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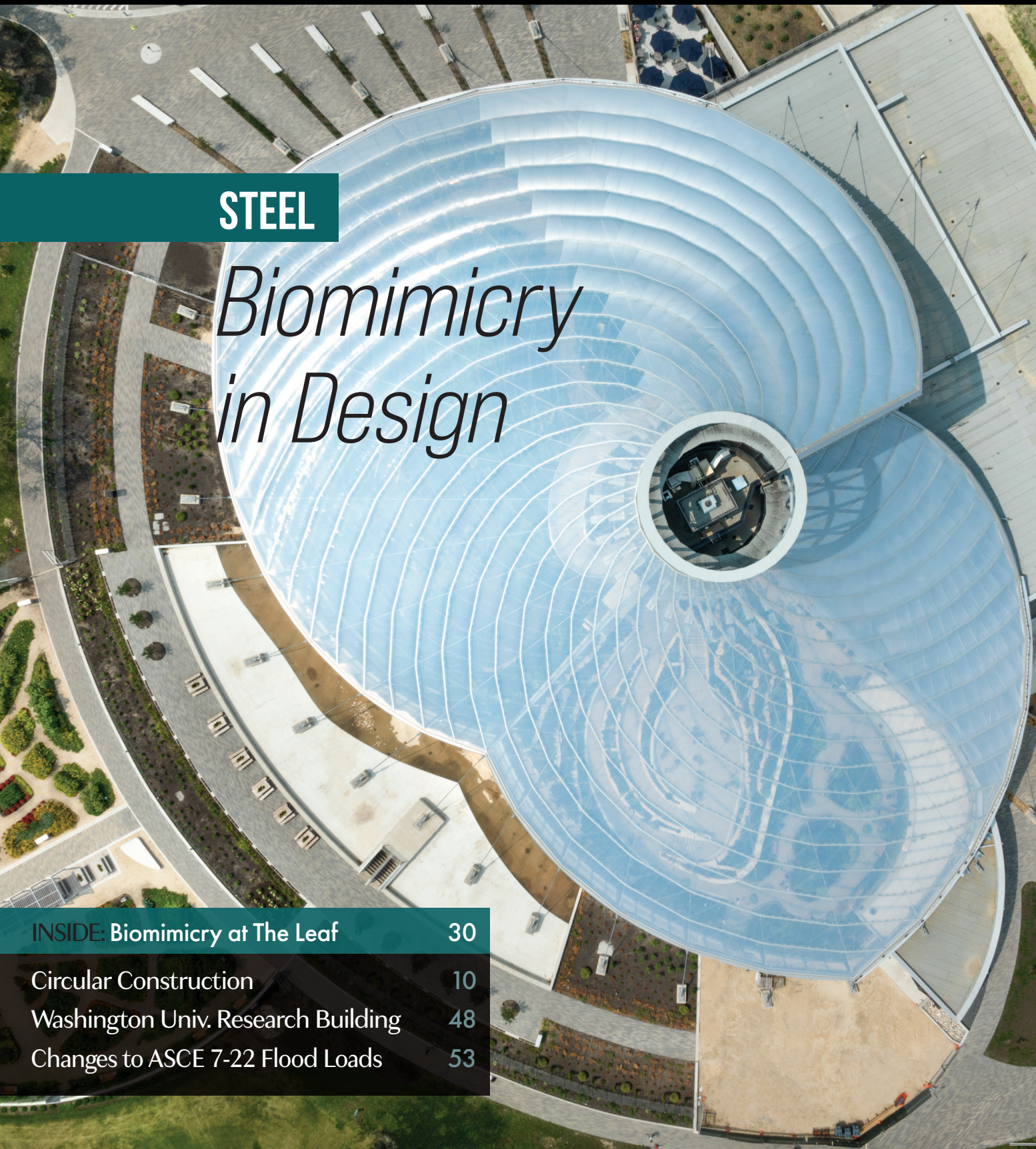

STEEL

Biomimicry in Design

Terrain Gardens at Devon Yards in Devon, Pennsylvania, reused steel trusses from a University of Maryland structure built with bolted connections for easy disassembly and then reconnected them in the new space to form the framework of their new venue. (Photo credit: David Greer.)

Designing New Structures for Deconstruction to Get a Circular Economy

Developers can see end-of-life profits from deconstruction by considering engineering pre-planning in new structure builds. **By Steven Anastasio, PE**

"Built-to-last" has been an underlying mantra in the field of structural engineering. When we pen structures onto the boards, we draw them to be more durable than any of the other building systems, so we can't fathom the end of life of the building. We design with the expectation that the structures will become fixtures on earth indefinitely, or at least to outlive ourselves.

Because of this, there is less motivation to plan for the back end of the building life cycle, especially in a developer driven industry, and when it can seem daunting to even predict the trends 20 years out.

Some trends are apparent right now, though. Buildings are becoming lighter and more efficient, technology and trends are changing more frequently, and methods of construction, deconstruction, and reconstruction are improving.

While recycling is a good strategy, it is not the overall goal. The overall goal is to have a circular economy where materials are reused for similar items as many times as they can before they are recycled.

The practice of incorporating deconstruction into the lifecycle of a building has been around for decades, albeit on the fringes because of the speed and lower cost of the wrecking ball and landfill placement. Now with sustainability requirements and lower carbon mandates, along with rising landfill prices, the time for serious consideration of building end-of-life and recycling has become imperative to consider early in the construction process. As the Urban Land Institute/PWC's 2024 Emerging Trends Report recently stated, "Real estate professionals can no longer ignore the embodied carbon elephant in the room, and stakeholders are putting on the pressure from all angles to address the issue."

