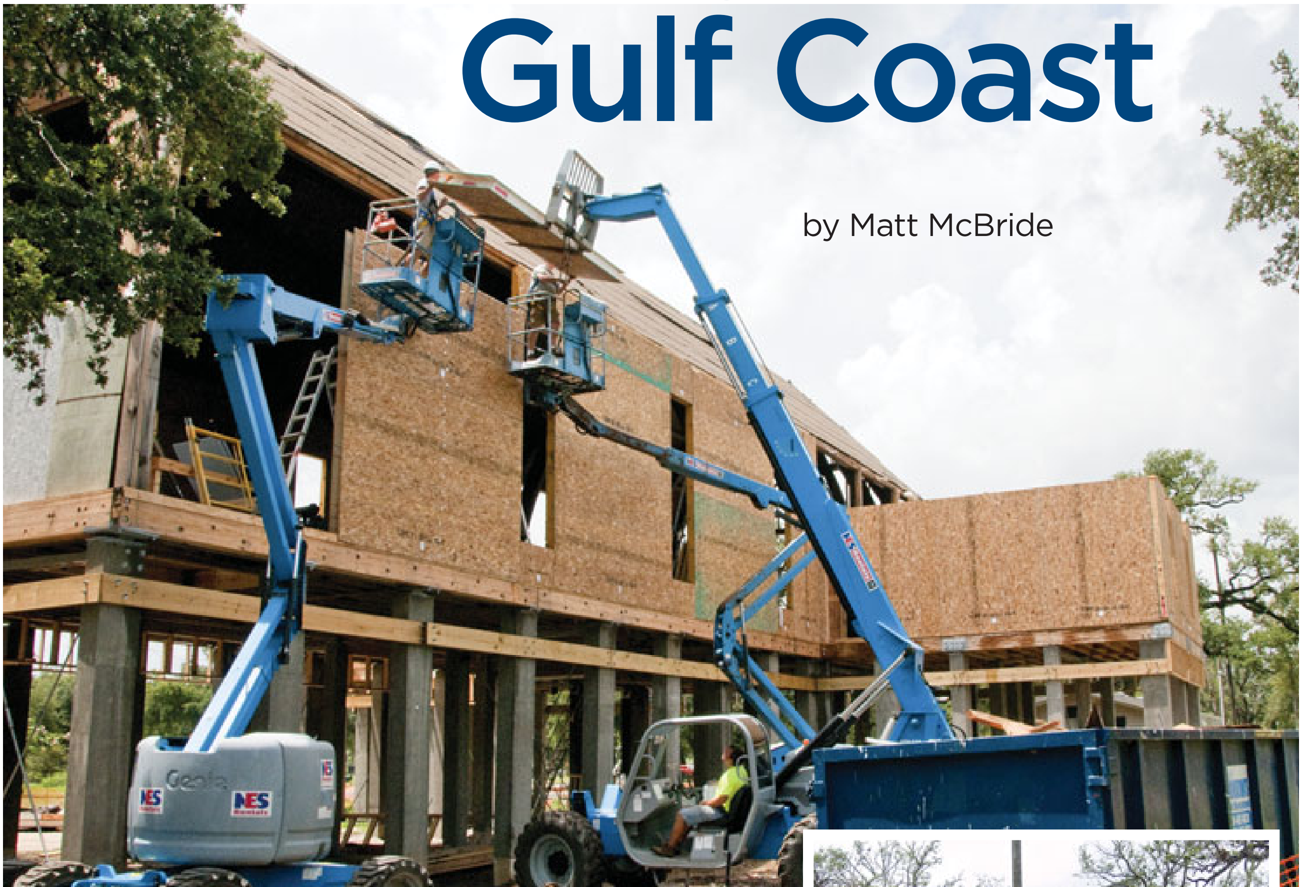
Rebuilding on the Gulf Coast



by Matt McBride

A combination of engineered lumber, steel, and structural insulated panels provides protection against the next hurricane

Trinity Episcopal Church used to sit on short concrete piers, about 4 feet above grade and 14 feet above sea level in Pass Christian, Miss. But when Hurricane Katrina devastated the Gulf Coast in August 2005, the 26-foot-deep storm surge left Trinity under more than 12 feet of water — enough to wash away the walls and another two buildings on church grounds, and enough to destroy the middle school across the street. Somehow, the building's floor system, laminated arch framework, and roof survived virtually intact.

