Transforming Architecture

The Rise of Structural Composites in Modern Building Construction

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BUILDING COMPOSITES™

The traditional model of building construction is straining under the weight of unprecedented challenges. Shortages of skilled labor are a familiar issue, but they've reached historic levels in recent years. Other concerns, like a growing focus on sustainability, are relatively new. And although material costs are finally showing signs of stabilizing, they're settling in at significantly higher costs compared to pre-COVID levels.

The combined impact of these pressures has many industry professionals thinking about the future. There's a growing sense that "the way we've always done it" simply won't work anymore. As the viability of traditional methods reaches a tipping point, staying competitive will mean embracing new technologies and innovative approaches.

This report aims to answer three questions:

1. **What's driving the current interest in new building construction technologies?**
2. **What barriers are holding back promising new technologies like structural composites?**
3. **Where are structural composites getting traction in building construction?**

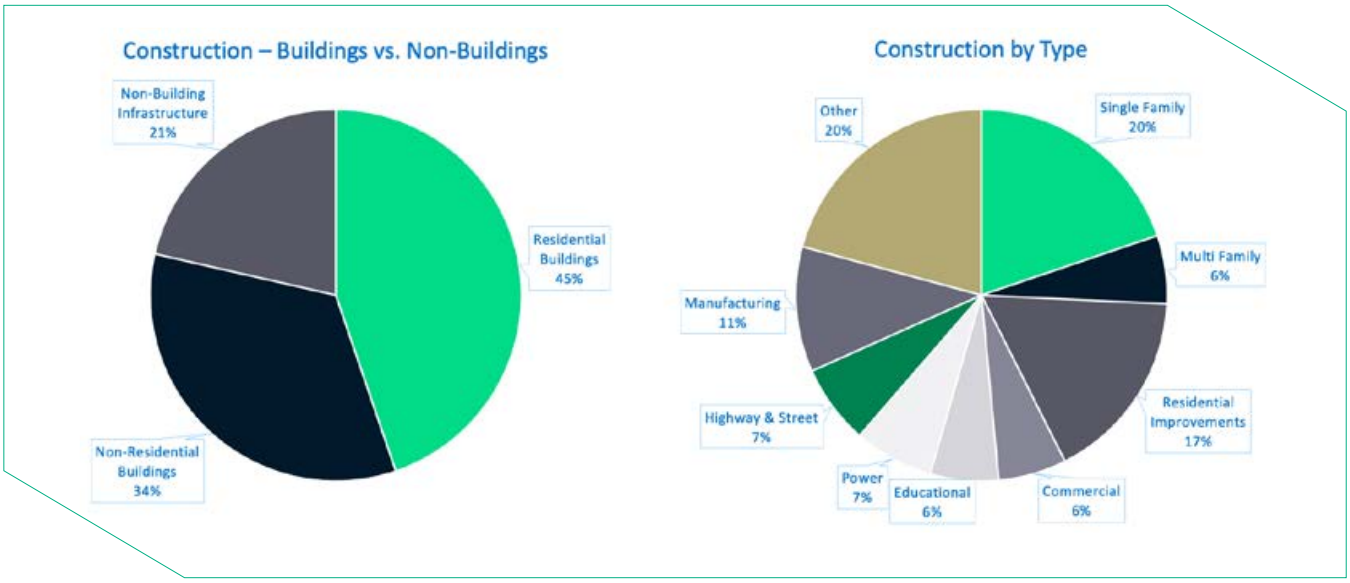
In addition, we'll explore how structural composites can be utilized in a more standardized and cost-effective way, using the development of the HyperWall™ exterior building skin system as a case study.

Why Is Construction Ripe for Change?

Total U.S. construction spending will reach around $2.15 trillion in 2024, accounting for about 5% of total GDP. About 79% of this comes from building construction — both residential and non-residential — while 21% involves infrastructure like roads and bridges.

More than 90% of building construction funding comes from private sources eager to benefit from new technologies.

Another key point is that about 75% of construction spending in the U.S. is from private sources. The total is much higher for buildings specifically: more than 90% comes from private, non-governmental sources, which is crucial to understanding why interest in new technologies is growing quickly.



U.S. construction spending is estimated to reach $2.15 trillion in 2024.

