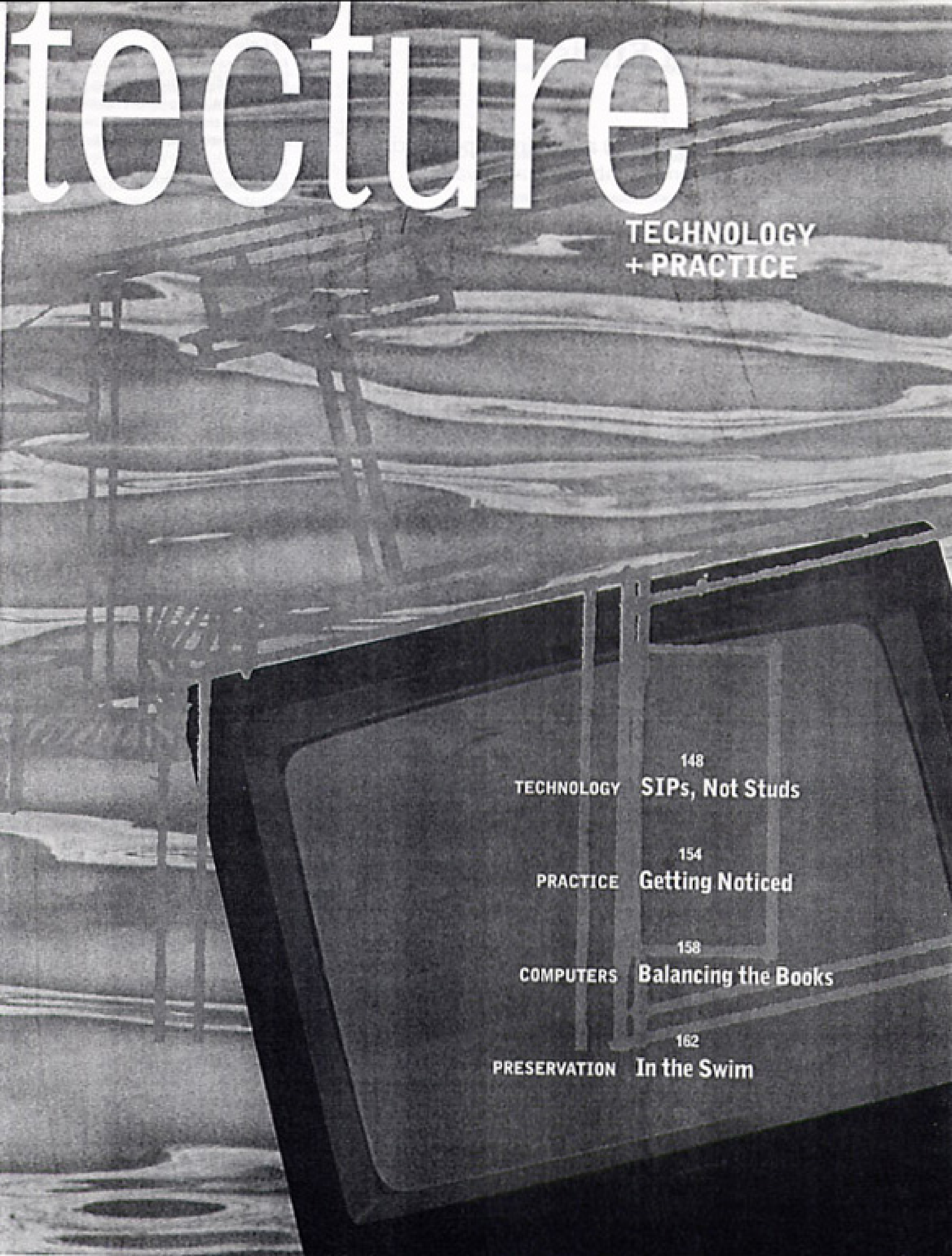
# tecture

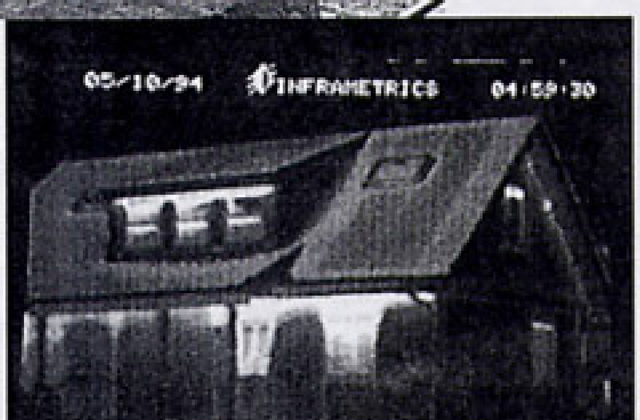
## TECHNOLOGY + PRACTICE



Technology

# SIPs, Not Studs

**Structural insulated panels (SIPs) are gaining popularity as an alternative to traditional lumber-framed walls.**




Infrared photograph (above) of SIP demonstration house in Springfield, Oregon (top), reveals high energy performance with low incidence of thermal breaching (indicated in yellow). Intended as production housing prototype, house was sponsored by Energy-Efficient Industrialized Housing Research Program of the U.S. Department of Energy and built by University of Oregon's Energy Studies and Building Laboratory and University of Central Florida's Solar Energy Center.

*By Colin M. Cathcart*

For 150 years, wood studs, also known as dimensional lumber, have gone unchallenged as the dominant structural elements in low-rise, wood-framed construction. But now, a growing number of architects and contractors are working instead with structural insulated panels (SIPs). SIPs, which have been evolving quietly for 50 years, offer structure, sheathing, insulation, and airtightness in a single product; they contribute to environmental sustainability; and they have recently become economically competitive with traditional stick framing.

The makers of SIPs can trace their roots to Frank Lloyd Wright's plywood-panelled Usonian houses. Alden B. Dow, a student of Wright dismayed by the Usonian's low insulation, constructed the first structural insulated panel houses—which are still in use—in Midland, Michigan, in 1952. Modern SIPs consist of a thick core of rigid insulation sandwiched between two wood-fiber skins. The insulating core and two skins are flimsy and insubstantial by themselves, but when combined properly, the stressed skin principle (see figure, opposite page) transforms these elements into a rigid construction panel that requires no wood studs. SIPs vary in thickness from 4 to 12 inches and in size from the standard 4-by-8-foot panel to full walls measuring 8 feet high by 24 feet wide. The skins are usually 7/16-inch-thick oriented strand board (OSB), but alternatives include plywood, waferboard, and gypsum wallboard.