After the storm, an engineer who checked out the building feared that the frame had been too badly racked to be repaired, and he recommended that the church be demolished. But members of the church's building committee weren't so sure and asked my company to take a closer look. It was true that all but one of the arches were out of plumb, but my laser measurements showed they were off by different distances — from $\frac{1}{2}$ inch to $1\frac{1}{4}$ inches in 16 feet — and in different directions. After inspecting the timbers and the connections, we concluded that the frame had already been out of plumb after being rebuilt following Hurricane Camille in 1969, but that it was still structurally sound.

The congregation wanted to salvage as much of the church as possible, and the decision was made to rebuild again around the existing arch frame. To make the church more hurricane-resistant and

Figure 1. The shoring crew first disconnected the floor framing from the foundation by cutting the steel bolts embedded in the short concrete piers (A), then installed cribbing and hydraulic jacks for lifting the building (B). Each jack was connected to a hydraulic manifold powered by a diesel engine (C), which was able to lift the 3,000-square-foot structure more than 10 feet with less than $^3/_8$-inch difference in elevation between any of the 10 lifting points (D).

to qualify for LEED certification, project architect Leah McBride specified SIPs for the walls and roof. And to meet local codes and FEMA's new base-flood elevation (BFE) recommendations — and thereby qualify for significantly lower insurance rates — we would raise the church another 10 feet above its former elevation, to 14 feet above ground level. That would put the finish floor of the new church about a foot above the area's new 23-foot BFE. My company was hired to be the general contractor for the project.

Lifting the Building

Before lifting the building, we used plywood gussets to repair a number of floor joists; they had cracked lengthwise where they'd been improperly notched to fit the steel brackets tying the floor system to the original foundation. We also replaced some termite-damaged lumber, then resheathed the entire floor with $^3/_4$-inch Edge Gold T&G panels (888/453-8358, ilevel.com).

Raising a 3,000-square-foot, 66-ton building more than 10 feet was a terrifying prospect, but I was reassured when I learned that the lifting contractor — Davie Shoring of New Orleans — had 150 other buildings in the air at the same time. It took the shoring crew only a couple of days to place the two 100-foot-long main steel I-beams and ten 30-foot-long cross beams, install cribbing for the hydraulic jacks, and break the building loose from the old foundation (**see Figure 1**).

The actual lift took about 11 hours, spread out over the course of two days in May 2009. The 10 jacks were connected to a diesel-powered hydraulic pump, which raised them simultaneously at a rate of 10 seconds per 6-inch lift. Then the crew would take about an hour to install more cribbing, lower the building onto the new cribbing, reposition the jacks, and repeat the process. By the time the building reached its final position, movement over

Figure 2. The rebar for new grade beams and pier extensions was epoxied to the original piers (A). Formwork for the pier extensions stopped a foot shy of the raised building to allow for setting the anchor bolt-studded cap plates and pumping the concrete (B). Diagonal steel rods provide lateral bracing for the exposed portions of the piers (C); note the cold joint at the base of each pier between the old pier and the pier extensions. Steel brackets welded to the cap plates anchor the transept framing to the foundation (D).

its 100-foot length was less than 3/8 inch, a virtually flat lift.

New Piers

While the lift was quick, we had to wait two months for the foundation contractor to complete the iron and concrete work needed to build the new pier foundation. Needless to say, I was anxious to get the building bolted down before the next storm season started. The shoring company reinforced the existing piers with grade beams and extended them with new rebar dowelled and epoxied into the old concrete (**Figure 2**). The crew also built new concrete piers for the two transept additions to the main building.

Steel work. To anchor the building to the piers, workers embedded 1/2-inch-thick steel plates into the concrete at the top of each pier during the pour. Each plate had four 3/4-inch by 12-inch J-bolts welded to it to strengthen the connection between the concrete and the steel.

We also bored holes through the forms and inserted short lengths of conduit so that later we could through-bolt steel brackets to the piers. These brackets accommodate 1 1/8-inch-diameter diagonal steel rods and steel tubing that reinforce the tall piers.

Around the perimeter of the building, ironsmith Craig Campbell welded 1/2-inch-thick steel plates to the steel framing brackets that the shoring company had cut loose from the old piers. These new plates extend out over the tops of the piers 5 inches from the original wall plane, and help support the 5-inch by 15-inch glulams that hold up the SIP walls.

