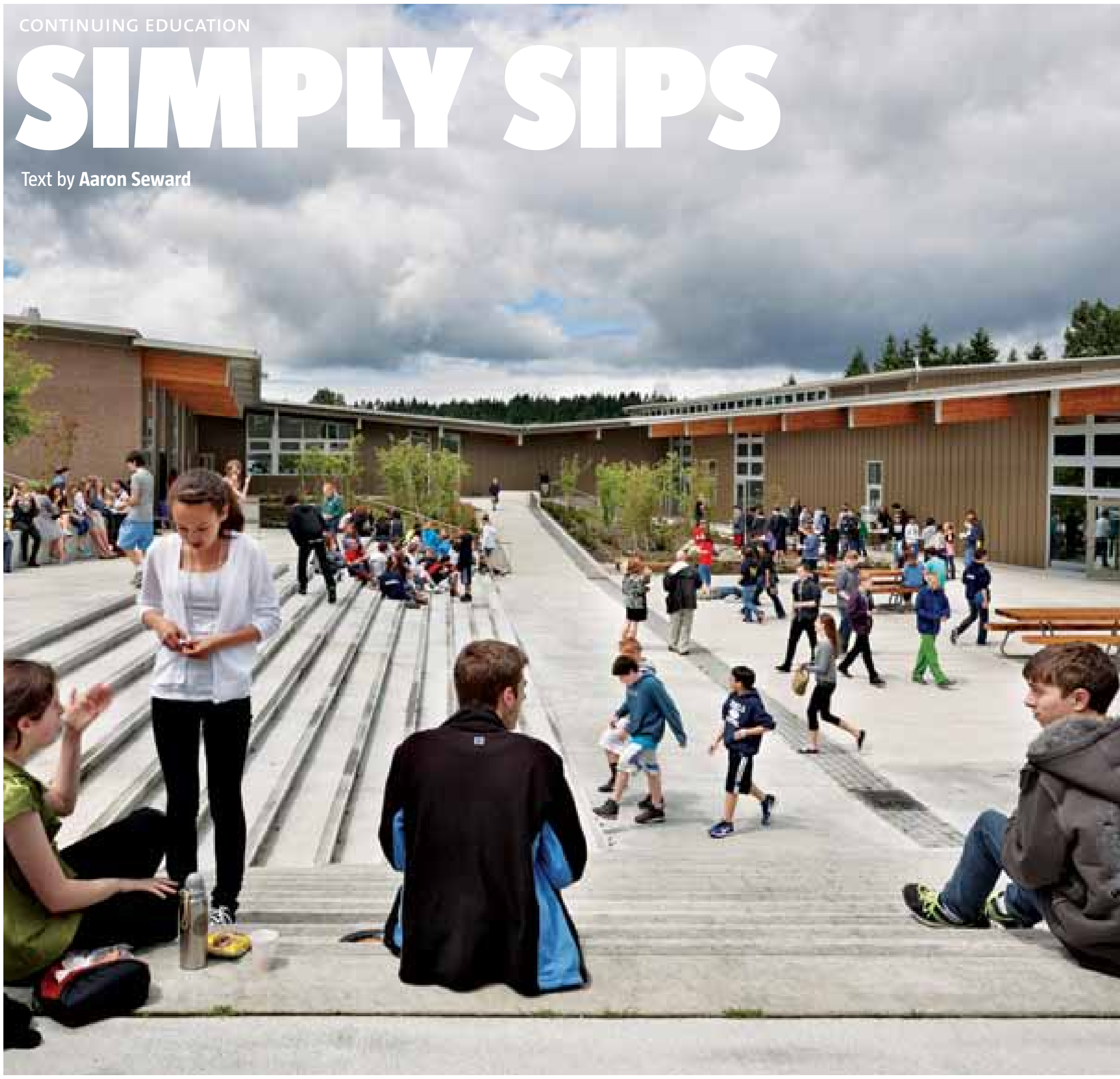
CONTINUING EDUCATION

SIMPLY SIPS

Text by **Aaron Seward**



BENJAMIN BENSCHNEIDER

BEFORE SPECIFYING STRUCTURAL INSULATED PANELS IN THEIR PROJECTS, ARCHITECTS MUST UNDERSTAND THE POTENTIAL BENEFITS AND SHORTCOMINGS OF THE SYSTEM.