Low-cost molded expanded polystyrene (EPS) is the most common SIP insulation, but cores may also be extruded polystyrene (XPS), polyurethane, or polyisocyanurate foams. The panel sandwich forms a continuous thermal break. "You can get a much higher R-value than with stud construction," says Tom Gray of the Pittsburgh-based Design Alliance Architects, "and their R-values are believable. There is no 'human factor' in applying the insulation, and there are no studs interrupting the insulation every 16 inches."

There is lively debate over the

merits of the various core materials. EPS, with a respectable R-4.2 per inch of thickness, is produced as an ozone-friendly board stock, and adhered tightly to each skin under pressure. Foam urethanes and isocyanurates, on the other hand, are "blown in" between braced skins using hydrochlorofluorocarbons (HCFCs), producing a strong natural bond by expansion under pressure. Also, thermal resistance is very high, between R-6 and R-7 per inch.

"The urethane and isocyanurate core panels will always have a place where high-performance and thin, space-saving wall or roof assemblies are needed," says Steven Winter, principal of Steven Winter Associates, an architectural and engineering technology consultant based in Norwalk, Connecticut. "It's a great product, but EPS is more cost-competitive in most applications."

Joints between panels may be constructed of proprietary spline systems, dimensional lumber, or wood I-joists (see figure, previous page). Windows, doors, and electrical chases can be factory precut—indeed, an entire building may be packaged for quick site erection—or generic panels may be supplied "raw" and cut and trimmed on-site. Panels are cut with circular saws or small chain saws, trimmed with "hot wire scoops," and fastened with long screws, staples, and adhesives.