A few days after the pour, we measured the strength of the new concrete. It registered at over 3,000 psi, which meant the building could finally be lowered onto the piers. Campbell then spent a couple more days welding all of the metal plates together, using shims as necessary. He also cut bolt holes in the plates, and we sprayed

Pier Connection Details

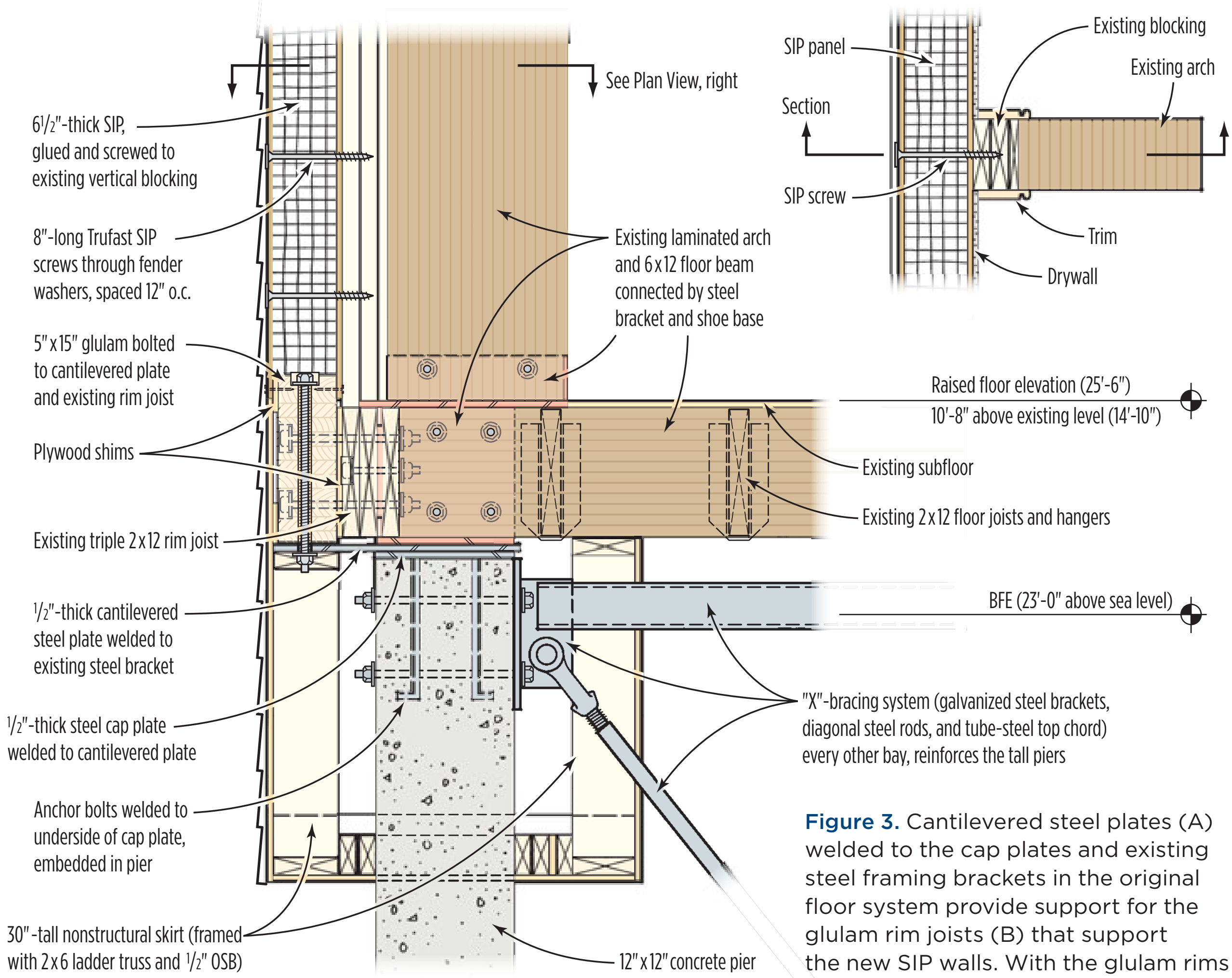


Figure 3. Cantilevered steel plates (A) welded to the cap plates and existing steel framing brackets in the original floor system provide support for the glulam rim joists (B) that support the new SIP walls. With the glulam rims secured to the original structure and the new transept floor framing completed, the building is ready for wall and roof panels (C).

