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PUB-WOOD

ENGINEERED TIMBER OPTIONS

Sustainable Public Buildings Designed and Constructed in Wood (Pub-Wood)

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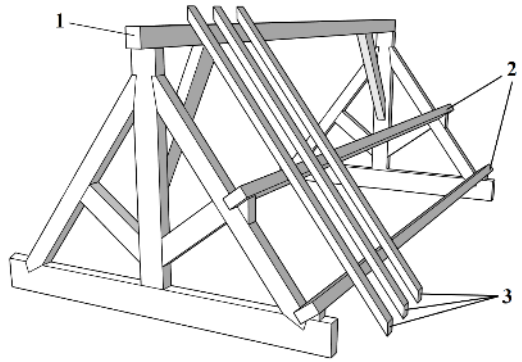
DEFINITION OF ENGINEERED TIMBER

Also called **composite timber**, **man-made timber**, or **manufactured boards**, includes a range of derivative timber products which are manufactured by binding or fixing the strands, particles, fibres, or veneers or boards of wood, together with adhesives, or other methods of fixation to form composite materials. These products are engineered to precise design specifications which are tested to meet national or international standards. Engineered wood products are used in a variety of applications, from home construction to commercial buildings to industrial products. The products can be used for joists and beams, which replace steel in many building projects.

Traditional carpentry

A timber roof truss is a structural framework of timbers designed to provide support for a roof



The ‘Forest’ of Notre Dame

Each beam that held up the lead roof was constructed from a single tree, requiring about 13,000 individual oak trees in total

Source: National Post

Design strategies for reduction of embodied GHG-emission (EG)

The table below shows the EG reduction potential for constructions in wood compared to other building materials.

Case study from UK (Main structural elements)	
• Masonry	34%
• Steel	30%
• Concrete	39%

Case study from UK (Facade materials only)	
• Bricks	24%

Case study from Sweden (Load- and non-load bearing elements)	
• Concrete	27-77%

Case study from Sweden (Facade materials only)	
• Concrete	15%

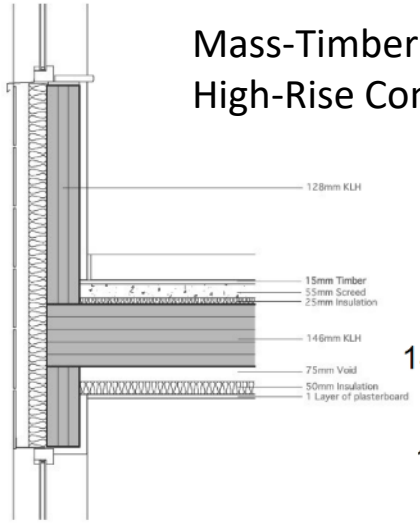
Source: Danish Building Research Institute (SBi, 2018)

TREE in Bergen, Norway

Fabricating timber building components uses half the energy needed to produce concrete, and just 1% of the energy required to manufacture steel.

- 14 stories, 49 m
- Glulam trusses along the facades for stiffness
- Consist of meter-thick glulam columns in a stacked modular design
- CLT walls
- Concrete floors on top of power floors
- Stacked modules, max 4 on top of each other
- Overall the building will avoid more than 21,000 tonnes of CO_2 emissions

The race for High-Rise Timber buildings has already started



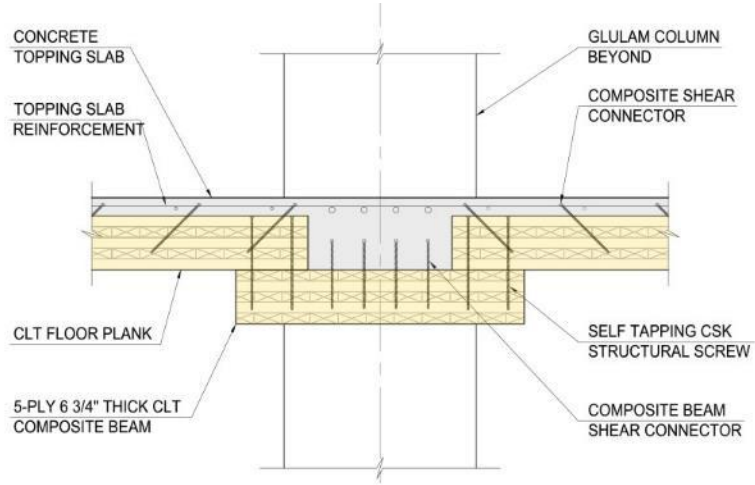
Mass-Timber Composite System for High-Rise Construction

