ALL-IN-ONE Construction

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A Seattle multistory residential project incorporates prefabricated elements inside a steel exoskeleton to address the restraints of a tight site in a dense neighborhood.

ISL

SLI

▲ The building comprises 13,907 sq. ft.

MODULAR CONSTRUCTION can certainly remedy some construction headaches.

Stacking units or modules into position, one on top of another, and bolting them together in a steel frame can bring numerous benefits to new construction projects in high-density areas: quicker construction, higher quality preassembled parts, faster turnaround times to market and occupy the building and a feasible, economical solution to build housing on small urban land parcels.

But in the AEC world, not everyone is prepared to take a leap of faith in engaging different work processes. Why change what has worked for decades? Retraining staff is time-consuming and costly. When it comes to prefab design and construction, it's essential for the entire project team—more specifically the architects, engineers, steel fabricators and the construction staff—to shift their mindset and operate like an assembly line when manufacturing a branded product. The winning combination usually comes in the form of investment into research and development, familiarity with cost-efficient manufacturing processes, owner/developer buy-in and keen multidiscipline teamwork to design and build in nontraditional ways.

◀ The exoskeleton of the building.

Leaping In

DCI Engineers got its first taste of such a workflow via the six-story 47+7 Apartments development in Seattle's University District. DCI collaborated with Sustainable Living Innovations (SLI), a Seattle-based, consolidated project delivery company affiliated with architectural firm CollinsWoerman. The project is the first use of SLI's prefabricated panelized floor and wall systems and component-based design technology, which produces repeatable, high-quality vertical housing that does not appear manufactured as portable model units. The fast-track building technology consists of prefabricated "sandwiched" panelized wall and floor systems that contain all plumbing, electrical, fire sprinklers and fin-

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DCI Engineers


SLI

◄▲▼ The external steel gravity and lateral system allowed for an efficient design that was very quick to erect. Bolted connections were used exclusively.


Sellen Construction

ishes for integrated utility installation (drywall was not installed in the project). A kit of parts was also included to facilitate assembly of the structural connections, similar to the contents of an erector set, and the building uses a steel exoskeleton framing system.

The building has 24 living units in a range of sizes (427 sq. ft to 534 sq. ft) and totals 13,907 sq. ft. Thanks to the panelized technology's design flexibility, the construction team was able to erect various-sized living units on a tiny urban site of only just over 6,400 sq. ft (60 ft by 107 ft) within 5½ months—50% faster than it would have taken had conventional construction been employed. The total project cost is an estimated $5.85 million, which includes one-time additional research and development costs for the system.

Prototyping and Sequencing

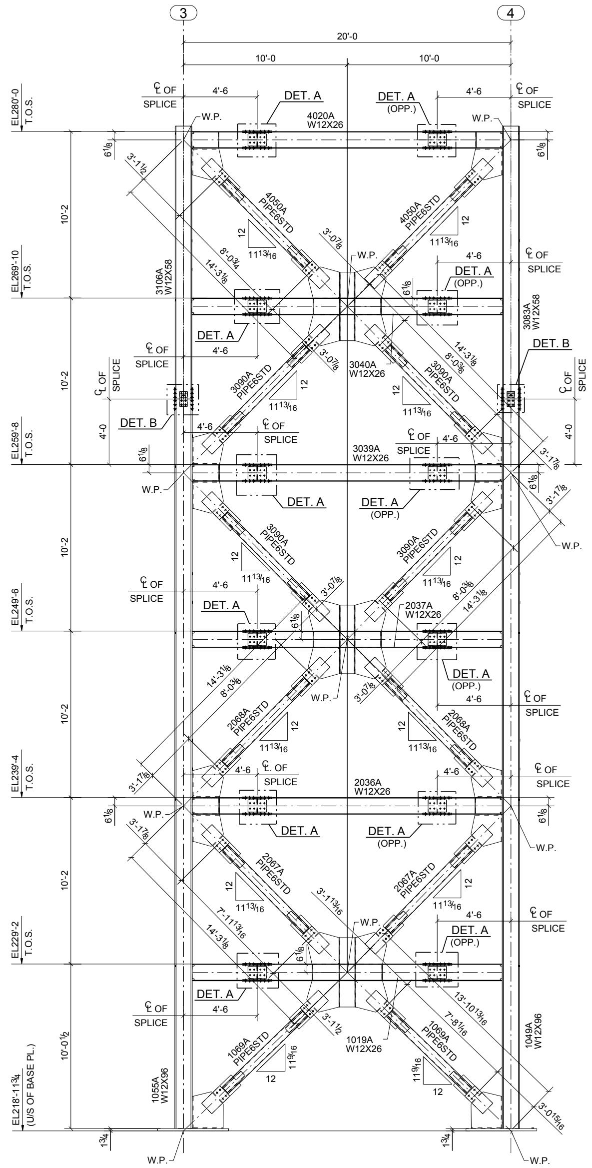
The design team began by developing partial-floor models and a full-scale model in a warehouse to investigate the best sequencing methods to shorten construction time. The research and development partnership of CollinsWoerman, Lydig Construction, DCI Engineers and McKinstry produced designs and concepts to test the ease of prefabricated panel installation, connectivity of vertical piping and utility systems and accessibility to the building's maintenance services.