There are four main drivers behind every major general contractor's desire to do things differently:

1. **Labor Costs and Productivity:** Construction labor costs have risen 50% over the last 14 years, with half of that increase occurring since the pandemic. Annual labor costs have increased by 1.6% from 2010 to 2015, 3.6% from 2015 to 2020, and 5.5% since 2020. Moreover, according to a working paper published by the National Bureau of Economic Research, construction labor productivity was about 40% lower in 2020 than in 1970 — a gap that continues to widen. This decline is particularly stark compared to the manufacturing sector — an industry that also deals with the configuration and assembly of physical objects — which saw productivity rise more than 900% over the same 50-year period.

   The paper concluded that further research is needed to determine why construction labor productivity continues to plummet while the U.S. economy as a whole continues on an upward trend. Many industry experts believe the single largest factor is increasing regulation, especially since the creation of OSHA in 1971, which has made construction significantly safer at the expense of productivity.

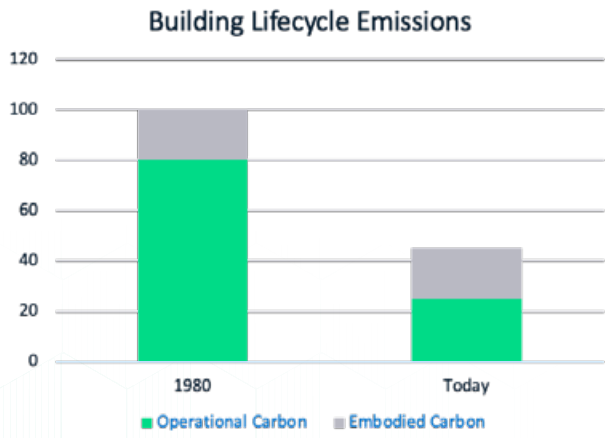
   As noted in a recent article published by *Construction Physics*, safety enforcement seems to be a much greater burden on construction than other sectors. This is partly because it takes place out in the open, where it's easier for inspectors to spot violations. The temporary nature of construction sites also means precautions that other industries only need to install once, such as guard rails and other fall protection devices, need to be installed and removed over and over again — sometimes on the same building. Other factors include pushback from residents and officials, and weak incentives to avoid slowdowns and stoppages.

2. **Labor Scarcity:** Compounding the first problem is the difficulty in *finding* skilled labor. In a 2022 survey conducted by the Associated General Contractors (AGC) of America, 93% of firms reported challenges finding workers, particularly for skilled positions. The outlook remains grim as a result of restrictive immigration policies, insufficient training, an aging workforce and perception issues. Many millennials consider construction to be a dirty, low-status and underpaid profession, even though the average wage for construction workers is well above the nation's median level.

3. **Material Costs:** Historically stable construction material costs have surged since 2020, with processed inputs increasing by 9.5% per year. Costs for fabricated metal structures have risen even faster: a 12.9% annual increase.

4. **Sustainability:** The energy crisis of the 1970s sparked a focus on energy efficiency in buildings — what we now call *operational carbon*. Momentum continued throughout the 1980s and exploded in the 1990s with the formation of the Green Building Council and its codification of building codes.

   The chart below shows the strides made in reducing operational carbon, but until recently, little attention was given to embodied carbon: the carbon footprint of building construction itself. As operational carbon continues to decline rapidly, embodied carbon will become an increasing area of focus for at least the next 20 to 30 years. For new buildings, especially those targeting net-zero operational carbon, embodied carbon emissions could account for more than 60% of the total carbon footprint over a building's lifecycle.



Promising answers to all four of these concerns are offered by structural composites.

The Composite Solution

Structural composites combine two or more materials with different physical or chemical properties to create a new material that exceeds the performance of its components. This paper focuses specifically on fiber-reinforced polymer (FRP) composites, which blend polymer resins with fiberglass reinforcements. Compared to architectural precast concrete and fabricated metal structures, these structural composites are stronger, lighter, more sustainable and can help to lower your installed costs.

Structural composites aren't new. They've been used successfully in marine, aerospace, automotive, rail and heavy civil engineering projects for decades; yet a surprising number of people hold back from using them in buildings. It's not unusual to meet someone at a conference who has concerns about composites in building construction — but doesn't realize they had flown into town on a plane built from the same material.

The market size for structural composites in U.S. building construction is relatively small. Most current applications are in low-structural areas, which are lower-risk for architects and capitalize on the material's light weight and corrosion-resistant properties. Several companies are making significant strides in this space, with the use of structural composites in building construction growing more than 8% per year.