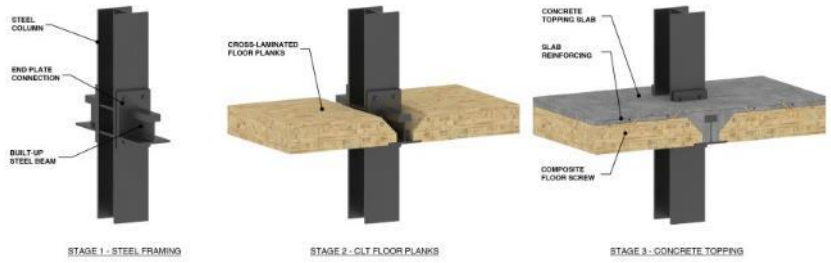
146mm CLT slab

300mm floor section

128mm ext. wall

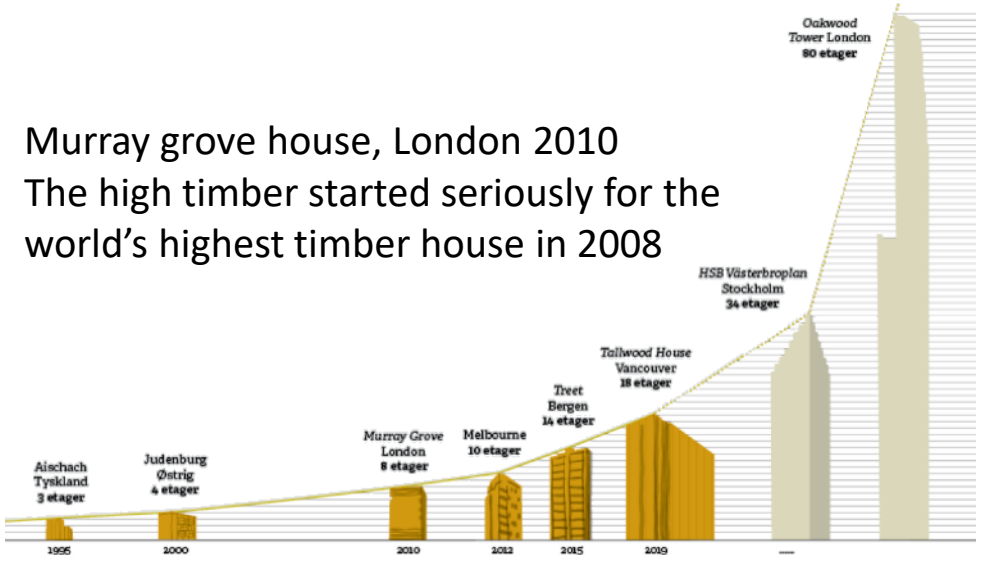
275mm wall build up





Source: architectmagazine.com (SOM)

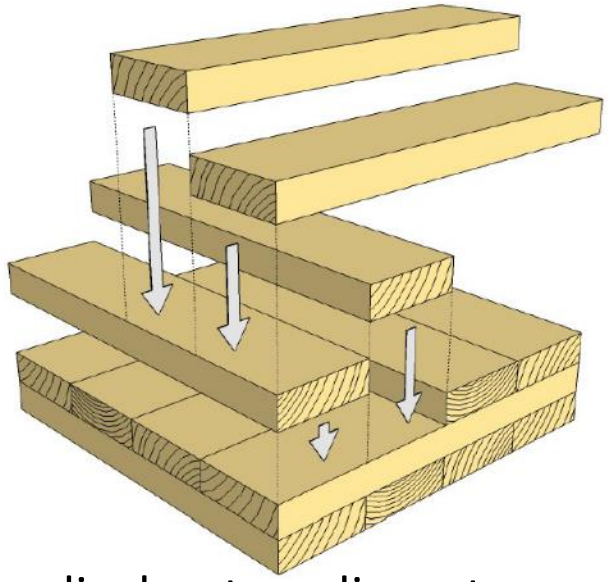
Murray grove house, London 2010
The high timber started seriously for the world's highest timber house in 2008