Mahlum Architects specified SIPs in its design for Finn Hill Middle School in Kirkland, Wash. The bulk of the construction for the 116,000-square-foot facility was completed in one year.

ON THE SURFACE, a structural insulated panel (SIP) looks quite humble, resembling little more than an oversized ice cream sandwich. However, the engineered building product—which comprises little more than an insulating foam core adhered to two structural facers—can be the key for any architect looking to build a high-performance project on a tight schedule. And, in many cases, a designer doesn't have to sacrifice aesthetics in favor of efficiency.

Like an ice cream sandwich, a SIP can come in many "flavors," the most common of which combines an expanded polystyrene (EPS) insulation core between two layers of oriented strand board (OSB). Variants include extruded polystyrene or rigid polyurethane insulation for the core, and plywood, precast concrete, or magnesium board for the structural facers.

The basic premise behind merging rigid insulation and structural sheathing to create structural insulated panels (SIPs) has been around since the 1930s when the U.S. Forest Service's Forest Products Laboratory experimented with ways to conserve resources. The system hit the commercial building market in the 1970s when SIP manufacturers began promoting their product as an alternative to standard dimensional lumber framing, primarily for the residential market in the Northeast.

SIPs can simplify and expedite the building-erection process by supplanting traditional dimensional lumber framing and fiberglass insulation with a prefabricated, all-in-one panel. Assembled under controlled factory conditions where waste can be greatly minimized, SIPs are manufactured as

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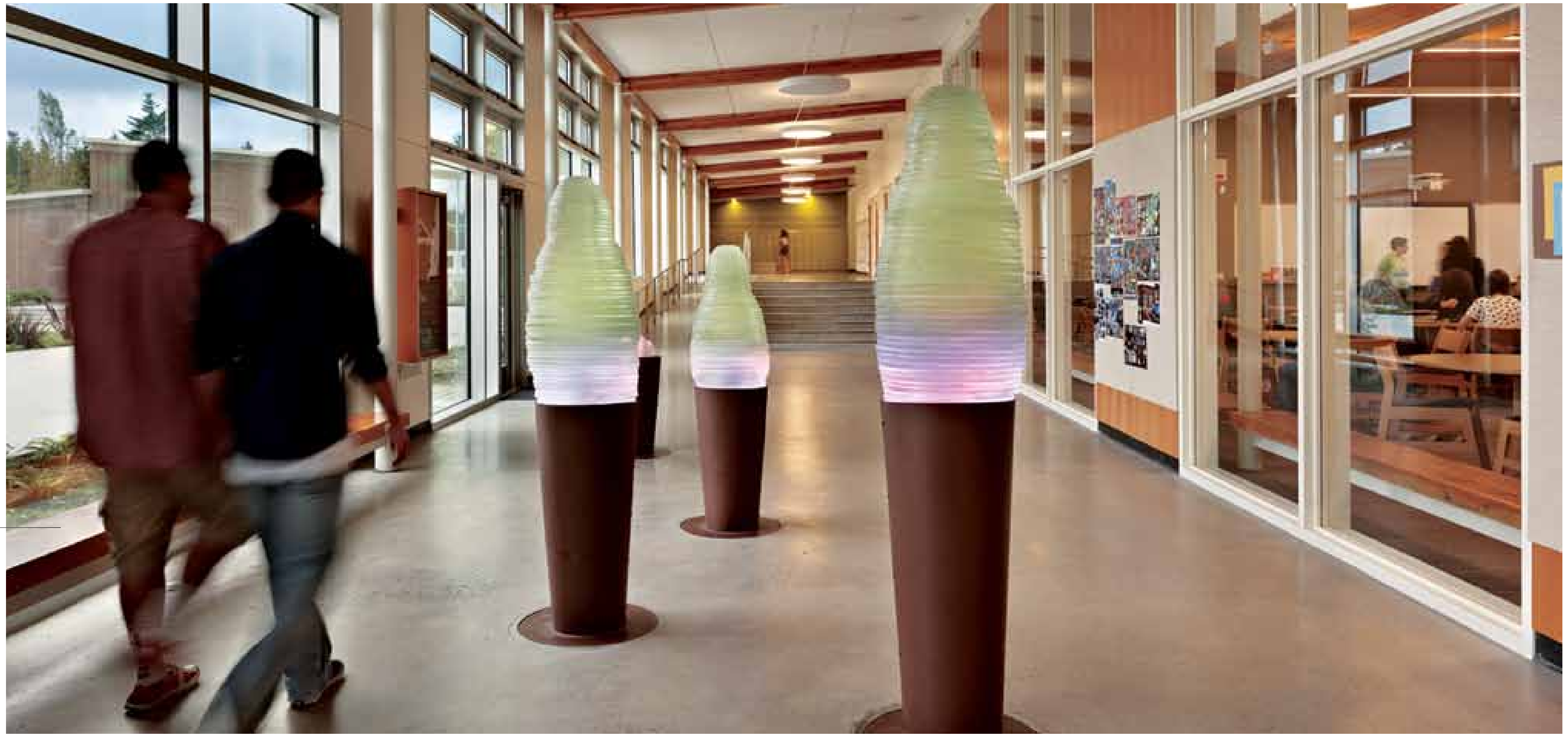
LEARNING OBJECTIVES
1. List the typical material combinations used in structural insulated panels (SIPs).