One of the original sequences tested was a concrete slab lift method. In this scenario, the foundation would be poured and cured first, then a separate concrete slab would be poured on top of that floor area. Once the concrete slab cured and the building's exoskeleton steel framing installed, the slab would be lifted into place (by crane) to the next level of the floor-ceiling system. This method was abandoned when the team found the lifting mechanism to be cost-prohibitive.

The chosen floor system ended up being a light-gauge steel and concrete composite floor, which is much lighter than the all-concrete floor option and also more suitable for incorporating in-floor MEP requirements. The prefabricated portion of the floor system consisted of the light-gauge framing, the metal deck and all MEP and ceiling components. The construction sequence entailed installing part of the steel-framed exoskeleton first, erecting the prefabricated SLI floor systems and then adding lightweight concrete on the metal deck.

Exoskeleton

The external steel gravity and lateral system allowed for an efficient design that was very quick to erect. DCI worked with a consultant to conduct a fire study on a steel exoskeleton framing design to eliminate fireproofing for the exterior skin, which



SLI

▲ The construction team was able to erect various-sized living units on a tiny urban site of only about 6,400 sq. ft (60 ft by 107 ft) within 5½ months.

◄ An elevation drawing of one of the braced frames.

allowed the architect to expose the steel structure. The consultant examined steel heat expansion and degradation under various fire scenarios and specified degraded material properties for design. The results allowed the engineering team to oversize the steel members for gravity loads to account for fire protection; this was more cost-effective and aesthetically pleasing than sheathing all the steel members.

The living units use 25-ft-long steel beams to achieve a column-free, spacious design. Having an exterior steel framing system allowed for 9-ft floor-to-ceiling height, full-height windows and more interior floor space. Bolted connections were used to easily build the exoskeleton frame and eliminate field welding activity, thus reducing labor and project costs. The project incorporated 124 tons of structural steel in all.

The Need for Early Involvement

Thoughtful systematic design and assembly sequencing typically determines the success of prefabricated building projects, and it certainly did in this case. Being part of the team early in the project positioned steel fabricator Metals Fabrication Company to come up with holistic solutions and improve the "production run" design before the final construction phase. To be a reliable supply chain provider, it takes frequent communication between

The Panelized System

MEP logistics are a major factor when coordinating prefab construction, and this is where the R&D work really paid off. The project team pieced together an entire building service system based on panelized sections, and the design criteria proved that prefab construction is not simply a matter of putting together basic Lego blocks. SLI's building maintenance access was intentionally configured at the back of the house so that service staff can access electrical panels outside of the living units instead of entering individual apartments.

Engineering solutions, in conjunction with project scheduling, guided the construction sequencing so that these service systems were connected appropriately while a professional inspector observed the assembly. The hydronic heating system was integrated into the floor below the metal decking so that the system components didn't interfere with the casting of the slab, and it helps the building operate with 75% less energy than conventionally constructed buildings.

Future, taller buildings featuring the panelized system will incorporate BRBF systems for external framing.

The living units use 25-ft-long steel beams to achieve a column-free, spacious design.

The units take advantage of floor-to-ceiling windows for ample natural light.

multidiscipline team members (and within your own staff) to encourage product precision and tight tolerances for steel members and light-gauge steel joists. Drilled holes for connections must be consistent and precisely located according to specifications.

This project was a successful example of such a workflow, such that for the next "fleet" of SLI buildings, steel will continue to be the primary material component and a hallmark to the SLI building brand, with the buildings intended to last 60 to 100 years or even beyond. In addition, future, taller SLI buildings are planned to incorporate buckling restrained braced frame (BRBF) systems for external structural framing, in order to enhance seismic performance—plus, composite metal flooring will be the norm. The next project will not be a prototype but rather the next in a line of structures based on an efficient, proven workflow. ■

Owner
Wallace Properties, Bellevue, Wash.

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Sellen Construction, Seattle

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Sustainable Living Innovations, Seattle

Structural Engineer
DCI Engineers, Seattle

Steel Team

Fabricator
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Detailer
Dowco Consultants, Ltd., Surrey, British Columbia

Units range in size from 427 sq. ft to 534 sq. ft.