Raised Floors for the Low Country

by Ted Cushman

Elevated floors on pier foundations are mandated in V zones and recommended in coastal A zones. But the moisture and energy details can be a head-scratcher.

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Charlie Carll, Research Forest Products Technologist at the U.S. Forest Products Laboratory, attaches temperature and humidity sensors to the underside of a floor system at Musicians' Village in the Lower 9th Ward of New Orleans. Researchers have begun a year-long effort at the community to document the performance of various insulation and air-sealing methods in raised floor construction.

According to the latest U.S. Census, more than 150 million Americans live in coastal counties of the United States (including the East and West Coasts, the Gulf Coast, and the Great Lakes coastlines) — many of them in areas that are at risk of flooding either from heavy rainstorms or from hurricane storm surges. As more people migrate to the coasts each year, that number is predicted to grow.

For new homes in these flood-prone areas, a pier foundation with an elevated floor system is a well-established solution. In many flood zones, it's the only option: to be eligible to participate in the National Flood Insurance Program (NFIP), or to qualify for federal aid in the event of a flood disaster, communities have to prohibit closed foundations for any building built in the FEMA-designated V zone (where there's a risk of storm-surge flooding accompanied by waves 3 feet high or higher). Many localities go a step further, requiring open foundations in the recently defined "Coastal A Zone" as well (the zone subject to waves between 1.5 and 3 feet high).

In the March/April 2008 issue of *Coastal Contractor*, we wrote that elevated slabs on fill within a perimeter stemwall can work well in a coastal A zone. But engineer Cathy Kaake, of the Southern Forest Products Association, recently noted, "Most floodplain managers I talk to are discouraging that type of foundation in that area." Mississippi Emergency Management Association's Al Goodman, the state coordinator for the NFIP, confirms that coastal counties are not allowing elevated slabs on fill in the coastal A zone. It's not that the

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FIGURE 1. Fully enclosed crawlspaces like this one see more severe moisture conditions than open crawlspaces that result when homes are supported by pier and beam systems, reports building science consultant Paul LaGrange. In this example, air conditioning ducts were already dripping condensation in early spring of this year. In general, ducts should be kept out of crawlspaces and placed within the conditioned living space wherever possible.

1.5-foot waves would damage the concrete foundation, he says: "It'll hold up okay, but it will divert the waves and the water against adjacent properties. That's why it's not permitted."

In fact, Cathy Kaake reports, "That's why my house got flooded in Katrina." After her house was built, builders had imported fill to raise the elevations of nearby lots and build homes on slabs. When the flood came, water that would have previously gone onto adjacent areas flooded Kaake's property instead — the kind of event that has happened often enough that regulators have begun to restrict the use of fill in flood zones nationwide.

Elevated to the proper height, and built according to the specs outlined in documents such as FEMA 55 (*Coastal Construction Manual*; www.fema.gov/library/viewRecord.do?id=1671) and FEMA 550 (*Recommended Residential Construction for the Gulf Coast*; www.fema.gov/library/viewRecord.do?id=1853), raised floors on pier foundations offer good flood resistance while allowing floodwaters to wash harmlessly under a home without impacting the neighbors. In regular A zones, where wave action is not an issue, raised floors on an enclosed perimeter foundation or on a filled slab are effective options. But an enclosed crawlspace foundation is required to have "flood vents" to relieve water pressure in the case of a flood.

STRUCTURE MEETS CLIMATE

There is a hitch, however: in any climate — and especially in the hot and humid Gulf Coast climate — raised floors can be a building science headache. Whether a builder places the floor system on pier supports or on a perimeter stemwall, he has to face interrelated problems of air sealing, insulation, and moisture protection that are neither easy nor cheap to solve. That's the consideration that leads building science consultant Paul LaGrange to say, "The best crawlspace is no crawlspace."

When he talks about crawlspace problems, LaGrange speaks from experience. A longtime builder in South Louisiana, he now works as a building science consultant who troubleshoots moisture and energy problems. He also runs an insulation company that has insulated scores of preexisting floor systems over crawlspaces. LaGrange has personally spent more hours under low-to-the-ground floor systems than he cares to remember. "We've done hundreds of them," he says. "We were doing it years before Hurricane Katrina hit."