**Designing with SIPs**

Designing with SIPs effectively imposes a 4-foot modular grid on the planning process, and a consciousness of the panel dimension typically leads designers to more volumetric and planar forms. Complex dormers, curves, hips, and valleys are feasible with SIPs, but will result in a higher cost over traditional wood-stud framing. Windows and doors can be cut into panels, but leaving out a panel for a window wall is simpler still.

Exposed beams and widely spaced trusses can support a continuously insulated envelope. "I wanted to build with a clearly expressed structural frame, services, and enclosure system," Paul Olsen of Jones & Jones in Seattle says of his Interbay Family Golf Center. He was also impressed with the process's speed. "We were fabricating panels while the steel was being erected."

**Construction advantages**

"Unlike much of the dimensional lumber coming off the trucks these days," says Will Zachman of Steven Winter Associates. "SIPs are, well, straight." This consistency is a benefit of the stressed-skin principle. In wood-framed construction, all loads are borne by the studs or rafters; the sheathing is discounted. All the elements of a SIP are stressed; the skins in compression and tension and the core in shear against buckling or racking. SIP skins present

## Rome wasn't built in a day, but this house was...

**Bear Valley, California, architect David Wright (shown here with his four children) received delivery of SIP panels at 8 a.m.**

**Workers prepare wall-to-floor connections with sealant and adhesives.**

**Double-spline joint and bottom plate anchor standard 4'x8' SIP panel into place.**

**At noon, crane arrives to assist crew in placing large or high panels.**

smooth and continuously nailable surfaces for cabinetry, fixtures, finishes, and accessories.

Erection is quick and methodical. "We unloaded the panels by number, started in the corner, and worked our way around the house," says Mark Sever of Sever Design Group Architects in Scottsdale, Arizona. "It took us two days to assemble and insulate the entire exterior. It's like a toy—'some assembly required.' You screw it down and you're done."

**Environmental advantages**

SIPs are becoming common in many areas—not just in severe climate zones. "With energy prices so high in California," Sever says, "we look at every angle to save on life-cycle costs, not just on first costs."

Beyond the extra insulation, there are important environmental advantages to SIP construction. OSB skins are made with young "farmed" wood fiber. In contrast, dimensional lumber is made from mature timber, which takes generations to regrow.

In the history of wood framing, insulation and airtightness were afterthoughts. In a 1993 experiment sponsored by the Department of Energy and conducted by the Florida Solar Energy Center, two identical houses were built side-by-side on the same street in Louisville, Kentucky, by the same builder. One was wood-framed, the other constructed with thin SIPs to yield an identical R-value. The contractor built the frame house tightly, with measured infiltration well below the national average. But the SIP-framed house had still-lower infiltration, resulting in 12 to 17 percent heating savings despite identical operating conditions. Generally, SIP construction requires neither a vapor barrier nor an air infiltration barrier like "housewrap." Contractors report high owner satisfaction with the quiet, comfortable solidity of SIP construction.

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Foam Core Panels and Building Systems, 2nd Edition (1992)
By Steve Andrews

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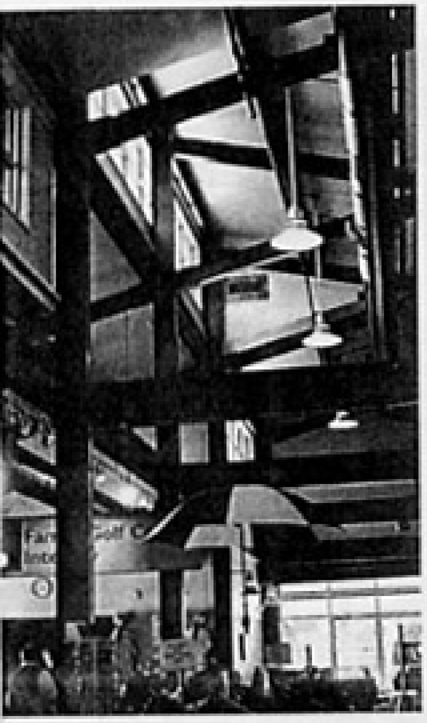
At end of day, shell of Wright house is complete.

