REINFORCED INSIGHT

Is Cross Laminated Timber a potential Trojan Horse?

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Front image shows a replica of the Trojan Horse exhibited at Canakkale, Turkey

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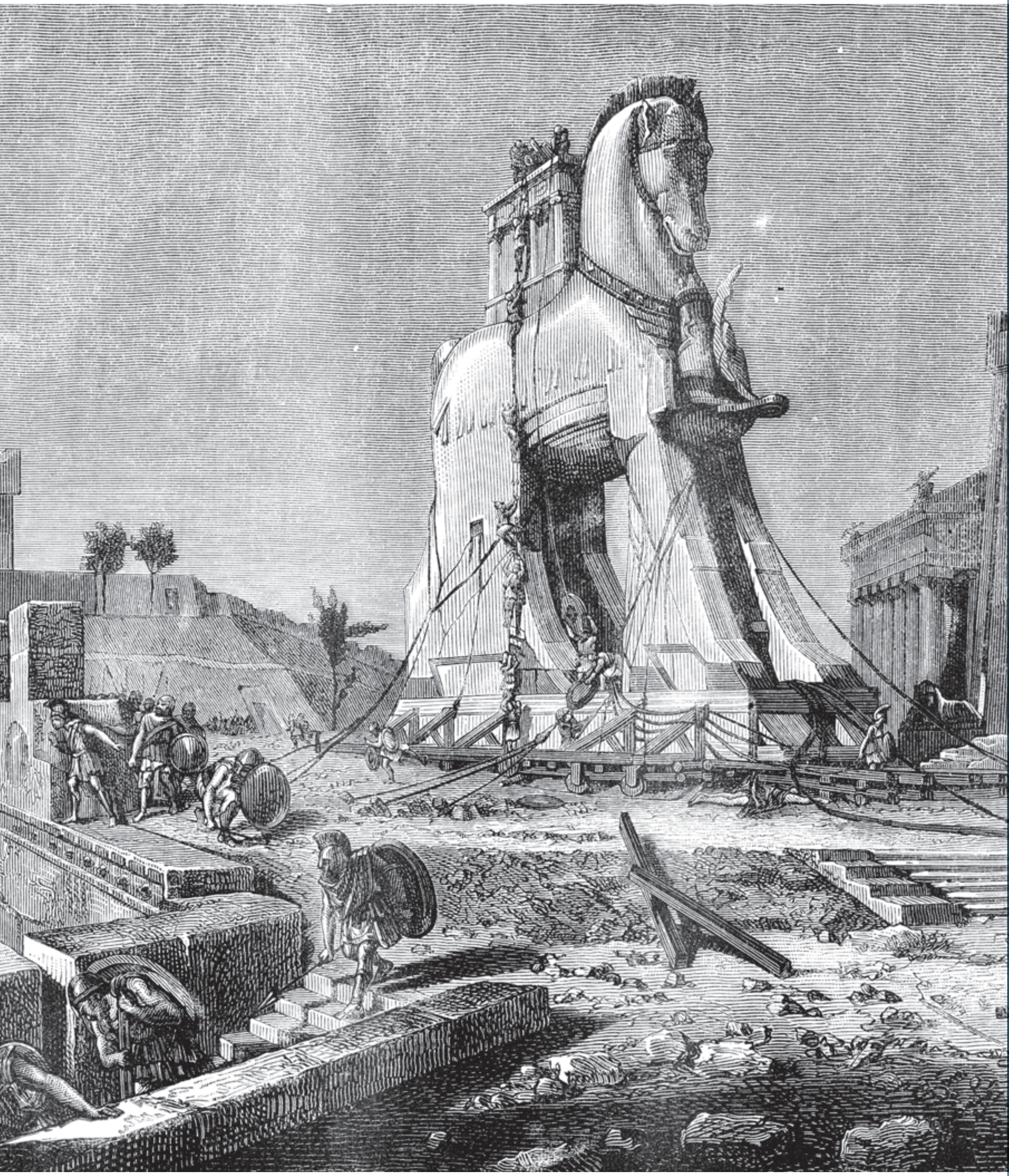
INTRODUCTION

The City of London, like other planning authorities in the UK, is considering relaxing rules to allow high-rise buildings to be built using cross-laminated timber. This goes against planning laws introduced after the Great Fire of London in 1666 that forbade timber buildings due to increased fire risk.

Like the Trojans who welcomed the Wooden Horse* into their city with subsequent dire consequences, those rushing to herald wooden skycrapers as the construction material of the future may do well to think again.