2. Describe the building performance benefits of SIPs.

3. Describe the construction benefits of SIPs.

4. Describe how SIPs contributed to the energy performance of the three project case studies.



completely flat systems that are void of the bends and bows that can encumber wood studs. The panels, capable of handling about 10 pounds per square foot (psf) of dead loads and live loads of up to 70 psf, can also be used in roofs and floors, spanning as much as 18 feet without the need for additional structural support.

In spite of these benefits, SIPs have not made significant headway into the framing market. Lumber has remained relatively cheap—between $15 and $30 per square foot—and framers aren't all that expensive either. The system's extra up-front cost—up to 20 percent higher than lumber—doesn't help make SIPs an easy sell. "It's not a product you see, so it's not like upgrading to beautiful cabinets," says James Hodgson, general manager of SIP manufacturer Premier Building Systems.

But as the conversation in the building industry turns from initial costs to long-term value, SIPs are garnering more attention from the industry. "The system is a high-performance envelope that will save utility dollars and create a more comfortable environment," Hodgson says. "Now it's becoming more prevalent due to environmental concerns, the reduction of the carbon footprint, and the rising cost of energy sources." Even in today's uncertain housing market, the SIP industry remains strong. A survey conducted by the Structural Insulated Panel Association (SIPA) in 2011 found that the overall production of SIPs had dropped 4 percent, less than half of the 8.5 percent drop in the number of single-family housing starts, the industry's primary market segment.

Unlike wood or metal studs, which can cause thermal bridging, SIPs are continually insulated walls. They exhibit greater heat resistance and less air infiltration than stick framing with fiberglass batt insulation. According to SIPA, an Oak Ridge National Laboratory study determined that a typical room constructed with 4-inch-thick SIP walls rated at R14 outperformed a similar room built with 2x6 stick-framed walls with R19 fiberglass insulation. Blower door tests revealed that the SIP room was five times more airtight than its stick-framed counterpart—a meaningful metric, considering that as much as 40 percent of a building's heat loss is attributed to air leakage.

Manufacturing SIPs also uses resources efficiently. OSB comes from fast-growing, underutilized, and less valuable trees than are required for dimensional lumber. EPS consists mostly of air; only 2 percent of the foam is plastic, which can be recycled. Since SIPs come to the jobsite in precut panels that are custom fit to the project, the wastes associated with stick-frame construction are eliminated, leaving almost nothing in the framing process to be trucked to the landfill.

