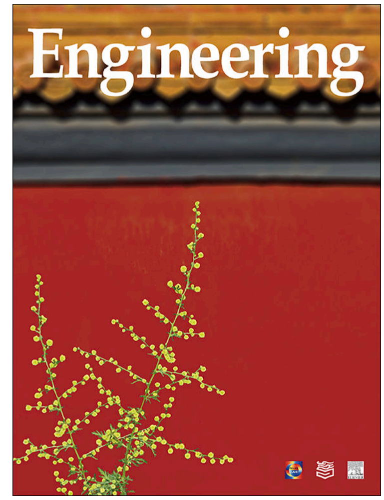

News & Highlights

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Superwood—Can It Replace Concrete and Steel?

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In October 2025, from its new 8400 m^2 factory, the company Inventwood in Frederick, MD, USA, began to ship its first commercial batches of Superwood, a new form of wood with a strength-to-weight ratio 10 times greater than steel [1]. According to the startup, which is already planning a production facility three times as large [1], the novel material has the potential to take the place of concrete and steel in buildings and help avoid the substantial CO_2 emissions associated with their use [2].

Manufacturing concrete and steel generates huge amounts of CO_2, and industries that make these materials are searching for ways to curb their climate impacts [3]. That quest is becoming ever more urgent, because the global floor area of buildings is predicted to increase by 55% by 2050 [4]. Using today's technologies, the resulting demand for steel and concrete would release a total 75 Gt of CO_2, equivalent to about two years' worth of greenhouse gas (GHG) emissions currently produced by burning fossil fuels [5].

Various projects are trialling greener methods to produce concrete and steel, but there is also growing interest in replacing these construction stalwarts with more sustainable alternatives, including wood. Since trees absorb CO_2 as they grow, using wood in new buildings can potentially lock away carbon. The process of turning trees into lumber can also leave a smaller carbon footprint than making concrete and steel, which generally means that "wooden buildings can have a lower environmental impact," said Kate Simonen, a professor of architecture at the University of Washington in Seattle, WA, USA.

But there is ongoing debate about the true climate benefits of building with wood and how much of the substantial amount of steel and concrete used in current construction it might displace (Fig. 1). The main challenge is less about wood's physical properties, and more about the scarcity of genuinely sustainable timber, said Hannah Audino, lead spokesperson for buildings decarbonisation at the London, UK-based Energy Transitions Commission (ETC), a global think-tank focused on strategies to achieve net-zero emissions by 2050. "There are huge limits to how far timber and other materials can go to actually displacing concrete and steel."

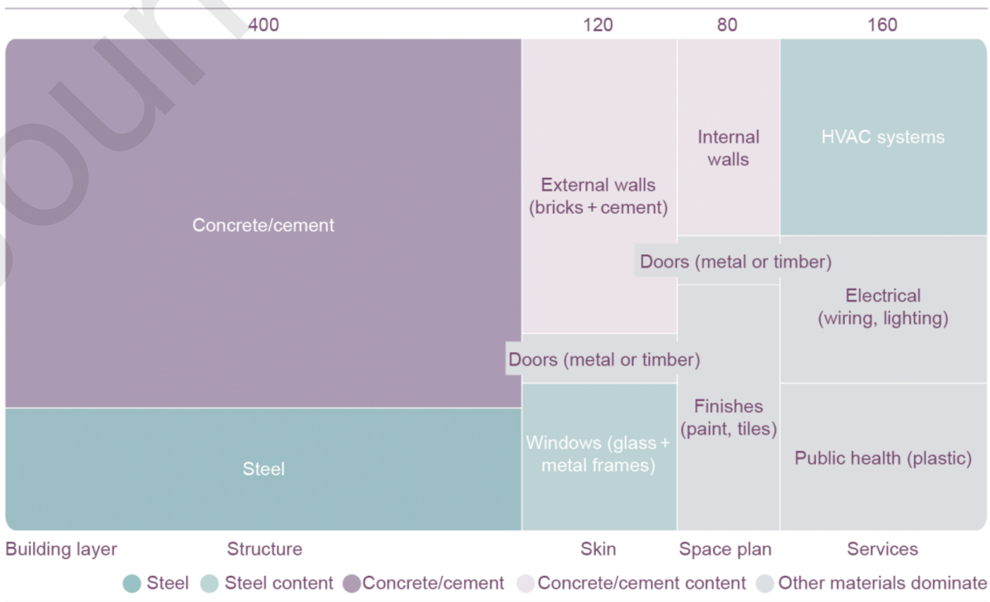

Fig. 1. Concrete/cement and steel account for an estimated more than half of the total CO_2 emissions generated by the construction of a typical building. Values given are kg of CO_2 emitted per m^2. Credit: ETC (CC0).