LaGrange notes there's a difference between the moisture environment under a floor supported by open piers and the situation within a fully enclosed crawlspace that has just a few air vents: "Normally, the moisture content of the air and the ground are higher under a fully enclosed stemwall-type application with vents as opposed to an open-type crawlspace." The wide-open arrangement is more common in South Louisiana, he observes. But both types of foundation experience elevated moisture under the home (**Figure 1**).

Traditionally, raised floors in Louisiana were built without insulation. But with the advent of air conditioning and the spread of modern energy codes, many of those older

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FIGURE 2. Fiberglass insulation installed under elevated floors is typically unprotected and poorly supported. At top, wire mesh has come loose and allowed insulation to fall. In the middle photo, material held up by tacked-on furring strips has become bunched and compressed. The drooping batts at bottom were simply nailed to the subfloor in a few places with cap nails. In all cases, the insulation's performance is degraded or negated.

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floors have been retrofitted with fiberglass insulation. Where the floor is not insulated, LaGrange says, floors are cold in winter and warm in summer. But when the floors have received fiberglass batts, the frequent result can be moisture condensation at the underside of the floor. Ineffective as an air barrier, the fiberglass allows hot, moist air to penetrate and condense under the cool air conditioned floor in summer.

"Fiberglass isn't the only problem, but it contributes to the problem," explains LaGrange. Often the insulation has not been installed in full contact with the subfloor; other times, it has grown moist from condensation, gotten heavy, and fallen away from the floor, leaving a gap (**Figure 2,** page 2). When he takes moisture-meter readings of the subfloor where the fiberglass has fallen down, LaGrange says, he finds higher wood moisture content than in areas where the fiberglass is tight to the subfloor. "And you can physically feel a difference in the fiberglass," he adds. "It's more moist when it's not in full contact with the floor."

The typical result of all that moisture is trouble with flooring in the occupied space — in particular, buckled wood strip flooring or mildew under the carpets. In some cases, moisture problems are more extensive: balloon-framed walls in older homes may be open in some spots to the moist under-floor space, so that moisture is drawn through the framing voids into many areas throughout the house, causing uncomfortable conditions and mildew. In severe cases, subflooring or flooring may be heavily attacked by fungi (**Figure 3**).

POSSIBLE PRESCRIPTIONS

For homeowners with these problems, LaGrange offers two possible prescriptions: "Either apply rigid insulation board directly to the underside of the floor joists, taping the seams and sealing the penetrations; or apply spray-foam insulation into the joist cavities, with vapor-retarder paint

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FIGURE 3. Insulation that keeps the subfloor area cool but allows moisture to penetrate exposes the floor to potentially damaging condensation. Over time, the consequences may progress from a small amount of mildew (left) to a major infestation of wood-destroying fungus (right). Before badly damaged wood is protected by more effective insulating material, it should first be cleaned and treated by a capable mold remediation contractor.