Engineered Timber Systems

1. Solid timber panels, Cross Laminated Timber (CLT)
2. Timber Concrete Composite (TCC)
3. Column & beam system, Laminated Veneer Lumber (LVL)
4. Dowel method, not utilising any glue (Brettstapel)
5. Column & beam system, Glue-laminated timber (Glulam)
6. Module timber units (box module)
7. Timber hybrid (combination)

Cross-laminated timber (CLT)



Is a wood panel product **made from gluing layers of solid-sawn lumber together.**

Each layer of boards is oriented perpendicular to adjacent layers and glued on the wide faces of each board, usually in a symmetric way so that the outer layers have the same orientation. An odd number of layers is most common, but there are configurations with even numbers as well (which are then arranged to give a symmetric configuration). Regular timber is an anisotropic material, meaning that the physical properties change depending on the direction at which the force is applied. By gluing layers of wood at perpendicular angles, the panel is able to achieve better structural rigidity in both directions. It is similar to plywood, but with distinctively thicker laminations.

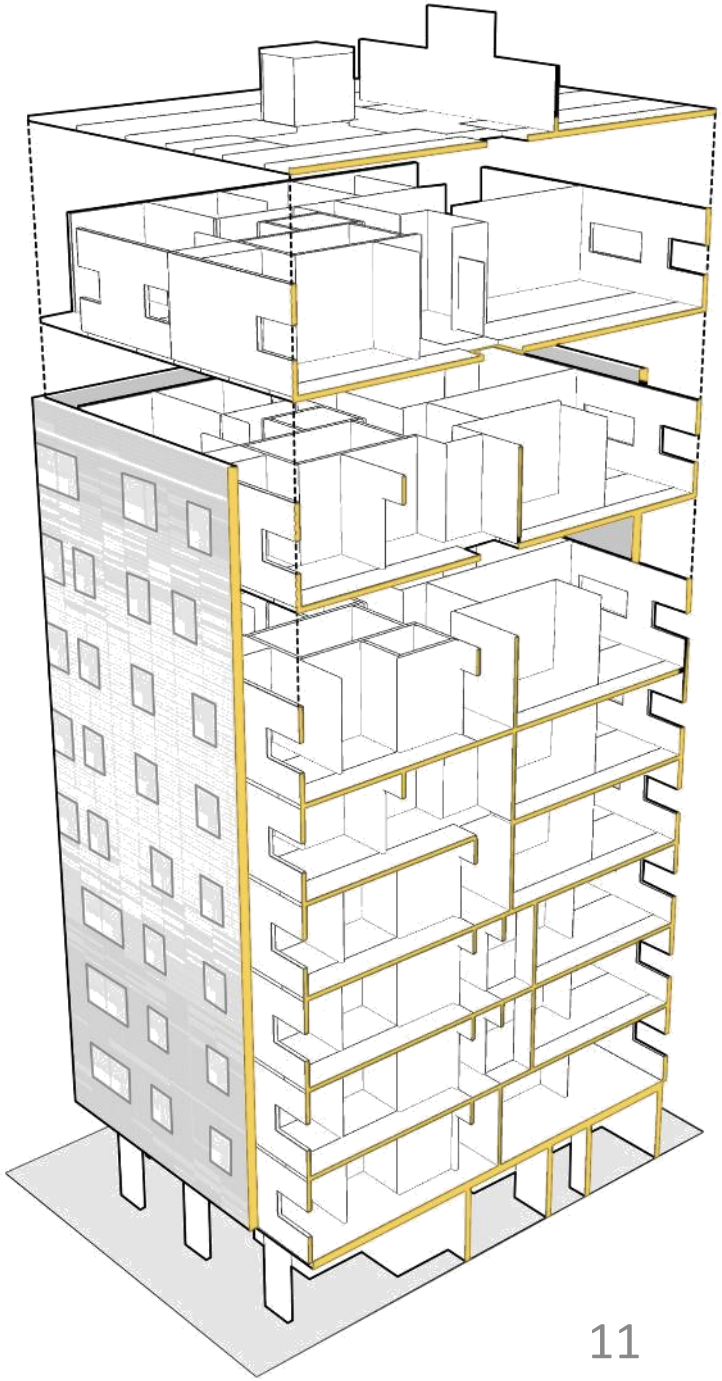
CLT EXAMPLES

CLT 60% utilization of the strain

Cross-laminated timber (CLT) high-rise building

Murray Grove is the first tall urban housing project to be constructed entirely from pre-fabricated solid timber, from the load bearing walls and floor slabs to the stair and lift cores. The main structure was constructed in just 27 days with a team of 4 people.