There are literally thousands of large-scale applications where structural composites have been used effectively in building design and have already endured for decades. Some of the most visible are architectural facades, typically one-off custom jobs that aren't part of the structural cladding. Although these designs are primarily cosmetic, they've demonstrated that composites are just as viable for exterior building applications as they've proven to be in ships, bridges and many other non-building projects.

The industry doesn't doubt the strength of composite materials. They've been trusted for years in seismic strengthening retrofits, reinforcing concrete pillars against earthquakes in thousands of buildings along the west coasts of the United States and Canada.

Structural composites have inherent resistances to heat, vapor and moisture, which can reduce on-site labor by eliminating the needs for additional insulation, waterproofing and vapor barrier installation. The same advantages contribute to lower embodied carbon emissions, which are further supported by the lighter weight of structural composites. This can minimize or eliminate the need for expensive and polluting heavy equipment, such as diesel-powered mobile cranes.

In addition, fiberglass costs have seen a lower annual pricing increase of around 7% in the last eight years. As a result, structural composites have become competitive with fabricated metal structures, which have grown 12.9% over the same period. The business case becomes even stronger when you factor in the lower installation costs of structural composites.

Why Is Change So Slow in Construction?

It's clear that there's an unprecedented appetite for innovative approaches in construction. So why isn't the adoption of new products, particularly structural composites, more widespread? There are several reasons:

	What do they need?	What do they value?
Architects	Requires significant amount of detailed information (testing, specifications, drawing details, code path guidance). Need to make their life easy or they will not use new products.	Code Compliance Aesthetics / Visuals Schedule / Speed of Construction Sustainability Cost
Contractors	Easy path to getting the product installed. Clear instructions or installation services. Subcontractors that know how to install. Schedule visibility	Cost Easy to Work With Schedule / Speed of Construction
Owners	Why doing something new (more risk) is worth it to them?	Cost Schedule / Speed of Construction Aesthetics / Visuals

Fragmented sales channels slow construction innovations.

Fragmented Sales Channels: Selling new technologies in building construction requires convincing three distinct decision-makers: architects, contractors and owners/developers, each with slightly different priorities.

Manufacturers need to address what contractors value in their products, but the sale of a product type is made when the architect specifies a solution. Contractors can, however, force architects to reconsider if they're not comfortable with the "new" technology.

Owners are another variable group. Developers tend to be conservative, focusing on costs, while owner-operators are more willing to invest in new solutions. Architects, on the other hand, are more focused on sustainability than contractors. This fragmented market makes gaining consistent sales challenging.

Market Fragmentation: The U.S. construction market is vast and diverse. For example, the largest construction company, Bechtel Corporation, accounts for only 0.5% of the market, while the largest architecture firm, Gensler, represents just 0.05%. This makes gaining traction slow, effortful and challenging to the typical venture capital model, where speed of capital investment return is paramount.

Building Code: All U.S. jurisdictions adopt slightly modified versions of the International Building Code, a complex set of "choose your own adventure" regulations. To sell into the building construction market, manufacturers must understand how their product or system fits into the code. This requires extensive, product-specific testing and qualification, making it expensive to bring new offerings to market.

Code compliance can be particularly complicated for structural composites, creating a barrier to entry that hinders the penetration of a fragmented and undercapitalized manufacturing base. Architects are understandably reluctant to do the legwork because they typically work on a fixed fee structure; anything that adds to their workload is a disincentive.

This has traditionally posed a barrier to structural composite applications, because most have been custom jobs. They lack neatly packaged code compliance paths, testing results, written specifications, standard drawing details and International Code Council (ICC) certification.

System Integration: The structural composites industry often tries to sell "composites" as a material, but architects and contractors work in *systems*, not materials or individual products. Their primary concerns are costs, schedule, risks and sustainability.

Building Composites was founded to bring about positive changes that address these issues. We aim to transform the market with product-based offerings and engineering standardization, moving away from the custom manufacturing models so often used with structural composites. We're achieving these goals by leveraging first-in-class engineering expertise, an automated approach to manufacturing, and significant market knowledge to create the HyperWall system.

The HyperWall Story

The HyperWall building enclosure system is the culmination of four years of research and development, including the construction of a 40 x 80 ft two-story test building, which was later donated to Virginia Tech University.