RIDGID-FOAM FLOOR INSULATION

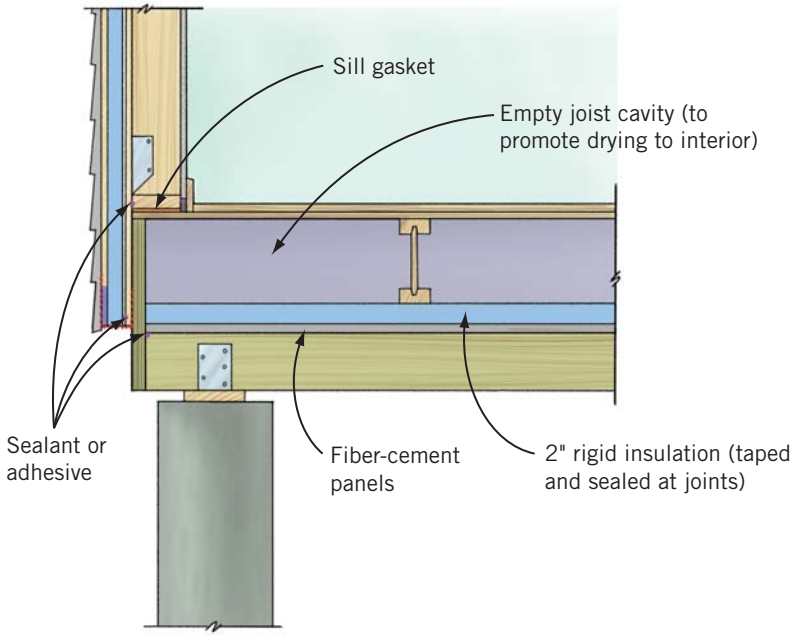

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FIGURE 4. This ideal recommendation for elevated floor insulation in the South Louisiana climate, devised by building scientist Joseph Lstiburek (www.buildingscience.com), calls for rigid-foam insulation under the floor frame as well as on wall exteriors between the sheathing and the siding. With this method, the insulation is almost completely continuous between the floor system and the wall system, while most of the house's framing is kept inboard of the insulation and air and vapor barrier, subject to controlled interior conditions rather than exposed to the stresses of the natural climate.

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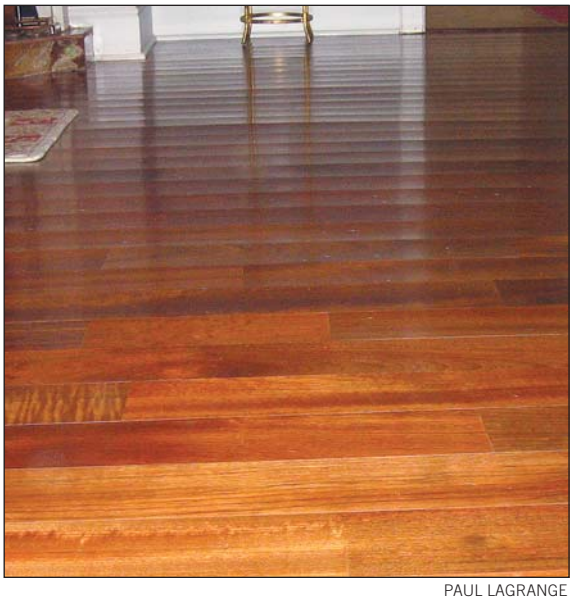

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FIGURE 5. In a very damp crawlspace, low-density open-cell foam may not protect structures from vapor diffusion and moisture attack. The surface of the spray foam at far left is glistening from vapor condensation. At left, rippled reflections of the wood flooring in the occupied space above the foam-insulated floor has cupped because of excessive moisture that penetrated the insulation. In the recently begun research project at Musicians' Village in New Orleans, scientists are trying to learn the best way to prevent such moisture problems.

on the underside." The rigid-foam alternative works well and is an attractive option for do-it-yourselfers, says LaGrange: "If you have access to reasonably priced labor, rigid foam is a great application. There is nothing wrong with it, assuming you do it right and seal everything." (See illustration, **Figure 4**, page 3.)

With spray-foam applications, LaGrange applies a skin of vapor-retarding paint to the insulation after installing it. That's because he uses an open-cell foam (Sealection 500 from Demilec, www.sealection500.com) that stops air movement but that, without the paint, might allow too much vapor to diffuse in through the foam (**Figure 5**). Despite its lower R-value per inch, LaGrange says, he prefers the open-cell foam for its flexibility and strong adhesion: occasionally, he has seen cracks open up between the more rigid, higher-density varieties of foam and the floor joists, as the floor systems flex and bend under foot traffic.

In Baton Rouge, La., insulation company Green Bean Insulation (www.greenbeaninsulation.com) has been plying the same trade as Paul LaGrange, using a high-density R-5-per-inch open-cell foam (**Figure 6**). Along with its flexibility and tenacious adhesion, Green Bean manager Mark Comarda points out, the porous foam (www.apexfoam.com) has the advantage that it is forgiving of bulk water leaks in the house above. "If you had a leak on top, like in the bathroom or a hot water heater, and that leak came down through the floor, it wouldn't penetrate a closed-cell foam, because closed cell foam is a complete moisture barrier. The water would just sit there between the foam and the wood, and eventually it would rot out the wood." The open-cell foam, explains Comarda, allows water spills to weep through and dry out naturally — or at least declare their presence so that the area can be opened up, dried, and repaired.

