Could wooden buildings be a solution to climate change?

Timber structures would allow us to draw carbon from the air and store it in our homes and offices – leading some to believe that wooden buildings are the future of architecture.

I'm standing in a seemingly ordinary construction site of an unremarkable office block in east London. The seven-storey building is about two-thirds complete – the basic structure and staircases are in place, with plastering and wiring just beginning. But as I walk around, something different slowly reveals itself. The construction site is quiet and clean – it even smells good. And there's an awful lot of wood. Building sites typically feature wood as the mould to pour the concrete into. But here, the wood *is* the concrete.

"Because a timber building weighs 20% of a concrete building, the gravitational load is vastly reduced," enthuses Andrew Waugh, the architect, who shows me around. "That means we need minimal foundations, we don't need massive amounts of concrete in the ground. We have a timber core, timber walls and timber floor slabs – so we reduce the amount of steel down to a bare minimum." Steel is typically used to form the main internal supports or to reinforce concrete in most large modern buildings. In this wooden building, however, there are relatively few steel sections. Those that remain are bolted together like a Meccano set, to be easily taken apart at the end of (or during) the building's life. "If you wanted to put a staircase right here," says Waugh, pointing to the ceiling, "you unscrew that [steel] beam there, get a chainsaw and cut a hole in the timber [floor]."

Globally, enough concrete is poured each year to cover the whole of England

Our dependency on concrete and steel to build everything from homes to sports stadiums, comes at a severe environmental cost. Concrete is responsible for **4-8%** of the world's carbon dioxide (CO_2) emissions. Second only to water, it is the most widely used substance on Earth, accounting for around 85% of all mining and linked to an **alarming depletion of the world's sand**. Globally, enough concrete is poured each year to cover the whole of England.

Some architects such as Waugh are therefore arguing for – and pressing ahead with – a return to wood as our primary building material. Wood from managed forestry actually stores carbon as opposed to emitting it: as trees grow, they absorb CO_2 from the atmosphere. As a rule of thumb, a cubic metre of wood contains around a tonne of CO_2 (more or less, depending on the species of tree) – which is **similar to 350 litres of gasoline**.

Waugh designed this 10-storey development in Dalston, London. The CLT structure weighs just one fifth of an equivalent concrete building (Credit: Daniel Shearing)

Not only does wood remove more CO_2 from the atmosphere than it adds through manufacture, but by replacing carbon-intensive materials such as concrete or steel it doubles its contribution to lowering CO_2. A recent advisory report to the UK government on the uses of “Biomass in a low-carbon economy” found that, “the greatest levels of [greenhouse gas] abatement from biomass currently occur when wood is used as a construction material… to both store carbon and displace high carbon cement, brick and steel.”

Between 15% and 28% of new homes built in the UK annually use timber frame construction, capturing over one million tonnes of CO_2 a year as a result. Increasing the use of timber in construction could triple that amount, the report concluded. “Savings of a similar magnitude may also be possible in the commercial and industrial sectors by utilising new engineered wood systems such as cross-laminated timber.”

Cross-laminated timber, or CLT, is the primary material on the construction site Andrew Waugh shows me around in east London. Because it’s described as an “engineered wood”, I expect to see something similar to chipboard or plywood. But CLT just looks like ordinary 3m (10ft) planks of wood, one inch thick, replete with knot-holes and splinters. The ingenuity is that the planks are made stronger by gluing them in layers of three, with each layer perpendicular to the other. This means that the CLT “doesn’t bow or bend, it has integral strength in two directions”, says Waugh. “[A CLT] wall supports the floor above, with a horizontal strength to carry a load above it, acting like a long beam”. That, he says, “changes architecture”.

Having built with CLT for a decade now, Waugh believes it can achieve anything a concrete and steel building can, and more besides. It was invented in the 1990s, partly in response to “the death of the furniture and paper industries", says Waugh. "Sixty percent of Austria is forest and they needed to find a new sales outlet. So, they came up with cross-laminated timber."

A cubic metre of wood contains around a tonne of CO_2 which is similar to 350 litres of gasoline (Credit: Alamy)

Other engineered woods such as plywood and MDF are around 10% adhesive (glue), often urea-formaldehyde, which can produce hazardous chemicals during recycling or incineration. CLT, however, is below 1% adhesive, and typically uses a bio-based polyurethane. The planks are bonded together under heat and pressure to fuse that small amount of adhesive using the moisture of the wood. To look at, smell and touch, it's as pure wood as a child's tree house – knots and all.

Many CLT factories in Austria are even powered by renewable biomass using the offcuts, branches and twigs. Some factories produce enough electricity to power the surrounding communities.

Despite the fact that CLT was invented in Austria, Waugh's London-based architecture practice, Waugh Thistleton, was the first to use it to construct a multi-storey building. Murray Grove, an otherwise ordinary nine-floor apartment block with grey cladding, caused "shock and horror in Austria" when it was being built in 2009, says Waugh. CLT had only ever been used for "nice and simple two-storey houses", whereas anything taller reverted to concrete and steel. But for Murray Grove, the entire structure above the first floor slab is comprised of CLT panels, with all walls, floor slabs and lift cores formed from timber, like a honeycomb block.