However, before specifying SIPs on their projects, designers should consider several erection and performance issues. While SIPA estimates that a construction team familiar with the system can erect a project in half the time it takes to put up a stick-framed building, workers unfamiliar with the system may be slower. "If this is the first time you're going to erect with SIPs, there is a learning curve," Hodgson says. "It adjusts the way trades work—you're not bringing in a person to cut holes through studs, because the chases are already there. There's no insulation application."

In addition, project design teams must take extra measures to manage air quality and moisture levels in a SIP building. The highly insulated and tight envelope creates an interior condition similar to that of a walk-in cooler; while the enclosure will maintain constant temperatures well, it also needs

The design for Finn Hill Middle School uses a 16-foot SIP module, which also created a uniform approach for Mahlum Architects to size the facility's classrooms.

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a robust air-exchange system to keep the atmosphere fresh and reasonably dry. For this reason, SIPA recommends that designers work with qualified HVAC professionals to ensure that the used air—which can contain moisture, fumes from adhesives, and particulates—is exhausted properly during occupancy.

The reasons for specifying SIPs and the benefits for designing and constructing with SIPs can vary widely, as the following three projects illustrate.

San Luis National Wildlife Refuge Complex
Located in the northern San Joaquin Valley in a vast tract of wilderness outside Los Banos, Calif., the U.S. Fish and Wildlife Service's (USFWS) San Luis National Wildlife Refuge Complex encompasses nearly 45,000 acres of wetlands, grasslands, and riparian habitats, as well as more than 90,000 acres of conservation easements on private lands for the protection and benefit of wildlife. The USFWS wanted to build a new visitors center for the refuge as well as relocate its existing office nearby to the preserve. The agency hired Arizona firm Catalyst Architecture to design the nearly 17,000-square-foot facility, which the agency required to target net-zero energy and LEED Platinum certification.

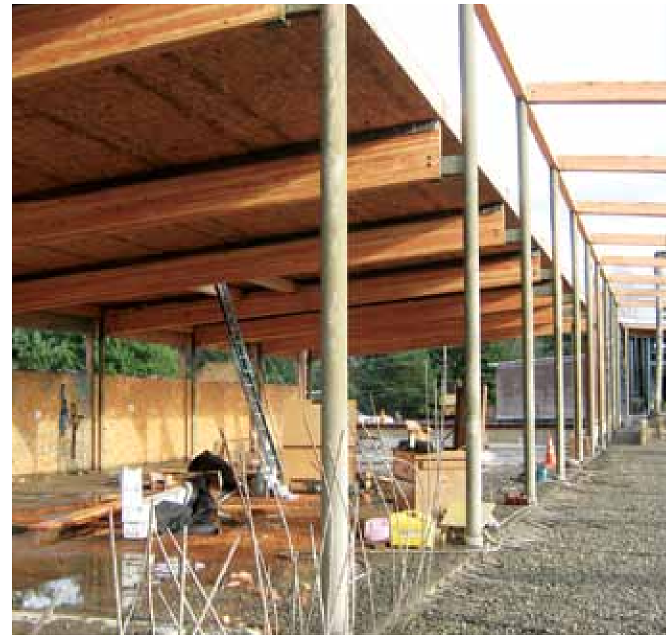
Catalyst employed a 55-kilowatt, roof-mounted photovoltaic array that—when used in combination with passive solar measures, strategic use of natural light, energy-efficient mechanical systems, and LED task lighting—delivered a building that goes beyond net-zero energy into net-positive territory by returning more energy to the grid than it consumes.

The project features 12-inch-thick SIPs for the exterior walls and 8-inch-thick SIPs for the flat and sloped roofs. Each panel comprises 7/16-inch OSB facers sandwiching EPS foam. The resulting building envelope achieves an insulation value of R30, which helped the project meet its sustainability target. Catalyst clad some portions of the envelope with weathering steel panels and others with plaster on lathing backed with felt to prevent water infiltration.

The use of SIPs on the project did not come without its complications. In order to open up the facility to views of the wildlife conservation areas, the architects had to orient the building on a north–south axis. As a result, the building's east and west elevations are the longest, a less-than-ideal orientation for controlling solar heat gain. To solve this problem, the designers minimized the amount of glazing on those walls, which are topped with north-facing roof monitors to bring ample indirect natural light into the interior. Not coincidentally, the sloped surfaces of the roof monitors create an ideal south-facing platform for photovoltaic arrays.