But the porous foam is still a highly effective air barrier. Many of the older Baton Rouge homes he treats have no plywood subfloor, Comarda says — just board strip flooring with many cracks and gaps that allow airflow. That makes the houses leaky and cold in winter, when temperatures can drop below freezing even in Louisiana. "That's when we get the most calls," he observes. Spray foam puts a stop to that source of discomfort. And after several years in business, says Comarda, "Nobody has complained that it doesn't work — not one person. We get an occasional call that we missed a spot

GREEN BEAN INSULATION

FIGURE 6. In this crawlspace, Green Bean Insulation installers have insulated and air-sealed ductwork at the same time as they insulated the floor system. The 1.2-pound-per-cubic-foot foam used here costs the same as 1/2-pound-per-cubic-foot material, says Green Bean's Mark Comarda, but is less porous and has a higher R-value.

or something, and we have to go back and hit it. But no complaints about the effectiveness of the product."

Foam is not a simple technology, however, and it takes expertise to use properly. "Foam is finicky," says Paul LaGrange. "The application depends on so many variables — humidity in the air when you're spraying, the moisture content of the floor assembly…. That's why we have one guy, our production manager, who is always on site when they're spraying, watching the guys recirculate the chemical, watching the temperature, recording the ambient conditions and the condition of what we're spraying to. It's his job to keep track of all those issues so if we do have a problem, we can go back and analyze what happened."

And foam does best with a clean, dry substrate. After inspecting a crawlspace, LaGrange says, he may have to advise a homeowner to call in a mold remediation contractor to clean the floor system and apply a nontoxic borate-based preservative treatment (in Louisiana, only licensed contractors are allowed to do this type of work). Sometimes, moisture-damaged materials have to be torn out and replaced before foam can be sprayed.

When he insulates under a raised floor, LaGrange notes, he also takes care to address ground moisture issues. If the floor is less than about 4 feet above the ground, he covers the ground with a 10-mil plastic sheeting, weighted down with gravel. But first, in some cases, it's necessary to raise the grade under the house. "It's very common around here that the ground has subsided over the years, and people have filled in their yard to compensate but have not done anything about it under the footprint of the home. So the area under the home becomes like a saucer that will hold water — even with a regular rain, to say nothing of rising floodwaters. Months after the hurricanes hit, it was nothing for me to go crawl under a house and see water puddled under there." That condition fosters rot as well as termites and mosquitoes — so when he finds it, LaGrange places gravel fill beneath the building to mound the ground up above the surrounding grade, before installing the plastic sheeting.

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FIGURE 7. Musicians' Village (left), a community of identically built Habitat for Humanity houses in New Orleans' 9th Ward, is the site for a research project into insulation performance in elevated homes. Existing fiberglass insulation, although relatively carefully installed, is still of dubious value in this application. Researchers plan to replace some of the fiberglass with other insulation systems, and monitor the results for a full year.

SCIENTIFIC SUPPORT

The field experience of contractors like Green Bean and Paul LaGrange speaks to the effectiveness of the spray-foam solution. But it's not the cheapest solution — and no one has ever gone beyond informal experience to scientifically compare the performance of high-density foam, low-density foam, rigid foam board, and fiberglass in under-floor applications under controlled conditions. At least, not until now: With support from the USDA Forest Products Laboratory and funding from the Southern Forest Products Association, in cooperation with the Louisiana State University extension program, researchers are now setting out to study all four insulation solutions in identical houses in New Orleans.