**Legend has it that the Trojan Horse was a huge hollow wooden horse constructed by the besieging Greeks to gain entrance into Troy during the Trojan War. The Trojans, believing that the horse was a gift to the Gods left behind by the departing Greeks, took it inside the city gates. During the night Greek warriors emerged from inside and opened the gates to let in the returned Greek army who then overran and took the city. The story is told at length in Book II of the Aeneid and is touched upon in the Odyssey. The term Trojan Horse has come to refer to subversion introduced from the outside. Beginning in the late 20th century, the name "Trojan Horse" was applied to deceptively benign computer codes that seem like legitimate applications but are written to damage or disrupt a computer's programming or to steal personal information.*

What is Cross Laminated Timber?

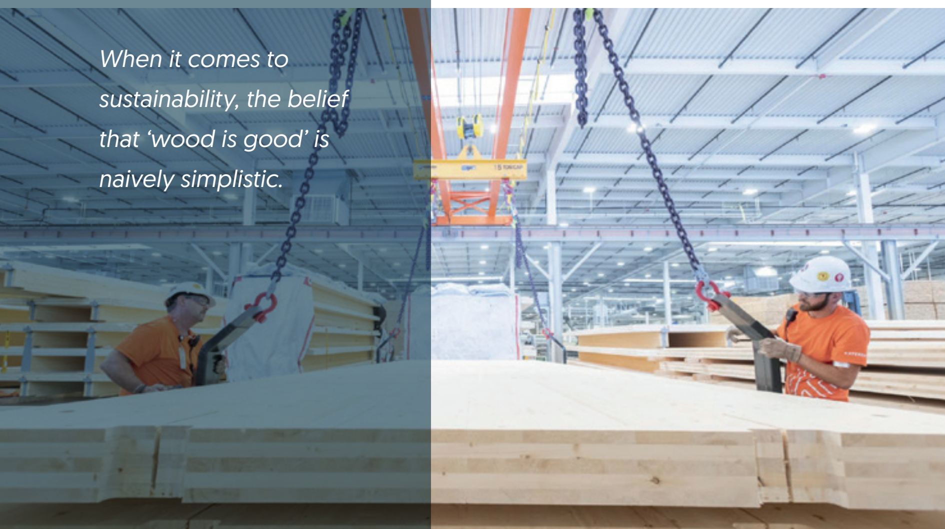
Developed in Austria in the 1990s, cross-laminated timber (CLT) is a comparatively new engineered construction material. It consists of timber boards that are arranged in layers of alternative directions that are bonded with adhesives. The layering is repeated until the required thickness, typically three, five or seven layers, is achieved. This is then compressed and dried to provide a strong and stable construction panel.

Advocates of CLT forward the charring rather than burning benefits of CLT, the fast ease of construction, robustness, the wellness of living in a timber building and, most notably, the environmental benefits of reduced CO_2 impact. However, just like the citizens of Ancient Troy, there is growing evidence that they may have been hoodwinked by the reality of these 'so-called' benefits.

NOT SO GREEN

When it comes to sustainability, the belief that 'wood is good' is naively simplistic. The supposed eco-friendliness of timber construction is more complicated and warrants closer examination. Indeed, such an examination may discover that timber may have been given too much credit as a green building material and that it may be better to keep the wood 'alive' rather than cut it down and build with it.

Forests are natural filters that absorb large amounts of carbon. When they are cut that is stopped and the carbon is released. Added to that is the carbon generated by the machinery that harvests the timber, transports the timber to mills, removes the bark and cuts the timber. Furthermore, slash piles are left behind after timber harvesting – cut branches, treetops and discarded trees. These are often burned or left to decompose further adding to the carbon impact of timber harvesting. In addition, the decomposing stumps will release further CO_2 for years after the loggers have left.



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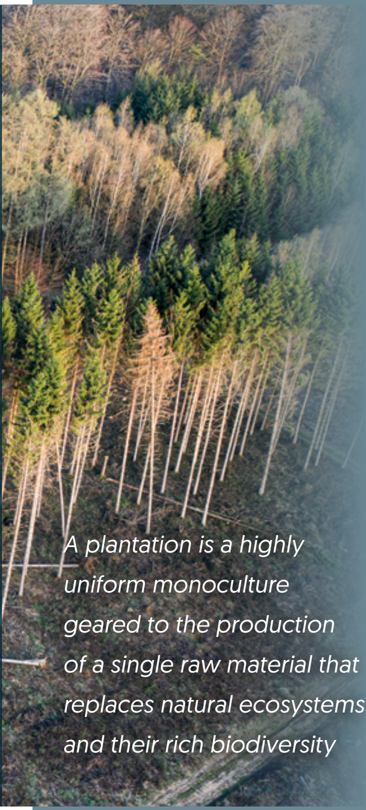
A further consideration is whether the timber has been harvested ethically in the first place. The diligence and duty standards required by the Forest Stewardship Council (FSC) is admirable. However, if the demand for CLT increases so will the demand for timber and for that demand to be met then the timber harvested may not so readily met those ethical standards.