Building with wood is hardly a new idea. "In the USA and Canada, wood has consistently been the primary building material for residential construction," said Simonen. And wood is not limited to low-rise construction. Built almost 1000 years ago in Yingxian, Shanxi, China, the Sakyamuni Pagoda of Fogong Temple boasts a towering height of 67 m (Fig. 2(a)) [6]. A more recent example is the Ascent MKE, a 25-story high-rise building in Milwaukee, WI, USA, completed in August 2022; the world's tallest mass timber structure at 87 m, the building features 259 luxury apartments, retail space, an elevated pool with operable window walls, and a sky-deck (Fig. 2(b)) [7].

(a) (b)

Fig. 2. (a) The Sakyamuni Pagoda of Fogong Temple in Yingxian, Shanxi, China, which is more than 67 m tall, was built entirely from wood and completed in 1056. (b) The Ascent MKE in Milwaukee, WI, USA, completed in 2022, is the world's tallest mass timber structure with a height of 87 m. Credit: (a) Charlie Fong/Wikimedia (CC BY-SA 4.0); (b) Michael Barera/Wikimedia (CC BY-SA 4.0).

Historically, though, building big with wood faced several drawbacks. The natural growth of trees limits the size of wooden beams, for example. While it is possible to build high with a latticework of wooden struts, it was concrete and steel that allowed the building of supersized city skyscrapers. Architects and engineers were also nervous about using flammable structural materials in multistory buildings.

But innovations have helped wood to catch up. One of the most significant is cross-laminated timber (CLT), a composite made by gluing planks of wood in crisscross layers. The grain of each layer typically lies at a 90° angle to its neighbors, giving the material strength in all directions, along with good fire safety properties [8]. A variation in which the grain of the layers lies parallel, called glulam, is used for beams and columns, while CLT is mostly used for panels in walls and floors. "The advent of laminated timber really brought a rebirth of heavy timber construction," said Simonen.

Superwood is the latest addition to the family of engineered woods. It was initially developed by researchers led by Liangbing Hu, since 2024 a professor of electrical and computer engineering and materials science at Yale University (New Haven, CT, USA). In his previous position at the University of Maryland (College Park, MD, USA), where he was a professor of materials science and engineering and director of the Center for Materials Innovation, Hu senior authored a heralded 2018 report published in *Nature* that first described an innovative two-step process that led to Inventwood's Superwood [9].

Wood contains three main structural polymers: cellulose, hemicellulose, and lignin. Long cellulose chains bundle into microfibrils to strengthen cell walls, while hemicellulose contains shorter chains and forms a flexible shield around the microfibrils. The lignin acts as a kind of glue to link these structural units together.

The method developed by Hu and colleagues involved soaking wood in a boiling solution of sodium hydroxide and sodium sulphite to remove some lignin and hemicellulose [9]. The wood could then be compressed at 100 °C to about 20% of its original thickness. This 'hot pressing' aligns cellulose nanofibers in the wood so they form chemical bonds to each other that strengthen the material.

This process has since been refined by Inventwood, which in 2022 received a 20 million USD Advanced Research Projects Agency-Energy (ARPA-E) grant from the US Department of Energy. Hu said that instead of removing the lignin, a different chemical treatment is used to alter it, producing less waste than with the original laboratory process (Fig. 3). At the laboratory scale, Superwood is now up to 20 times stronger and stiffer than natural wood [10]. The compression process also blocks the wood's pores, which prevents fire from spreading through the material. While fire will char its surface, the material's density excludes the oxygen needed for combustion, preserving its structural integrity—unlike steel, it will not warp with excessive heat.

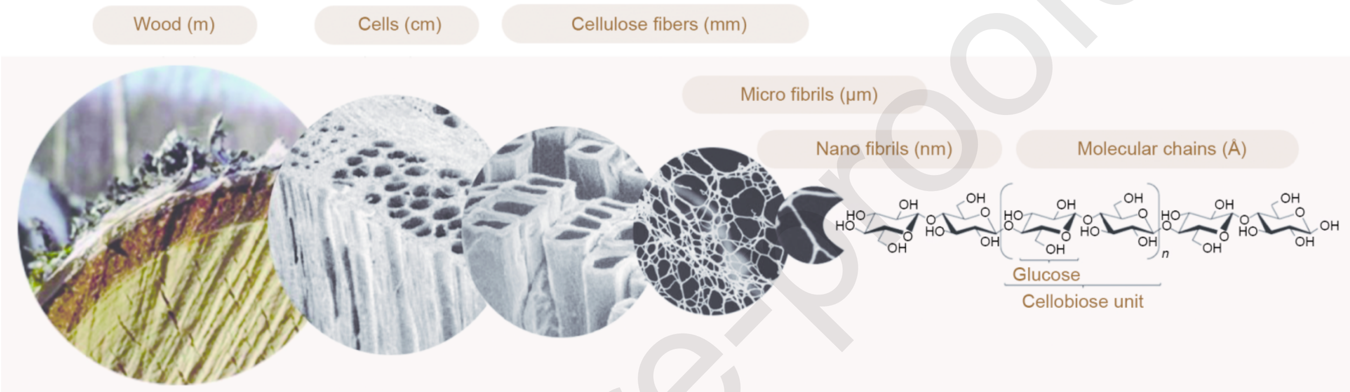

Fig. 3. Wood is a highly porous material that contains almost 50% cellulose by mass. To strengthen wood, researchers used a chemical treatment to remove some of its lignin and hemicellulose and then compressed it at 100 °C to reduce its thickness by 80%. Its well-aligned cellulose nanofibers makes this densified wood more than 10 times stronger and tougher than natural wood. Credit: Inventwood, with permission.