The houses, built by Habitat for Humanity to house musicians displaced by Hurricane Katrina, sit on pier foundations and were originally insulated with fiberglass batts between the floor joists (**Figure 7**). Now, researchers led by FPL

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TEST ASSEMBLIES

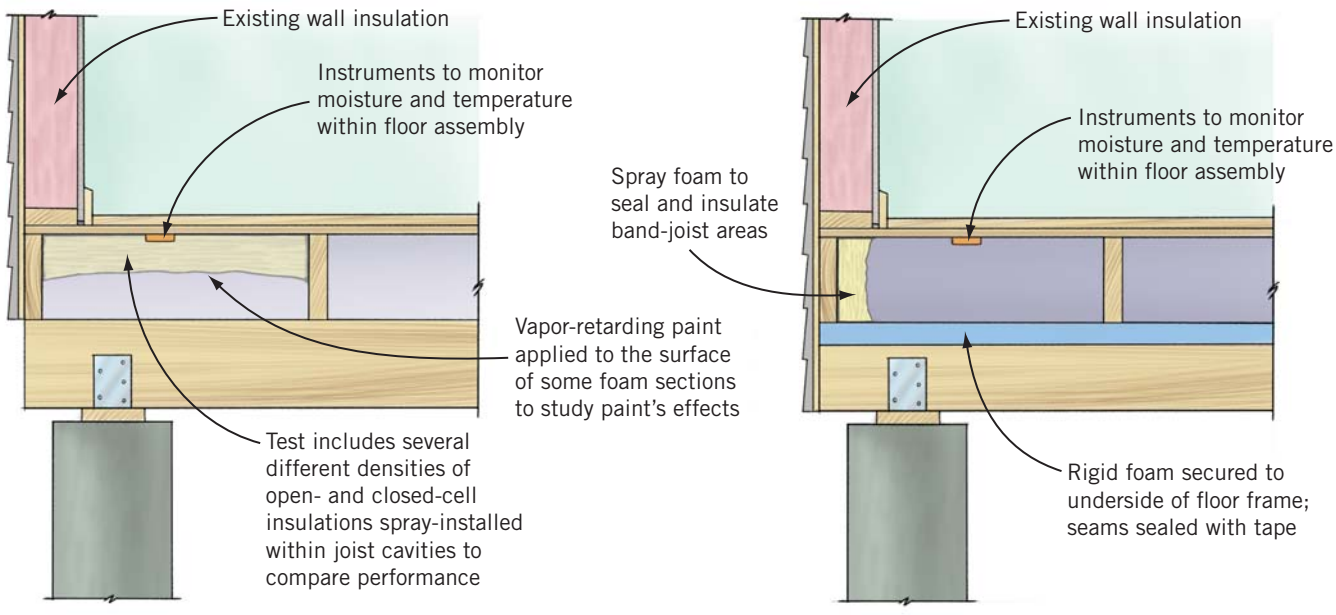

FIGURE 8. For research sponsored by LSU, FPL, and SFPA, rigid insulation will be attached to the underside of some Musicians' Village Habitat for Humanity homes. Band-joist areas will be sealed and insulated with spray foam, and subfloors, house interiors, locations under the house, and outdoor locations away from the home footprint will all be instrumented so that temperature and humidity conditions can be monitored as weather changes, day by day and week by week, through a full 12-month annual cycle.

The Musicians' Village research project will study the performance of various types of spray-foam insulation, with and without an additional layer of vapor barrier paint, side by side with a rigid foam board insulation method and with the preexisting fiberglass insulation originally installed in the homes' floor systems.

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scientist Sam Glass are removing the fiberglass and installing moisture sensors and thermometers in the floor frame cavities, as well as in the space beneath the floors and in the yards next to the houses. They're also placing temperature and moisture sensors in the house living space to monitor indoor conditions. Then, contractors will install four different insulation and vapor barrier systems under the floor (**Figure 8**), and the scientists will use data-loggers and field observations to record how the floor systems and the home interiors behave for 12 months.

Southern Forest Products Association engineer Cathy Kaake says her organization is convinced of the flood-resistance advantages of raised floor construction in low-lying areas. SFPA offers detailed guidance on constructing the structural assemblies on its website (www.raisedfloorliving.com). But as Kaake admits, the moisture and energy details are not as comprehensive as the structural details. "We put in the best information we had at the time," she says. "But that's why we are supporting the FPL and LSU research — we want to come up with the best-practice solution. It's the number one question I get when I go out and do seminars for engineers and builders and code officials: 'What is the best way to insulate? What is the best way to control moisture?' And that is what we want to answer." ~

Contributing editor Ted Cushman has been covering residential building science and construction since 1993.