Then there is the energy required to heat the kilns to dry the wood. To this must be added the heating and pressure processes to fabricate the CLT panels. The CLT lumber is placed into a vacuum chamber where it is subjected to temperatures of up to 150°C and pressure from 700 to 6000 psi. Once this process is complete, the panels are then cut and glued to the required shape and size. All-in-all, quite an intensive industrial process that should be taken into account.

A major reason why harvesting forests for construction materials is not so green is the resultant monoculture of the industrial timber plantations that are planted as farmed replacements. Such plantations should not be viewed as forests. A plantation is a highly uniform monoculture geared to the production of a single raw material that replaces natural ecosystems and their rich biodiversity. Increased demand for CLT could well increase the prevalence of monoculture 'green deserts'.

Furthermore, whereas forests are recognised carbon sinks, the same should not be said of new forced plantations which, unlike forests allowed to regrow naturally, can actually be net emitters of carbon due to the disturbance to the soil and the degradation of the previous ecosystem.



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A CHEMICAL COCKTAIL – SOMETHING IN THE AIR

The range of processes and chemicals necessary to manufacture and protect CLT should be considered against its vaunted green credentials, in particular the glue to bond the panels together and the chemicals used for fire retardants and waterproofing.

The manufacture of CLT involves gluing of multiple panels. Glues include polyurethane adhesives (PUR) or phenol resorcinol formaldehyde (PRF). Health concerns have progressively reduced the acceptable level of formaldehyde vapour (a recognised carcinogenic) emitted by glued wood panels in inhabited spaces. This has resulted in some CLT fabricators using polyurethane glue – another petrochemical derived product – instead. Fire-retardant treatments for timber designed to slow the rate of fire spread can also present a toxicity hazard. Indeed, more smoke and higher gas concentrations such as carbon monoxide can be given off burning some fire retardants under high flashover heat fluxes.

Further chemical treatments are necessary to ensure CLT waterproofing and resistance to termites. Quite a chemical cocktail for a supposedly green building material that touts wellbeing as being one its benefits

OPERATIONAL CO_2

The main CO_2 driver for a building is not the embodied CO_2 of its construction but the ongoing CO_2 resulting from its use and operation. It is estimated that the embodied energy used to produce the construction materials is generally less than 10% of the operational energy (including heating, cooling and lighting) over a 50-year period. Operational CO_2 can account for up 90% of a building's lifetime CO_2 emissions.

Lightweight timber construction, including CLT, has low thermal mass compared to the high thermal mass of heavyweight construction. This means that it has limited ability to absorb and emit heat and so even the fluctuations of heat and coolth. Heavyweight construction's ability to absorb heat can play an active role in natural cooling and ventilation systems. Lightweight construction is far more reliant mechanical ventilation. Mechanically ventilate a CLT building and, over its lifetime, its operational CO_2 emissions will far surpass any supposed embodied savings.

Being lightweight construction also means that CLT buildings may need additional sound proofing and vibration damping. In addition, the exposed timber finish will have low light reflectivity requiring extra lighting provision. All of this equates to higher operational and performance CO_2 compared to heavyweight construction which provides inherent thermal mass, four hours fire proofing, flood resilience, soundproofing and vibration damping without the need for any additional finishes and mechanical systems. Remember, these additional finishes and systems come with additional CO_2 both in terms of initial manufacture and ongoing maintenance and operation and should be part of any lifecycle CO_2 building calculation.

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TIMBER BURNS

One would not expect to paraphrase Jane Austen's opening line in Pride and Prejudice when discussing CLT but 'it is a truth universally acknowledged' that timber burns. It is a truth that timber supporters are willing to fudge.

For example, many cite the success of the TF2000 fire test on a six-storey timber-framed building undertook by the Building Research Establishment in 1999. A fire was started in the structure and successfully put out by the fire brigade in 64 minutes. However, what was not reported was that in the early hours of the following day a fire in a cavity in the structure reignited the whole block and took several hours to get under control. A subsequent report by Chiltern Fire into the cause of the cavity fire cited the need for proper cavity stops and the recognition that fire crews may find such fires difficult to spot.