The project has since inspired hundreds of architects to build tall with CLT, from the 55m Brock Commons Tallwood House, in Vancouver, Canada, to the 84m, 24-storey 'HoHo Tower' currently under construction in Vienna, Austria.

Since 2001, Canada's forests have emitted more CO_2 than they absorbed

Recently there have been calls for **tree planting on a colossal scale**to capture CO_2 and curb climate change. However, whilst young trees are efficient and effective carbon sinks, the same is not so true for mature trees. The Earth maintains a balanced carbon cycle – trees (along with all other plants and animals) grow using carbon, they fall and die, and release that carbon again. That balance was knocked out of kilter when humans discovered ancient stores of carbon in the form of coal and oil, which had been captured during previous carbon cycles, and began burning them, releasing the resulting CO_2 into our atmosphere far faster than the current cycle can deal with.

While young trees absorb carbon dioxide, older plants emit more than they take in (Credit: Alamy)

Many pine trees in managed forests, such as the European spruce, take roughly 80 years to reach maturity, being net absorbers of carbon during those years of growth – but once they reach maturity, they shed roughly as much carbon through the decomposition of needles and fallen branches as they absorb. As was the case in Austria in the 1990s, plummeting demand for paper and wood saw huge swathes of managed forests globally fall into disuse. Rather than return to pristine wilderness, these monocrops cover forest floors in acidic pine needles and dead branches. Canada's great forests for example **have actually emitted more carbon than they absorb since 2001**, thanks to mature trees no longer being actively felled.

Arguably, the best form of carbon sequestration is to *chop down* trees: to restore our sustainable, managed forests, and use the resulting wood as a building material. Managed forests certified by the Forest Stewardship Council (FSC) typically plant two to three trees for every tree felled – meaning the more demand there is for wood, the greater the growth in both forest cover and CO_2-hungry young trees.

Rewilding and protecting virgin forests is essential. But unmanaged monocrops help no-one, and floors full of dry pine needles are also the primary cause of wildfires – something that North America and many parts of the world experience on a now annual basis. Managed harvesting greatly reduces that risk.

These benefits have not been lost on the US authorities. Melissa Jenkins, of the US Federal Forest Service, explained at a recent meeting of the Environmental and Energy Study Institute (EESI), that “we have a situation of overstocked forests: if a wildfire blows through, these fires burn hotter, they burn faster and they take a lot more effort to put out… If we can build markets for these wood products, landowners will be more likely to sustainably manage or sustainably thin their land.” She highlights that CLT in particular as having the potential to reduce “wildfire risk [and] support rural economic development and jobs”.


Unmanaged woodlands are at greater risk of forest fires (Credit: Alamy)

The market seems to agree. Less than five years after its arrival on US shores, there are now CLT projects underway in almost every mainland US state. More importantly, unlike the UK – which currently imports all of its CLT – the US is investing in domestic CLT manufacturing, with factories in Montana and Oregon, and more planned in Maine, Utah, Illinois, Texas, Washington State, Alabama and Arkansas. **Amazon’s new “tech-hub” building in Minneapolis** is made from nail laminated timber (like CLT, but **using nails rather than glue**). The 2018 Timber Innovation Act also included provisions for research and development into mass timber.

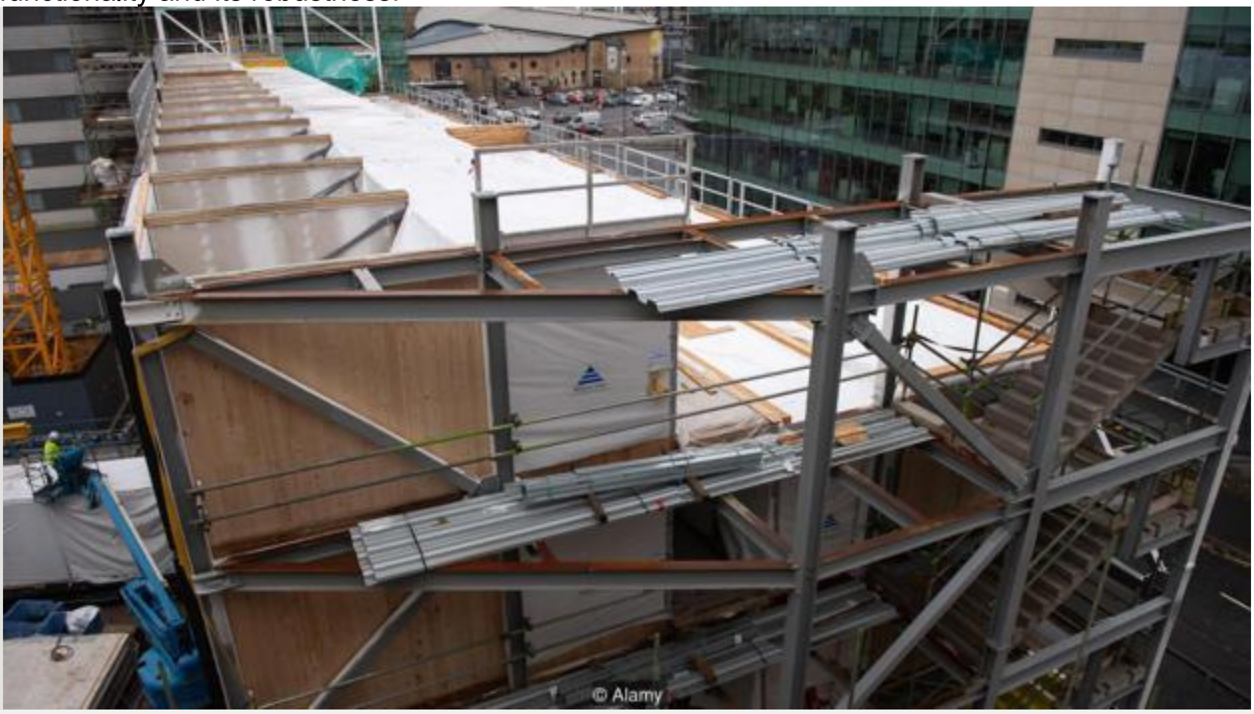
Structures using wooden materials also tend to be quicker and easier to build, therefore reducing labour costs, transport fuel and on-site energy use. Alison Wring, director of Aecom, an infrastructure company, cites a CLT residential block of around 200 apartments that “took just 16 weeks [to build]… whereas if it had been done traditionally with a concrete frame it would have taken at least 26 weeks.” Similarly, says Waugh, a recent 16,000-square-metre CLT building he worked on, “would have needed around 1,000 cement truck deliveries for the frame alone. To deliver all the CLT, we needed just 92 deliveries.”