While Inventwood makes Superwood from low-cost, fast-growing trees such as poplar, it claims its process works with wood from more than 19 different species of tree [11]. In the long-term the company hopes to make load-bearing beams, Hu said, but is now mostly using Superwood to produce cladding panels and decking (Fig. 4). The company says the cost of its products is similar to other high-end claddings or tropical hardwood [1].

Fig. 4. Inventwood has refined its wood compression process to create Superwood, a product it claims is stronger and lighter than steel. Superwood is initially being sold by the company for use as cladding panels and decking. Credit: Inventwood, with permission.

In another recent advance, to avoid the chemical treatment step altogether, Hu and colleagues used genome editing to create poplar trees that provide wood with depleted lignin content [12]. Their research showed that, once compressed, the harvested wood from the genetically altered trees had the same properties as the chemically treated Superwood.

Although InventWood has yet to release a detailed life-cycle analysis of the carbon-saving potential of Superwood, Hu said it is already clear that the material is carbon negative—sequestering more carbon than is emitted during its manufacture—"and that number is going to become more negative as we scale up and simplify the process."

Hu's team has estimated that if Superwood were used in place of structural steel beams, columns, and connections over the next 30 years, it could avoid 37.2 Gt of CO_2 emissions [13]. Others, however, are skeptical that wood construction materials could have such a substantial impact. In a 2023 report on timber buildings, the World Resources Institute (WRI), a Washington, DC, USA-based global non-profit that works on sustainability issues to protect the environment and improve people's lives, pointed out that when a tree is harvested, roots and small branches are generally left behind [14]. This means at least one-third of a tree's mass remains in the forest, where it decays and releases its stored carbon. Turning logs into lumber also creates a lot of waste bark and sawdust, which is often burned.

The potential climate benefits of timber construction also depend on harvesting wood from sustainably managed forest plantations, in which tree planting matches or exceeds extraction. Such forests are already in high demand to meet rising demand for wood in other sectors. The WRI report concluded that if a greater need for construction timber were satisfied by cutting into other forests, it would actually increase CO_2 emissions compared with using concrete and steel [14].

According to a February 2025 ETC report [4], only 11% of timber is currently harvested sustainably. If one-quarter of the world's concrete were to be replaced by timber, that would require an additional forested land area some 1.5 times the size of India. Overall, the ETC report suggests that maximizing the use of wood and other substitute materials in construction could reduce concrete and steel demand by less than 10% in the coming decades. Instead, it suggests much greater emissions reductions could be achieved by designing buildings so that they require less material—for example by siting new buildings in areas that would allow the size of their foundations to be minimized.

Cement and concrete currently account for about 7%–8% of global CO_2 emissions [4]. Most of these emissions arise from turning calcium carbonate into lime, a key ingredient in the cement that binds concrete. In all, producing 1 t of cement generates about 0.6 t of CO_2. One way to reduce these emissions is to capture and store the CO_2 released from calcium carbonate, which is technically feasible but expensive [15]. Another strategy involves substituting alternative materials, such as clay or recycled concrete, for some of the cement in concrete [16].

Steel production accounts for another 7% of global CO_2 emissions, with about half of that steel used in construction [4]. Producing 1 t of steel creates roughly 2 t of CO_2 emissions, mostly from the coal used to fire blast furnaces that convert iron ore into iron. An alternative process called direct reduced iron (DRI) uses natural gas in place of coal, which can halve the CO_2 emissions of ironmaking. This iron can then be turned into steel using an electric arc furnace. Roughly 5% of the world's steel is already produced using the DRI process.

Various projects are now trying to make so-called green steel by using clean-burning hydrogen instead of natural gas, which could reduce emissions even further [17]. In Sweden, for example, Stegra (formerly known as H2 Green Steel), plans to use renewable electricity to generate hydrogen for DRI-based steelmaking. But in October, the company said it needed an extra more than 1 billion USD from investors to keep its delayed project going [18]. Similar projects are also struggling, hit by high energy costs and uncertain demand for green steel, which is more expensive than conventional steel [19].

While Superwood and similarly enhanced wood products will likely play some role in decarbonizing the construction industry, it seems realistic that most building will continue to rely primarily on concrete and steel. The question is whether—and how soon—these materials can be produced without substantial GHG emissions. According to Audino, global research and development efforts to cut the carbon footprint of concrete and steel are moving far too slowly. "It is technically and economically feasible to get to net-zero concrete and steel by 2050 with technology we have today," she said. "But it is going to take time to scale these solutions up and slow progress leads to more cumulative emissions along the way, putting us at risk of not limiting global warming to 1.5 degrees."

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