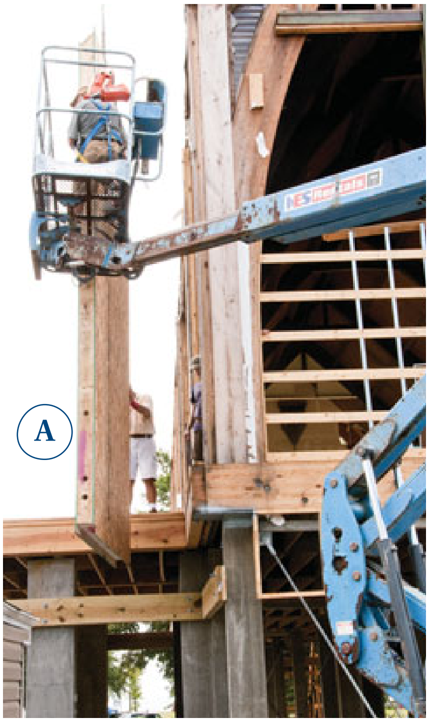


Figure 4. The floor was 14 feet above grade, so man lifts were essential for safe handling of the large panels (A, B). Panel edges were relieved at the bottom to fit over the glulam rim joist, and at the sides and top for the 2-by connecting splines (C). The wall panels were first glued and nailed to the glulam band and splines, then fastened to each other and to existing framing with structural screws (D).

the steelwork with Rust-Oleum's Cold Galvanizing Compound (800/323-3584, rustoleum.com) to protect against corrosion.

Then we bolted the big perimeter glulams to the steel plates with 1-inch all-thread rod and to the framework of the church with ¾-inch bolts 16 inches on-center (**Figure 3, page 4**). To account for the thickness of the panels' inner OSB skins, we shimmed the glulams out from the framing with ⅝-inch plywood shims.

SIP Walls

We used 6½-inch-thick R-38 wall panels and 8¼-inch-thick R-50 roof panels from Georgia-based SIPS Team USA (229/246-8880, sipsteamusa.com). The panel design is rated for 140 mph winds, and with this much insulation we expect that the church will use 35 percent less energy to heat and cool than if it had been built to simply meet local codes. Because this was our first SIPs project, we opted to hire a SIPs installation trainer from the manufacturer, who supplied both his expertise and a pair of lifting devices.

The T&G-style wall panels have EPS foam cores and 7⁄16-inch-thick OSB skins on both faces and range in size from 8 feet by 2 feet to 8 feet by 24 feet. They connect by way of 2-by full-width LVL or sawn-lumber splines, which fit into ¾-inch-deep recesses in adjacent panels' edges (**Figure 4**). We oriented panels both vertically and horizontally, depending on door and window openings and wall sizes. According to the manufacturer, each SIP acts as a shear panel, and screwing and gluing them together creates an assembly that acts as a single diaphragm to resist lateral seismic and wind loads. This was a key factor in our decision to use SIPs, since it would have been difficult to cost-effectively add stick-framed walls with similar shear and uplift resistance to the building shell.

Before setting the first wall panel in place, we applied plenty of low-VOC adhesive to the glulam and laminated arch framing. Then we nailed through the OSB skins into the glulams 6 inches on-center in a staggered pattern on both sides, creating an uplift-resistant connection between the panel, glulam, and foundation. The panels are fastened to the arch framing with Trufast ¼-inch by 8-inch structural screws supplied by the SIP

Figure 5. To prevent wind deflection, the tall window walls were reinforced with full-length flitch-beam stiffeners (right), which were bolted to the glulam rim joists (above) and recessed into the wall panels.

manufacturer. As we set each subsequent panel, we also glued and nailed the spline connections between the panels with the same 6-inch on-center staggered pattern.

To reinforce the 16-foot-tall sanctuary walls to meet local wind-code requirements, we installed flitch beam stiffeners on both sides of each window (**Figure 5**). The stiffeners consist of three $1\frac{3}{4}$-inch by $5\frac{1}{2}$-inch by 16-foot LVLs sandwiched around a pair of $\frac{1}{2}$-inch by 5-inch by 16-foot steel plates; each one weighs 650 pounds. We bolted them to the glulams with 1-inch-diameter bolts, then glued and nailed the SIPs to the stiffeners.