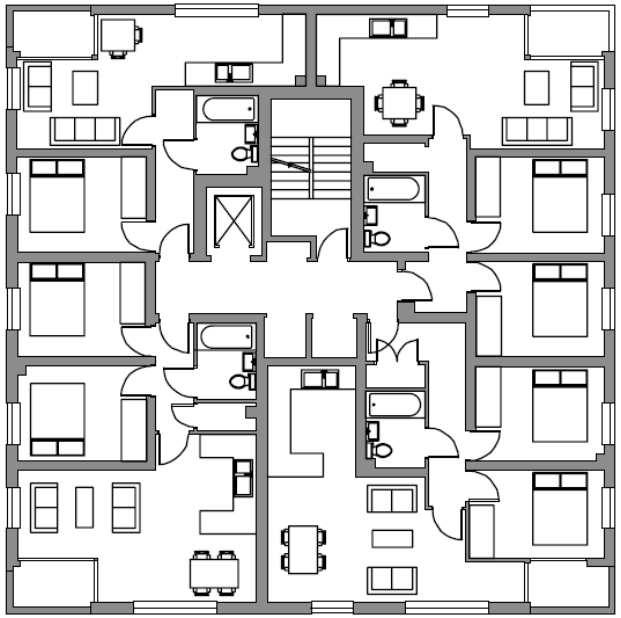
- Location Hackney, London
- Honeycomb CLT Structure
- Load-bearing walls, floors, cores
- 29 flats and 3 tenures
- 9 storeys
- 900m3 of timber
- Completed within 49 weeks (2009)

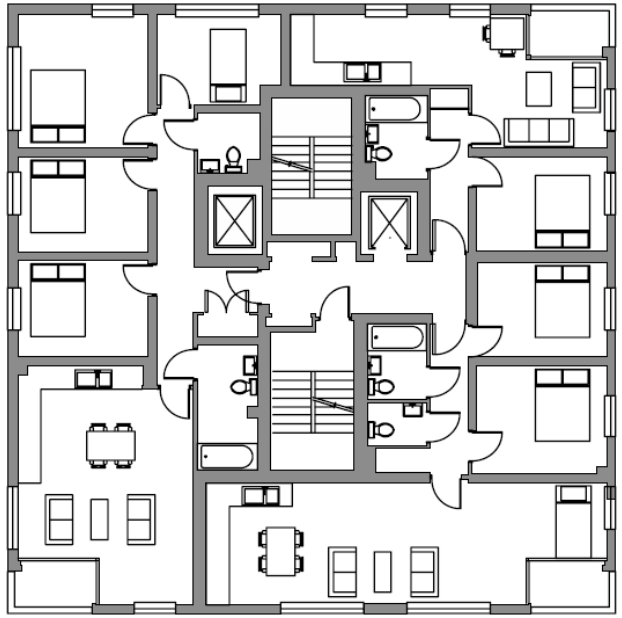


Source: waughthistleton.com

Cross-laminated timber (CLT) high-rise building

The nine-storey tower is built from a tight honeycomb of structural panels, with a timber core providing stability. So the 29 fully insulated and soundproof apartments can all have different floor plans.





Source: waughthistleton.com

Timber-Concrete Composite (TCC)

Is a technology which focuses on **optimizing performance** by engineering a **structural connection between timber and concrete components.**

This hybridization enables designers to reduce cross sections, increase spans, and streamline structures in pursuit of sustainable architecture. These panels reduce the proportion of the carbon-intensive concrete components by allowing timber to carry the load. Timber-concrete composite panels can be used as floor panels or wall panels. One common option for connectors is to use diagonally inclined screws half-drilled into the timber elements, left protruding into the concrete topping, creating the composite action. There are also many proprietary connectors available, including HBV mesh connectors.