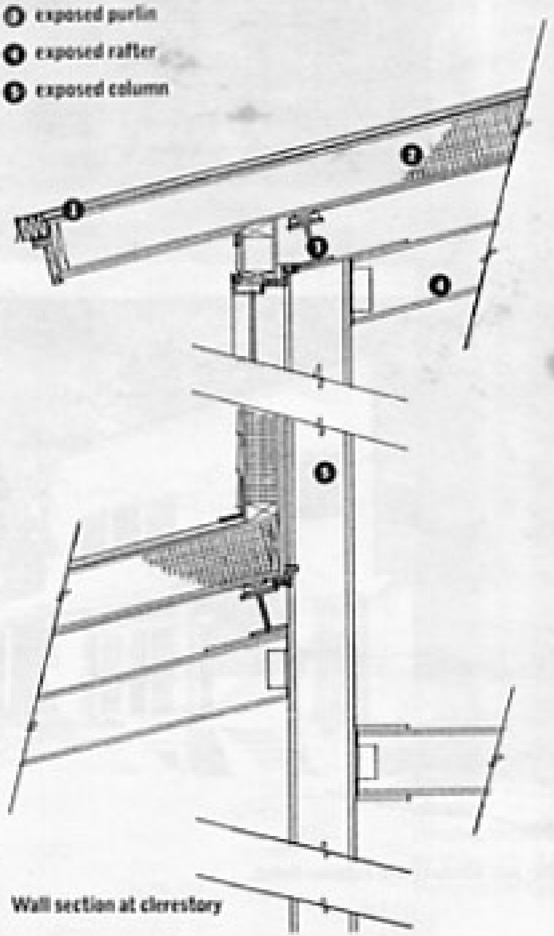
Caulk, adhesive, and long panel screws secure roof panels to wood beams and steel framing.

Builders later add windows and exterior finish.



By exposing framework of Interbay Family Golf Center in Seattle, architect Jones & Jones achieved continuous SIP envelope.

1. steel roofing
2. 10" EPS SIP
3. exposed purlin
4. exposed rafter
5. exposed column



Wall section at clerestory

### Resistance to SIPs

The building industry's resistance to SIPs comes primarily from the familiarity of wood-framed construction and a legitimate fear of the unknown. Traditional wood-framed structures do perform well. G.Z. Brown, an architect and director of the Energy Studies in Buildings Laboratory at the University of Oregon, reminds us of the benefit that the SIP learning curve will be hard to overcome in the face of the construction industry's decades of experience with wood-framed houses. "Even though a SIP house goes up faster, with less skill, we can't underestimate the tremendous investment our country has made in wood framing. Architects cash in on that investment with every bid."

Plumbers and electricians can also be puzzled about how to run services through solid SIP construction, and breaking an insulated envelope for a chase is bad practice in any case. "The electricians had a learning curve," reports the Design Alliance's Gray. "We predrilled many panels, designed a baseboard chase in other areas, and ran most of the wiring through interior walls."

### Codes and cautions

The major code groups now recognize SIP tests for strength and fire resistance, but local building officials may require engineering calculations for each SIP building. Generally, architects draw generic panel modules, thicknesses, and spans for competitive bidding, and specify that the winning bidder supply signed and sealed panel drawings for approval. For fire resistance, codes require that panels have an interior fire-resistant layer of gypsum wallboard or a cementitious fire coating. Neither EPS nor urethane is particularly flammable, but EPS melts at 200 degrees, prohibiting construction for large buildings or public facilities without tested fire-resistant assemblies or sprinklers.

Bugs have been known to take up residence in panels. Some manufacturers have solved this problem by salting the panel with a borate, or pesticide. Architects should specify that panels be effectively treated against insects and take care to detail the sill against infestation.