At the top of the eaves walls, the panels are beveled to match the 12/12 roof pitch, and the foam is recessed 3 inches to accommodate a double 2-by top plate. The panels were shipped with one 2-by plate already installed; after all of the

Figure 6. Preinstalled 2-by walk boards reinforced the connection between the lifting hooks and the OSB skins of the roof panels (above, above right). Placing the hooks slightly off-center eliminated camber in the panel, making it easier to slide the edge over the spline of the previous panel (right).

Figure 7. The second-story floor system in the transept addition (above right) hangs between the top of the first-floor wall panels and 6x16 glulam beams that span the openings between the arches of the old structure (above). The 32-foot-long structural ridge beam fit into reinforced pockets in the gable SIPs (right).

wall panels were in place, we installed the second continuous beveled 2-by top plate, gluing and nailing it to both the 2-by underneath and the OSB skins, and staggering the panel joints by a minimum of 4 feet. We also screwed down through the continuous top plate into each wall stiffener with four 8-inch-long Trufast screws.

Roof

Most of the roof panels were 8-foot by 24-foot SIPs weighing 900 pounds each. Since they were set on top of an existing roof deck, we couldn't have attachment points for the lifting straps. Instead, we used what we called hay-hooks: four iron hooks (provided by the SIP manufacturer) driven through the top skin of the panels (**Figure 6, page 6**). Since we needed walk boards on the panels anyway, we placed them so that they would reinforce the OSB where it was penetrated by the hay-hooks.

We quickly found that installing the hooks somewhat off-center — so that the heavy panels hung from the crane at a slight angle — helped take the crown out. This allowed the tongue-side to slide into the groove side much more easily.

We glued and nailed the roof panels together at the joints, and screwed the panels together at the ridge. With doubled plates at the eaves and gable ends, we had plenty of wood to make the connection between the roof panels and wall panels with glue and 5⁄16-inch-diameter by 13-inch-long Trufast SIP screws. Later, after the crane was off-site, we returned to fasten down the panels to the three existing intermediate 6x12 purlins under the 3x6 T&G roof decking, also with 13-inch screws. All told, we used more than 8,000 of these heavy-duty screws to hold the wall and roof panels in place.

Transepts

The transept wings on each side of the main sanctuary were essentially new construction and went together smoothly. After framing and sheathing the first floor on top of the piers, we glued and screwed doubled 2x6s around the perimeter and slipped the wall panels into place (**Figure 7**).

We hung the second-floor I-joists from the tops of the first-floor wall panels with top-mount joist hangers. Where the transepts intersect the main sanctuary, the joists hang from recessed 6x16 glulam beams that carry the floor loads and stiffen the main walls. Then we sheathed the floor, and repeated the process with the second-story wall panels. At the gables, panels were notched and reinforced to receive the 32-foot-long structural ridge beams that support the roof panels.

Finishing Up

Since the bottoms of the SIPs were 14 feet above grade, we wanted to disguise the overall height of the church with a conventionally framed "skirt." To satisfy FEMA requirements, this skirt had to be nonstructural and somewhat less substantial than the SIPs so that it would break away in the event of flooding. Therefore, we framed 30-inch-tall wall sections with 2x6s underneath the glulams. Where the deck, stairs, and hvac platforms would be attached, we bolted PT 2x12 ledgers to the piers at the same elevation, helping to create the illusion that the church is only 10 feet above grade (**Figure 8**).

Cost. The SIPs package cost $128,000, including all of the associated fasteners and hardware and two weeks of site time by the factory's trainer — a small percentage of the project's $1.9 million total budget. And even though we'd never worked with SIPs before, it took less than four weeks for my five-man crew to assemble the panels. I doubt we could have stick-framed and insulated a building this size with the same energy efficiency and hurricane resistance for anywhere near that price.

As we moved on to the housewrap and trim and reinstalled the stained-glass gable-end window — salvaged from 4 inches of mud in the church parking lot — the old building's familiar profile began to reemerge. But this church will be much better equipped than its predecessors to weather the next storm that hits Pass Christian.

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Figure 8. The nonstructural skirt wall (A) and lowered entry deck (B) make the church appear lower to the ground than it actually is, but there's also elevator access from the finished slab underneath the building (C). With the arches and finish ceiling intact — and the original stained-glass window back in place — the interior looks almost unchanged (D).