COURTESY CATALYST ARCHITECTURE LLC

To capitalize on views, Catalyst Architecture oriented the San Luis National Wildlife Refuge Complex on a north–south axis, but limited glazing on the longer elevations.



MAHLUM ARCHITECTS

Finn Hill Middle School employs SIPs in its walls and roofs, creating a tight building envelope. Currently undergoing commissioning, the project is striving to be 47 percent more energy efficient than targets set by the U.S. Department of Energy's Energy Star program.

The serrated building profile posed problems for the SIP construction. The facility's wall and roof monitors created extra on-site sizing and customization that essentially negated potential efficiencies in erection time. "What we've learned from working with SIPs is that you want to eliminate or reduce the number of jigs and jogs in the envelope," says Catalyst partner Matthew Ackerman, AIA. "In our experience, they're more suited for boxier buildings."

Compounding the complexity of the envelope, the building required additional structural bracing to meet seismic load requirements; the site is located in a liquefaction zone adjacent to a major fault line. The construction team had to carve channels through the SIPs on site to thread steel beams throughout the structure.

"That was a coordination issue," Ackerman says. "If we had been more aware of how SIPs worked, that coordination would have fallen in our lap before it became a problem on site. SIPs were still an excellent choice, given the client's goals; it just takes understanding the product and what its limitations are."

Finn Hill Middle School

In Kirkland, Wash., the Lake Washington School District wanted to replace Finn Hill Junior High School's multibuilding facility with one single-story building that would become Finn Hill Middle School. The district challenged Seattle-based Mahlum Architects to deliver a new 116,000-square-foot facility capable of accommodating 750 students on the same site as the existing facility.

Logistically, construction on the new facility would have to wait until after the old school was demolished. Then the project would have about one year for its construction. The district also wanted the new school to further its goal of becoming the most energy-efficient school district in the state. These goals led Mahlum to specify SIPs.

To optimize construction efficiency, Mahlum based its design on a 16-foot SIP module, a height that the panels can span without requiring additional structural bracing. The one exception was the school gym's high ceilings, which called for additional metal-stud support embedded in the walls.

The 16-foot module also created a uniform approach to sizing the classrooms. "One of the cool things about the SIP design process is that you get shop drawings for whole building," says Anjali Grant, AIA, Mahlum's project architect. "It all comes out numbered and panelized. You can see the entire building laid out and see how it will arrive on site."

Given the Pacific Northwest's wet climate, water intrusion was a major concern. "If there is moisture, you don't want it trapped at the sheathing plane," Grant says. "Rainscreens and air barriers are appropriate when cladding this system." Mahlum specified a fluid-applied-membrane air-barrier system clad with painted fiber cement board and concrete masonry units.

Finn Hill's tight envelope helped the school strive to be 47 percent more energy efficient than targets set by the U.S. Department of Energy's Energy Star program; the school is now in the commissioning phase. The facility is also set up to be net-zero energy; currently, it is outfitted with 1,452 photovoltaic panels that generate 42 percent of the school's energy needs. The facility has a south-facing roof area that can accommodate more panels to generate the balance of the school's electrical consumption in the future.

Chicago Parks District Field House Prototype 1
While OSB SIPs currently dominate the commercial and residential markets, precast-concrete SIPs, which were first produced in the 1960s, are making headway in the industry. Though they employ the same insulating material—typically EPS—as their OSB counterparts, precast SIPs can be used architecturally as well as structurally. They also offer a durability ideal for high-traffic projects, such as public facilities and schools.

"It carries loads, creates a good durable finish, doesn't burn or mold, and the insulation gives you high R-values," says Brian Miller, managing director of business development at the Precast/Prestressed Concrete Institute (PCI), an industry organization based in Chicago. Precast SIPs also possess thermal mass, he says, allowing them to absorb and release energy slowly. While offering R-values similar to those of OSB SIPs, the precast panels' combination of thermal mass and insulation creates a high-performance wall system that can create up to 25 percent savings on heating and cooling costs, according to PCI.