### Costs of SIPs

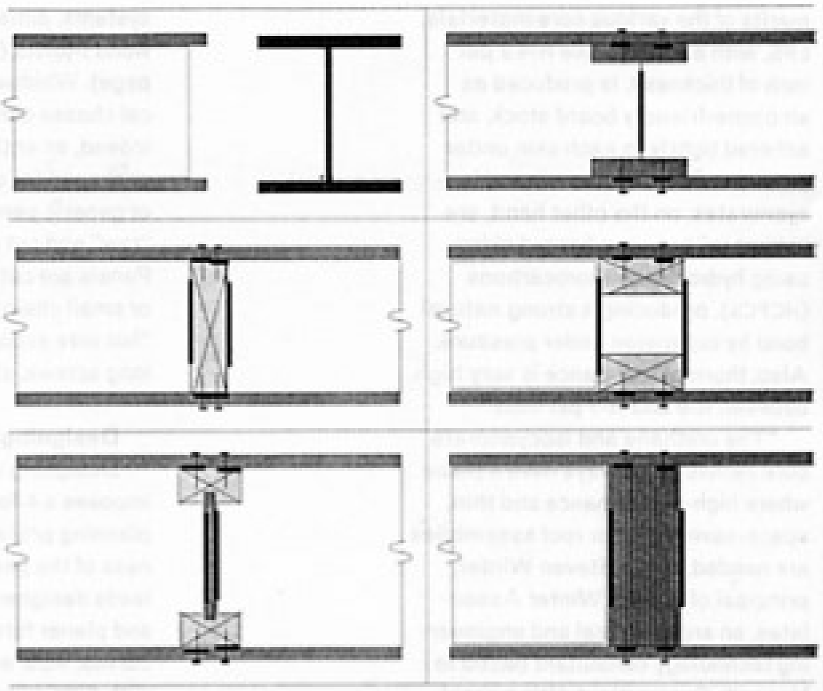
SIP shells generally cost 2 to 10 percent more than an insulated and sheathed wood frame, but provide 30 to 50 percent more insulation. With wood framing, additional insulation requires deeper lumber dimensions or double framing. SIP insulation, by contrast, gets less expensive as the panels get thicker, since the skins and the manufacturing and installation process all remain the same. Brown's SIP demonstration house was actually cheaper to build than an equivalent wood-framed house, but 2-by-8 studs were required to get enough fiberglass insulation in to achieve the same thermal performance. The panels themselves are more expensive than the materials in an insulated frame wall, and although panels go up faster than frames, most contractors are hesitant to credit SIPs construction with any labor savings.

In regions with higher labor costs, severe climate, or high energy costs, SIP construction is now cost-effective. Panel costs are stable or decreasing slightly with automation and increased volume start to be felt in the marketplace. Alternative SIP skins like textured plywood outside or Fiberbond, a new interior skin that provides strength, finish, and fire protection, promise further savings by reducing finish costs.