TCC EXAMPLES

The prefabricated elements save a lot of work steps and is a clean solution. It eliminates moisture and dirt that could damage the wood surface. According to the Technical University of Graz assembly procedure and system comparison, it could be proven that the assembly with composite system was as fast as with the conventional and CLT on-site pour construction.

Laminated Veneer Lumber (LVL)

Is a wood panel product **made from gluing layers of spruce veneers together.**

In horizontal construction, typical spans for LVL are from 5 to 12 meters. As well as floor and roof construction, LVL can be used for trimming and supporting beams and for stiffening. In fire, the charring speed is 0.6 mm/min.

Finnish laminated veneer lumber is made by gluing 3 mm thick spruce veneers together. Depending on the veneer product, all the veneers are in the longitudinal direction or some of the veneers are glued crosswise.

Laminated Veneer Lumber (LVL)

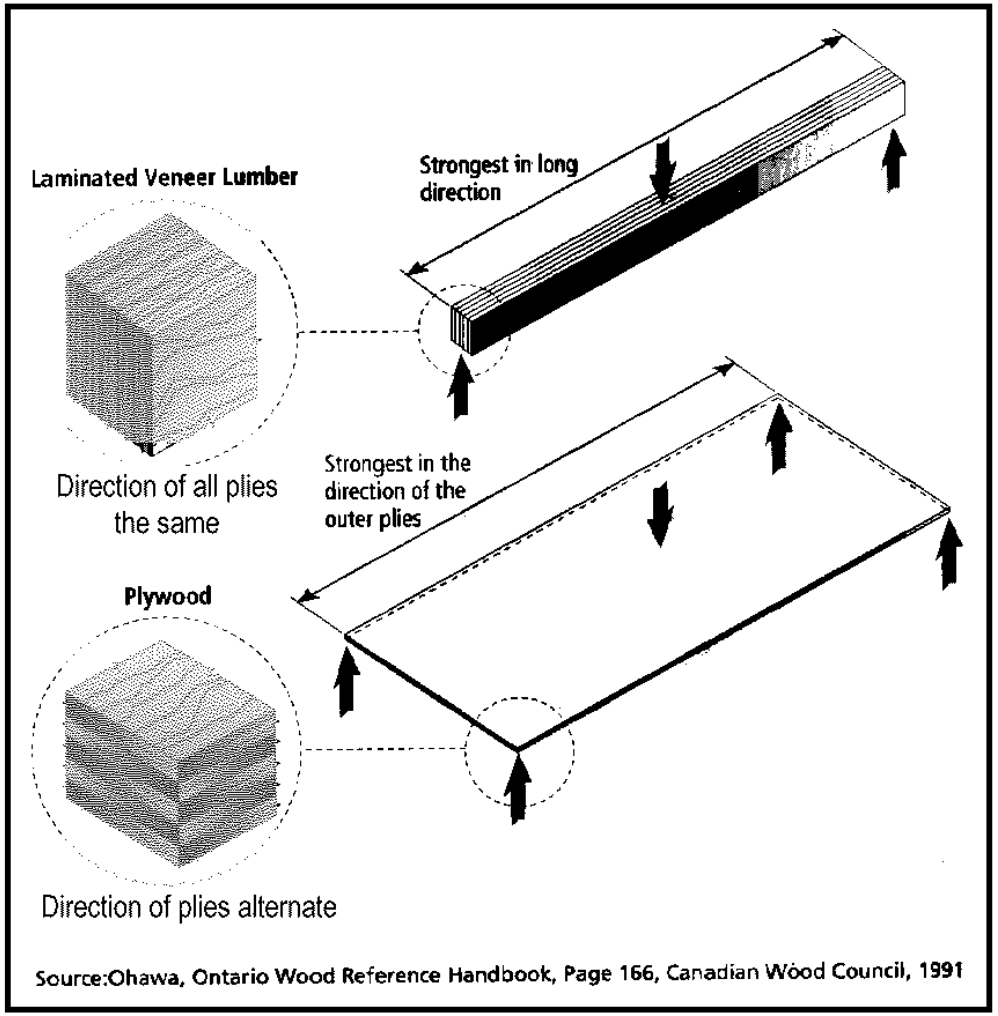
It is an engineered wood product that uses multiple layers of thin wood assembled with adhesives.