As we were developing the HyperWall system, we consistently heard about four unmet needs when discussing building exteriors with architects, contractors and developers:

1. Faster construction
2. Fewer on-site workers
3. Less coordination with various trades
4. Growing demand for sustainability

HyperWall is a prefabricated panel system designed specifically to address these needs. It combines a structural composite sandwich panel, glazing, thermal insulation, architectural interest and fire resistance in a single package. By consolidating multiple on-site trades into a turnkey solution handled by a single subcontractor, HyperWall panels enable buildings to be closed as much as 50% faster, while reducing embodied carbon by at least 50% compared to precast concrete alternatives.

Installing glazing in a factory is possible because the panels can handle much higher strain and weigh much less than concrete. HyperWall panels also eliminate the need for additional waterproofing or vapor barriers, as those are inherent to the product. This approach appeals to contractors because only one subcontractor is responsible for the warranty and all coordination, increasing construction speed and reducing risks. The Building Composites team also makes it easy to coordinate with other trades by performing all detailed engineering for building connections for the benefit of on-site steel and concrete subcontractors.

At one-third the weight of precast panels, the HyperWall system offers a significantly lighter package than anything else on the market. As a result, the panels require fewer truckloads to transport, reducing fuel costs and associated emissions.

The HITT Contracting headquarters in Falls Church, Va., will feature 344 HyperWall assemblies, complete with factory-installed jumbo glazing.

Bringing a new product to market requires someone willing to share the risks. For Building Composites, that was HITT Contracting, which will use HyperWall panels in their corporate headquarters, scheduled to begin construction in January 2025. The HyperWall system will reduce the construction time required to close the building by as much as 50%, with significantly less on-site labor and equipment. It will also reduce the building's embodied carbon by at least 50% compared to architectural precast concrete.

Structural composite systems like HyperWall building skins enable architects to add striking visual appeal to their designs.

Cracking the Code: HyperWall Panels Pass the Tests

Building Composites began engaging in the ICC process as soon as the right combination of materials had been refined for the HyperWall system. Successful testing to date has included:

Structural Testing

- Coupon-level testing (tensile, compression, shear, etc.)
- Full-scale connection and wind load testing

Flammability Testing

- NFPA 285 Vertical Burn Testing
- NFPA 268 Ignitability Testing
- ASTM E-84 Horizontal Surface Burn Testing

Functional Testing

- R-value
- Sound Transmission (STC)
- ASTM E283 Air Infiltration Testing
- ASTM E331 Water Penetration Testing
- ASTM C794 Caulking Adhesion Testing

Expanding Creative Options (and Elbow Room)

The HyperWall system enables architects and designers to think in completely different ways than they've ever been able to before. Even normal buildings can be more elaborate and creative than a typical "glass box".

One of the big ways this can play out is by increasing the amount of available space inside a building. Precast concrete panels require smaller window openings to accommodate their structural requirements than the HyperWall system. Because HyperWall panels are lightweight and have a high R-value, they can hang on the outside of the building, allowing for a much thinner, non-structural interior stud wall. You'll get the look of a metal wall panel system but with the ability to create larger interior openings, plus significantly more options for color and texture.

To give just one example, the rentable square footage of a 410,000 square foot mixed-use residential building was expanded to 425,000 square feet by utilizing the HyperWall system instead of a metal panel or precast system. The potential revenue from that extra space will add up over time.

Key Takeaways

- The building construction industry is motivated to find new ways to do things given the headwinds that they face on numerous fronts: labor costs, labor scarcity, surging material costs, sustainability concerns, etc.
- Architects, owners and contractors don't care about structural composites or any other advanced materials, but they *do* care about the benefits these materials can offer: lightweight, durable, eco-friendly and flexible designs leading to cheaper, faster, more sustainable construction.
- New products and technologies need to address the four things that matter most to building owners: schedule, price, risks and sustainability. Each owner will weigh these attributes differently. But if manufacturers don't make at least one of them better, owners won't be motivated to risk using a new product.
- Embodied carbon reduction is a growing concern that will become increasingly important to building owners in the coming years.
- HyperWall panels leverage the advantages of structural composites in a system format, enabling levels of flexibility and creativity no other material can offer. Building Composites LLC has organized testing and engineering details to make it as easy as possible to specify the HyperWall system and is working to secure ICC certification.

About the Author

Andy Loff is a hands-on serial entrepreneur with an extensive background in structural engineering, business development, construction, manufacturing and technological development. Prior to founding Building Composites, he helped launch multiple successful engineering and fabrication companies utilizing composite materials and other advanced solutions. His areas of expertise include structural engineering, product development, operations management and construction operations.

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