In a 600,000 square-foot multi-family high rise of 48 stories which utilizes cast-in-place concrete, the embodied carbon makes up 38% of the total carbon in the building with the structure itself making up 63% of the 38%. So, if you look at the overall operational and embodied carbon in the entire building—the structure alone makes up 24%. Traditionally, when the lifecycle of that building expires, the owner has the option to reallocate for a different purpose, if the structure and systems make that feasible. If not, the structure will be demolished, taking with it all of that embodied carbon and sending it to the landfill. This is a huge waste and potentially a missed opportunity to gain the associated revenues for reusing, recycling, and reallocating materials. More developers are now exploring strategies for deconstruction of a building from the onset of the construction cycle. This early focus allows them to see the potential for reselling the materials at the terminus of the building, while incorporating sustainability practices. This has led to active conversations with architects and engineers about planning for deconstruction.

What Is Deconstruction?

In 2018, the EPA estimated that 600 million tons of Construction & Demolition (C&D) debris were generated, and the average building demolition created 155 pounds of waste per square foot of building area. A 50,000-square-foot building creates 3,875 tons of debris when it is demolished and carted away.

Currently, the industry is selectively recycling building components.

If the debris is elected to be directed to a recycling plant in broken rubble form—the components are separated and resold either in the component's same use or downgraded for other uses. This recycling process is laborious and mechanically intensive. For instance, concrete is crushed down, and an Eddie current separator sorts the metals. Wooden material and foams are separated in a water bath. It is estimated that three-quarters of construction waste can be recycled; however, about one-third is recovered.

Recycling construction materials is difficult. That's why deconstruction is so important. The structural materials take up a huge portion of the landfill, often making it more impactful. The architectural products are certainly more complex to deal with, but when everything goes into a landfill and isn't considered for recycling, the size matters most.

To bridge this gap, it is on the design professionals to specify and design buildings that facilitate reuse and recycling after demolition.

Demolition is complete disposal, whereas the EPA Resource Conservation and Recovery Act (RCRA) defines deconstruction as "the selective disassembly of buildings to facilitate the reuse or recycling of valuable materials." Focused on salvage, this method takes whole, or partial, components of a structure and carefully disconnects them. For example, a connection that can be unscrewed is much easier than a welded one which requires more invasive disconnection measures that could compromise reuse. It's essentially going in the reverse order of building a structure. You start first by removing finishes and fixtures and then progress to the structural elements, like electrical and plumbing infrastructure, and then to the core structural elements such as beams and trusses. Reuseable/recyclable elements are then resold or stored for reuse.

Good candidates for deconstruction are buildings with short life cycles, or re-location cycles, such as those for retail, health-clinics and task-oriented buildings (storage, showroom, military, classrooms and agriculture). By assessing the lifespan of the building—is it more permanent or temporary—a developer can get an idea of the kind of construction that lends itself to deconstructability. For a use that will change frequently (yearly), a highly temporary construction—like a shipping container—works well and provides flexibility for new uses. A use that will be maintained for one to five years can use modular box construction and panelization of components for easy disassembly. For a building that will have a low turnover frequency—five to ten years—conventional and durable materials can be bolted together and disassembled in part, or as a whole.

A fine example of deconstruction reuse can be found at the Terrain Gardens at Devon Yards in Devon, Pennsylvania. Terrain is a garden center and restaurant that has incorporated indoor/outdoor event space into their operations. Focused on creating an immersive natural experience for their retail space and events, Terrain reused steel trusses from a University of Maryland structure that had used bolted connections for easy disassembly and then reconnected them in the new space to form the framework of their new venue. The result was a one-of-a-kind, sustainable setting that supported the values of the organization.

Engineering Considerations in Deconstructability

To effectively plan for deconstruction from an engineering perspective, the original building concept needs to include:

- Materials assessment—Implementing durable and non-toxic materials
- Easily separable—Use of mechanical fasteners instead of adhesives and glue
- Simplicity—Simple components that have limited material types and sizes
- Limited components—Small numbers of large components
- Clear plans—Labeling and providing diagrams as a roadmap for future removal
- Transparency—Systems need to be visible and identifiable, not hidden behind walls
- Regularity—Similar and repeatable systems throughout the building
- Disassembly safety—Worker safety during deconstruction.

Assessing a Building for Deconstruction

Architects and engineers play a key role in guiding developers through a property assessment for deconstructability. The following questions provide an outline for working with building owners to decide deconstruction pros and cons for a property.

Why are you considering deconstructability? If your business' mission is focused toward sustainability, then it's clear that deconstructability is a good avenue to consider on every project. If it's not so clear cut, taking the time to find a building application where shorter, modular building lifecycles lends itself to reuse/recycling of materials may serve the dual purpose of making a profit at the end of building lifecycle while shining a positive sustainable light on the developer.

What is the anticipated end use of the building (including sub-lifespans)? The longer the anticipated lifespan of the building the more difficult it becomes to anticipate the long-term trends and therefore, uses and value of the construction materials. The shorter life buildings have end of life uses that can be predicted more easily and with more tangible markets and buyers for the building components.

Who is on the back end using the building or materials, and who is deconstructing it? Likely, the same contractor who builds a structure will not be the same one who deconstructs it. In that circumstance, simplicity of design and connection is incredibly important to the successful deconstruction and materials in the future. Additionally, is there already a market for recycling the reuse of materials that are being used? If there is, there's a better opportunity for projecting values in the future.

These are just some of the questions that should be considered when choosing whether to pursue a deconstruction strategy on a new build. Pre-planning with a qualified, experienced deconstruction engineer will help ensure a smooth structure transition at end of life and the successful capture of associated revenues from materials reuse/resale.

Full references are included in the online version of the article at **STRUCTUREmag.org**.

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