Advantage:

- Stronger than CLT and glulam
- Dimensions and strength close to steel
- Uniform, dimensionally stable
- Reduced cross section
- LVL 80% utilization of the strain

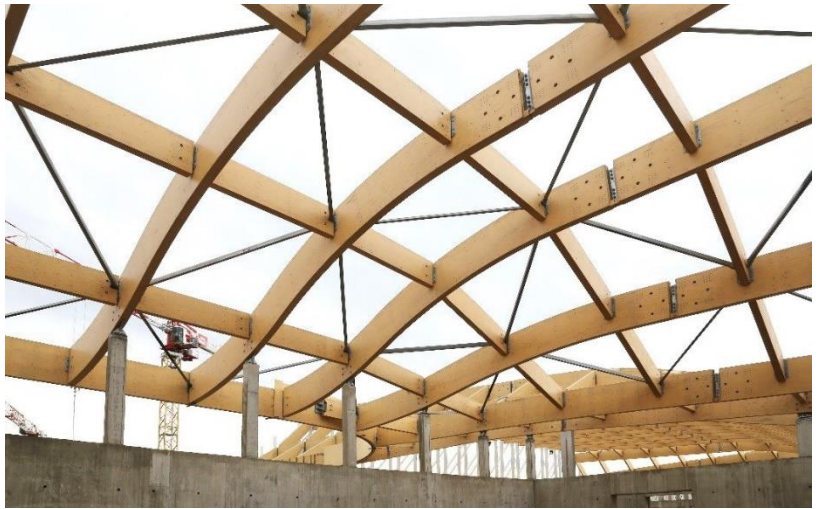
Disadvantages:

- More expensive, but less need to be used



LVL EXAMPLES

LVL 80% utilization
of the strain



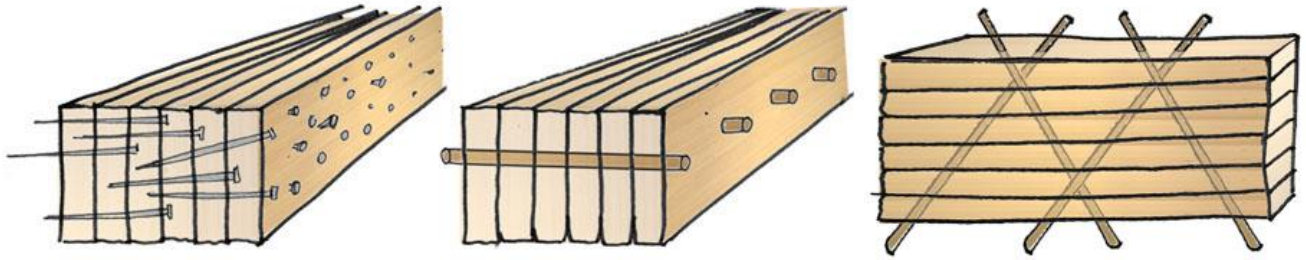
Laminated Veneer Lumber (LVL)

LVL flanges + MDF/OSB3. I-beams are dimensionally stable, and do not distort or shrink. I-beams are lightweight yet incredibly strong, resulting in a quick and reliable installation.

Brettstapel construction

The most common form of Brettstapel today is **the perpendicular dowel method with the majority of systems not utilising any glue.**