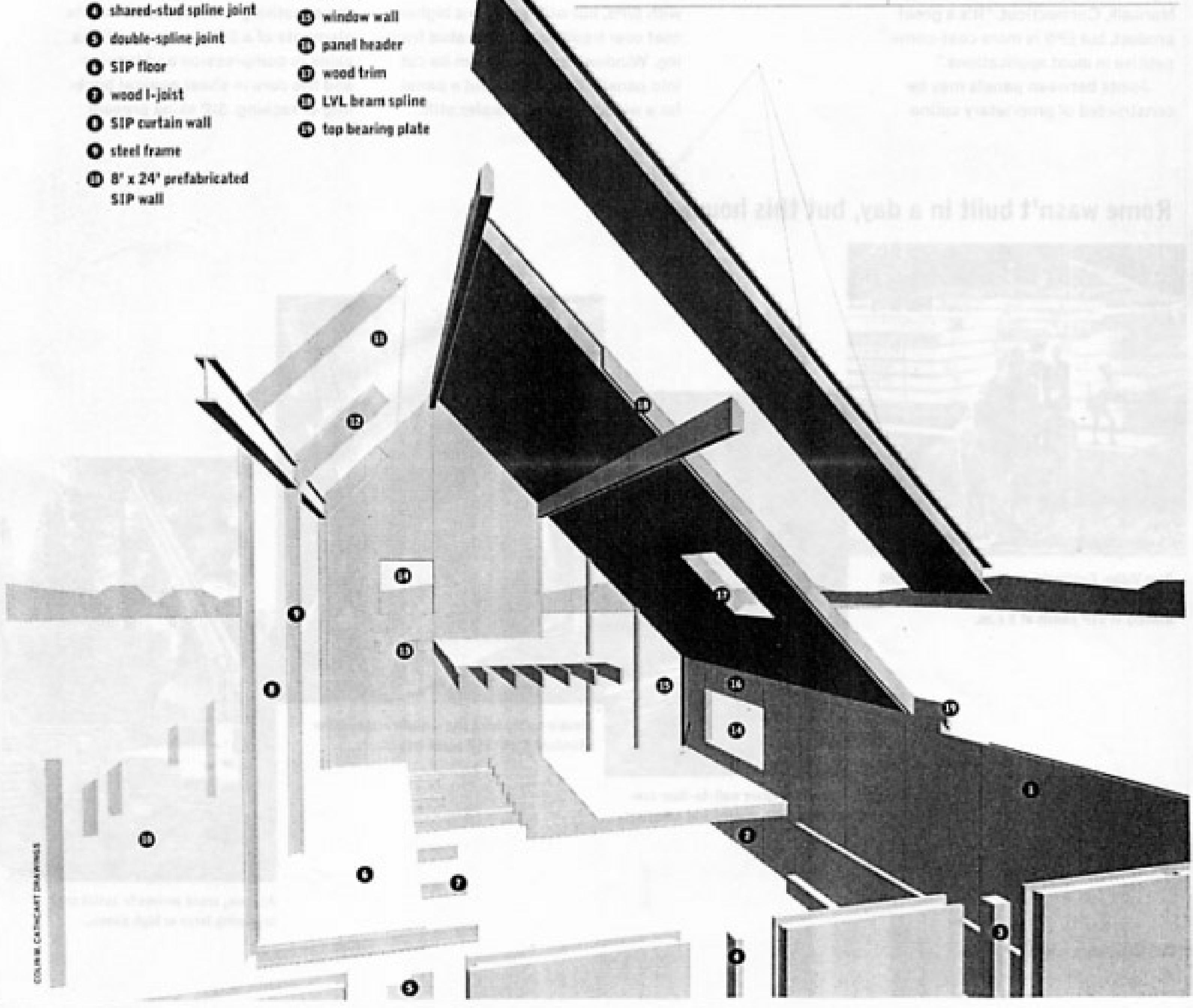
Over the last 10 years, the SIP industry has provided convincing tests, gained solid construction experience, and demonstrated cost-effectiveness. In the next 10 years, SIPs could very well replace rafters for "cathedral" ceilings and mono-pitches, just as roof trusses have largely replaced wooden rafters in flat ceiling construction. And in exterior walls, finally, after 150 years, the stick frame is about to get some serious competition.

*Colin M. Cathcart is an associate professor of architecture at Fordham University and a principal of Kiss + Cathcart in New York City.*

**Stressed-skin principle and SIPs: SIP skins (top left) take compression and tension, similar to I-beam's flange, while insulation takes shear forces and provides rigidity against buckling, as in I-beam's web; double-spline joint (top right) has splines connecting interior and exterior skins; shared-stud joint (center left) is inserted in recesses in insulation; prefabricated one-piece spline (center right) eliminates thermal bridging; wood I-beam spline (bottom left) provides structure, enabling longer spans; laminated veneer lumber (LVL) beam (bottom right) relies on wood for structure and longer spans.**



1. standard 4' x 8' SIP
2. SIP foundation panel
3. one-piece insulated spline joint
4. shared-stud spline joint
5. double-spline joint
6. SIP floor
7. wood I-joist
8. SIP curtain wall
9. steel frame
10. 8' x 24' prefabricated SIP wall
11. roof SIP
12. steel purlin
13. joist hanger
14. window
15. window wall
16. panel header
17. wood trim
18. LVL beam spline
19. top bearing plate



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