Advocates of CLT point to the fact that mass timber buildings using CLT as the primary wall and floor elements have no concealed spaces within the primary structure due to its solid construction. Spaces for building utilities can be pre-formed with gypsum drywall to provide fire protection as is the case with other forms of construction. They also forward the limited char rate of CLT which can deliver structural fire resistance from 30 minutes to two hours. In laboratory-based testing it has been shown that CLT initially chars on the outer layer for up to two hours before fire fully penetrates the inner layers and destroys its structural strength. The maximum two hours fire resistance of CLT compares poorly with the 4 hours resistance provided by reinforced concrete without the need for any additional finishes or retardants.

The fires tested in laboratories underline that the performance of CLT is not always fully understood given the complexities to the char rate being dependent upon the panels thickness, the number of panels and the type of adhesive used. The consensus amongst many fighters is that there is no real data to determine how CLT performs in the real world where fires fuelled by an abundance of man-made flammable materials can burn fast and hot enough to cause floors to collapse within 20 minutes. This has led to many fire departments doubting the validity of using CLT for multi-storey buildings.

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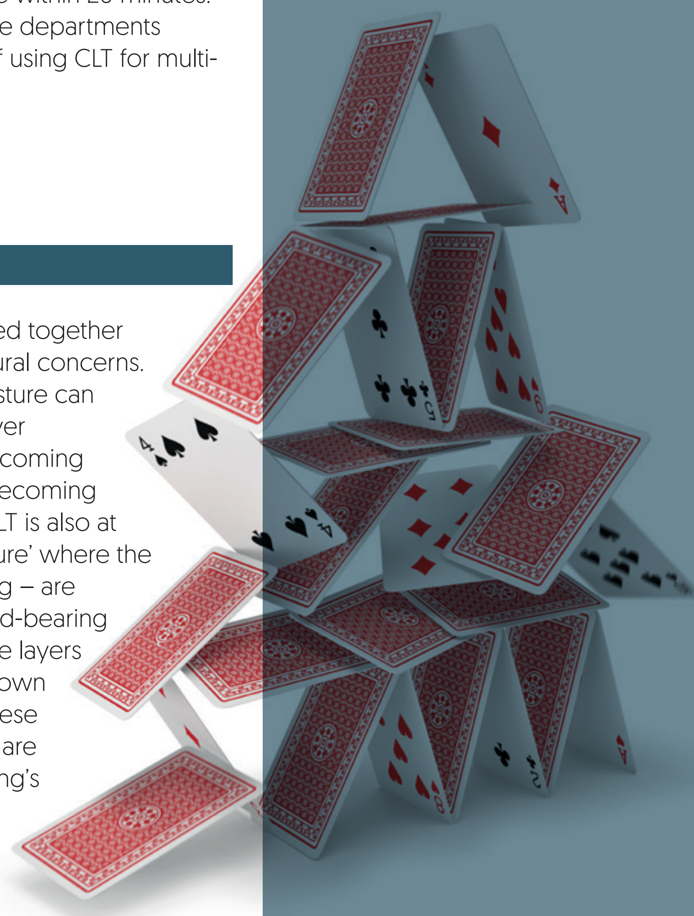
HOUSE OF CARDS

Many of the concerns of using CLT for hi-rise buildings relate to fire. However, structural integrity should also be a major concern. In 2014, Oregon State University decided to replace its ageing forestry school building with once that would showcase the potential of CLT. During construction, a 4 by 20 foot panel of the CLT floor collapsed after it became 'de-laminated' (unglued) at one end. Fortunately, no one was hurt. Upon inspection a further 85 CLT panels were marked as structurally unsound and had to be replaced.

The fact that CLT is glued together raises long-term structural concerns. Water ingress and moisture can result in glue bonds, over years and decades, becoming unglued and the CLT becoming structurally unsound. CLT is also at risk of 'rolling shear failure' where the panels – usually flooring – are subjected to heavy load-bearing pressure. This can cause layers in the panel to break down and separate. Often, these are inner layers and so are not visible to the building's occupants.



END OF LIFE

Finally, there is the 'end of life' question. Carbon only remains trapped in timber for as long as the building remains standing or is reused for another building. If the timber rots or is burned then all the stored CO_2 is released.

The recycling of timber may be compromised by the use of chemical preservatives and coatings for fire proofing, to prevent rotting and provide water proofing. This is exacerbated with CLT and its multiple layers of adhesive bonding.

The recycling of reinforced concrete structures is well-practiced. A comprehensive life cycle analysis for CLT must take account of the current insufficient data and unanswered questions for long-term performance, demolition and recycling.

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