Other countries are turning to timber, too. Monika Lebeničnik, a sales engineer for Ledinek Engineering, an Austrian-Slovenian firm that makes the presses for CLT factories, sent me her order sheet going back to 2013. It begins with a trickle of orders from Austria and Scandinavia. But from 2017 onwards, there is sudden take-up from Japan, France, Australia, Latvia and Canada. “Annual capacity of such lines range from 25,000 to 50,000 cubic meters [of CLT],” explains Lebeničnik. Data suggests that 1,000 cubic metres of CLT equates to around 500 harvested trees; factories processing 50,000 cubic metres are therefore trapping the sequestered carbon of 25,000 trees per year.

There are even advantages that make the material particularly attractive to countries like Japan, since it has been found to perform well in earthquake tests. A joint Italian-Japanese research team built a seven-storey CLT building and tested it on a “shake table” (a cool but eerie **video of this exists on Youtube**). They found that it could withstand shaking at the level of the 1995 earthquake in Kobe, Japan, which destroyed more than 50,000 buildings. With serendipitous timing, says Waugh, “the Americans planted lots of trees in Japan as part of the Marshall Plan – that was over 60 years ago, and they are reaching maturity now”.

Counterintuitively, CLT also performs well in fires. It is designed to withstand heats of up to 270C before it begins to char – the charring on the outside then acts as a protective layer for the structural density of the wood behind it. By contrast, at similar temperatures **concrete can spall and crack**, and **steel loses its strength**.

Not everyone believes that the future is CLT, however. When I ask Chris Cheeseman, professor of materials resources engineering at Imperial College London, whether wood could usurp concrete as our primary building material, his response is blunt. “No. That isn’t going to happen. It might happen locally with some small schemes. But you’ve got to appreciate the massive use of concrete, and the massive importance of concrete to infrastructure and society. It is an exceptionally good material because of its functionality and its robustness.”



Structures made from CLT are much quicker to construct than concrete buildings (Credit: Alamy)

There is also the “end of life” question. Carbon only remains trapped in the wood for as long as the building remains standing or is reused in another building – if it rots or is burned for energy, then all the stored carbon is released. Doug King, a chartered engineer and building sustainability advisor, tells me, “unless we attend to the disposal of timber materials at their end of life there is no guarantee that the overall cycle is making a positive benefit to society.” Previous research work by Arup in 2014 estimated that half of all construction timber ends up in landfill, 36% is recycled and the remaining 14% burnt for biomass energy.

Despite these issues, Waugh remains ambitious. The average lifetime of a building is 50-60 years – that, he believes, is more than enough time for architects and engineers to work out the re-use and recycling issues. Turning it into **biochar could be one possibility**. Waugh’s buildings are made to be easy to take apart for re-use by future generations.

Fundamentally he – along with a growing **group of international architects** – is convinced that mass adoption of CLT is an important weapon in the fight against climate change. “It’s not a fad or a fashion,” he tells me as we finish the tour of his east London build, and I take my final, incongruous breath of the forest air. “The largest commercial developer in the UK have just bought this building. For me, that’s where you want to be… I want this to be mainstream. Everybody should be building with this.”

I return to my original question: could we realistically return to wood as our primary building material? “It’s not only realistic, it’s imperative,” argues Waugh. “It has to happen. In architecture you always go back to the sketch: the sketch is climate change.”

Source: BBC