect the damage and even harder to repair it.

That one sentence—“we can’t do that because of the risk of a waste-pipe leak”—changed the whole approach. Instead, we had to find a way to keep the steel and concrete within the thermal envelope—and somehow minimize the thermal bridging between the steel floor structure and the steel columns that supported it.

The solution came from a Passive House contact. We would isolate the steel columns from the steel floor frames with a load-bearing fiberglass insulation plate, as shown at left. The plate’s not a lot of insulation—only



Above, the thermally broken steel-plate connection supports steel girders under the galvanized pan for the structural slab. All of the steel floor frame and the concrete slab ended up inside the thermal envelope.



This view of the Elm Street building under construction shows the partially constructed wall with sealed Zip System sheathing and “half SIP” nailbase. The exposed steel and concrete floor structure seen here would later be enclosed with framing and insulation.

R-2—but that’s a lot less conductive than steel. Three-dimensional heat-flow modeling enabled us to quantify the heat loss at those connection points and account for them in our overall calculations.

WALLS AND ROOF

In specifying the assemblies for the Elm Street project, we had a big head start: The architects had recently finished a similar project, a senior living facility called the “Wright House,” in Shelburne, Vt. The Wright House didn’t reach Passive House performance metrics, but it did hit some important building-science benchmarks—in particular, achieving an impressive 0.75 ACH50 airtightness test, very close to what PHIUS was asking for this new project. This made design decisions for Elm Place easier, because the architects could use the Wright House as the base design of Elm Place.

Many elements of the design were set from the beginning. The building’s shape and orientation (small end to the south, long sides to the east and west) were determined by the lot dimensions. The population of seniors living in one- and two-bedroom apartments was a given, as was the garage located beneath the apartments on the first-floor level. The building is not just an apartment house but a full-service senior living facility, so the project also included quite a bit of common space: three multi-use spaces, a lounge, offices, a nurses’ room, and laundry rooms.

The floor plan for the project went through three versions during the design phase as the architects worked to limit the cost per square foot (a process unrelated to the Passive House analysis).

But early on, I took a preliminary rough design and modeled it using version 8.5 of the Passive House Planning Package (PHPP). The first run of energy modeling used R-values typical for a single-family Passive House in northern Vermont (R-55+ walls, R-90+ roof, R-60 suspended floor, R-40 slab). The results showed a building that was way below PHIUS targets for heat loss—and also pushed the project significantly over budget. Clearly, we had room to reduce the insulation significantly to hold down costs.

Wall R-values. Above is a view of the wall system we ended up with. It’s more heavily insulated than a code-compliant single-family house wall in Vermont, but less insulated than a typical Passive House. It’s a 2x6 wood frame insulated with high-density fiberglass batts, with airtight drywall on the interior face and Zip System sheathing with Zip Tape-sealed joints on the outboard side. Over the Zip System, we applied either a 3-inch polyiso nailbase panel from Hunter Panel or 3-inch foil-faced polyiso rigid insulation (depending on the cladding chosen for that part of the wall). This provides an R-value of about R-37 or R-39.

Airtightness. The PHIUS Passive House standard no longer imposes a one-size-fits-all airtightness criterion of 0.6 ACH50. Instead, the required airtightness depends on the ratio between building surface area and volume. Making the allowable air leakage proportional to the exterior envelope area redresses a bias against small houses in the previous standard. It also allows more flexibility of design in terms of massing. This helps out with a building such as Elm Place, where lot dimensions wouldn’t allow a blocky cube-shaped form; we had to hit an equivalent ACH50 of about 0.71,



Above, a view of the completed Elm Street project, with administrative and common areas near the street and apartments to the rear, above the parking garage. The building reached Passive House certification at an upcharge of about 2% from the client's earlier Wright House project.

where a square building of similar square footage would have had to reach something more like 0.3 ACH50. We passed the multi-point blower-door test, but with little room to spare.

Moisture and vapor. In an ideal world, a Passive House wall would be vapor open on two sides, allowing inward and outward drying. Our wall doesn't achieve that: It allows drying inward, but not outward. The budget wouldn't allow, for example, the wood I-joist exterior wall with vapor-open weather barrier membrane that a lot of custom Passive House homebuilders are using now. Our R-70 truss roof system, insulated with spray foam against the roof sheathing and high-density fiberglass under that, also allows inward drying only.

RESULTS

To be certified by PHIUS, the building had to meet the new climate-specific criteria released in the organization's 2015 standard. We readily passed the criteria for annual heating demand, maximum heating load, annual cooling demand, and annual cooling load. We barely squeaked by the threshold for airtightness. And we were definitely challenged by the criteria for "primary energy," defined as the amount of fuel that has to be fed into a power plant in order to supply the site energy needed by the building for plug

loads, lighting, and other power uses.

Primary energy is a tougher nut to crack for a multifamily building than for a stand-alone home. In our case, the ventilation system we could afford was less efficient than top-of-the-line equipment preferred by high-performance custom builders, with relatively low heat exchange core efficiency and high electrical consumption per cfm. This building also needed commercial clothes dryers, which don't come in ventless versions—so we had to direct-vent the dryers, which required high volumes of makeup air. Elevators, a necessity for a building of this kind, also use power.

Even so, Elm Street was able to meet the Passive House standard for a cost per square foot that was only about 2% above the cost of the Wright House, the customer's most recent previous project. This means that even in a cold-climate state like Vermont, with its 8,200 heating degree days, if the building is big enough, going for Passive House levels doesn't have to mean a prohibitive increase in construction costs. Going forward, all of us on the design team for this project expect to improve our skills as we gain experience, and develop even better-performing and more-cost-effective systems. In our view, all large buildings should be built to Passive House standards in the future.

Chris West is a certified Passive House consultant practicing in Vermont.