Chicago-based architecture firm Booth Hansen chose precast concrete SIPs for its design of a field-house prototype for the Chicago Parks District, which mandated that the project achieve LEED Silver certification. The 18,000-square-foot facility—designed

25

The percentage of potential energy savings generated by building with SIPs due to reduced heating and cooling loads

with the potential to expand another 12,000 square feet—contains administrative and support functions, a gymnasium, and several fitness rooms.

One challenge that the designers faced in using precast SIPs for this project was the looming wall heights—up to 31 feet in the gymnasium. In order to provide adequate structural support within the panels to manage the walls' dead loads, the SIPs were fabricated with concrete-composite ribs that tie together the exterior and interior concrete wythes. Because concrete is a poor thermal conductor, the risk of thermal bridging due to the connectors is not significant.

On the other hand, using precast SIPs allowed for fast erection times—even faster than those possible with conventional OSB SIPs; not only can the structure's precast envelope and insulation be installed in one fell swoop, but precast SIPs can also be prefabricated with interior and exterior wall finishes already applied. The concrete can be molded to resemble brick, wood grain, or nearly any texture the designer can imagine. It can also be embedded with finishes such as brick veneer.

At the Field House Prototype 1, the exterior finish of the precast SIPs is exposed concrete with aggregate; form liners created articulated shadow lines, adding texture and a sense of permanence that is appropriate to a civic building. The finished interior wall, also exposed concrete, provides durability and eliminates the need for painting.

Saving Energy and the Environment

Structural insulated panels offer yet another instrument in a designer's toolkit to create high-performance, economically efficient, and environmentally sensitive buildings. Along with creating tighter envelopes than are possible with traditional stick framing, SIPs combine the reliability of an engineered product complete with the waste-reducing benefits of prefabrication.

With the proper coordination and experience among the design and construction teams, SIPs can also lead to significant time savings on site and become a source of long-term energy savings—no small feat for today's budget- and eco-conscious clients.

QUIZ

1. Which of the following materials can be incorporated into structural insulated panels (SIPs)?
a. Expanded polystyrene
b. Extruded fiberglass
c. Oriented strand board
d. Precast concrete
e. Gypsum board

2. The benefits of prefabricating SIPs include:
a. The potential for an expedited construction and assembly process.
b. Installer certification programs.
c. Reduced wholesale cost.
d. Reduced material waste.

3. What is one hindrance to greater adoption of SIPs?
a. Initial cost
b. Installation cost
c. Prohibitive building codes
d. Insufficient use in the industry

4. Building performance benefits of SIPs include:
a. Increased thermal bridging.
b. Greater heat resistance.
c. Reduced risk of water damage.
d. Significantly more airtight construction.

5. True or False: Though a construction team familiar with the SIP system can erect a project in half the time it takes to erect a stick-framed building, workers unfamiliar with SIPs may be slower.

6. True or False: Construction with SIPs can be extremely airtight to the point that architects should consult HVAC professionals to ensure that air is exhausted properly during occupancy.

7. The San Luis National Wildlife Refuge (SLNWR) Visitors Center uses SIPs for both __________ and __________, resulting in an envelope that achieves an insulation value of R30.
a. foundation walls
b. exterior walls
c. roofing
d. flooring

8. Two of the challenges and design considerations related to specifying SIPs at the SLNWR Visitors Center include:
a. Seismic loading required channels through the SIPs for steel bracing.
b. The building design had to be rectilinear rather than curved.
c. The building had to be oriented on a north–south axis.
d. The roof slope had to be decreased to incorporate SIPs.

9. True or False: The tight construction schedule for Finn Hill Middle School discouraged architects from using SIPs.

10. Precast concrete SIPs can be used architecturally and structurally. Identify other benefits described in relation to the Field House Prototype 1 project:
a. Precast SIPs have a high thermal mass.
b. Precast SIPs can be installed with wall finish already applied.
c. Precast SIPs can be erected even faster than conventional OSB SIPs.
d. All of the above.

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