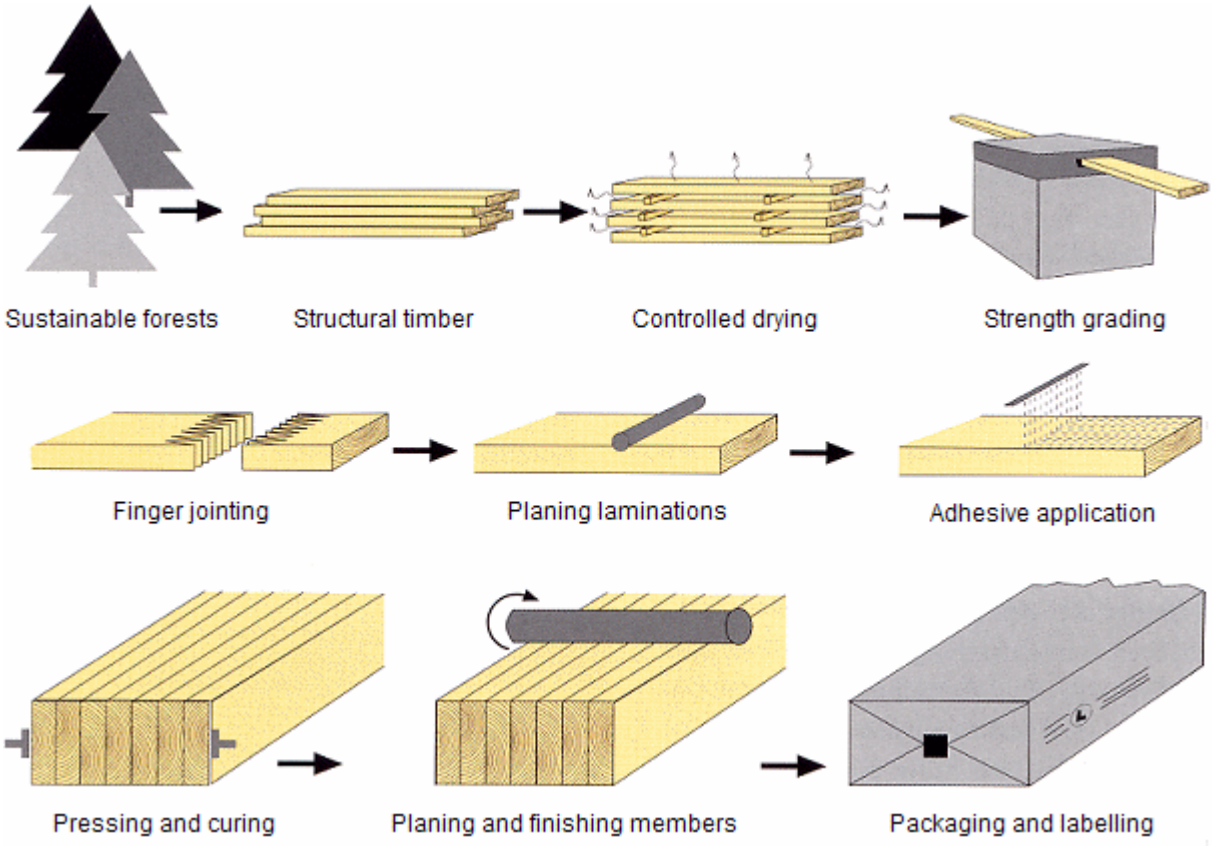
Brettstapel is the term commonly used for solid timber construction that does not generally use glues or nails. Fabricated from softwood timber posts connected with hardwood timber dowels, this relatively simple method of construction has the potential to utilise low grade timber that would otherwise be unsuitable for use in construction, to form load-bearing solid timber wall, floor and roof panels. The system works by using dowels with a moisture content lower than that of the posts; over time the dowels expand to achieve moisture equilibrium thus 'locking' the posts together and creating a structural load-bearing system.



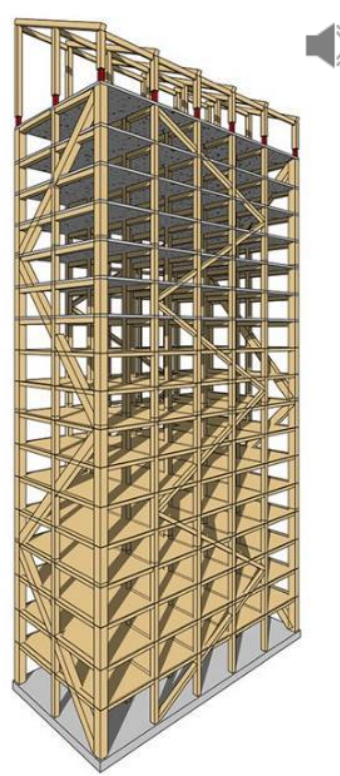
Glue-laminated timber (Glulam) beams and columns

It is made by **gluing together, under pressure and heat, laminates of timber** that have been **accurately planed.**

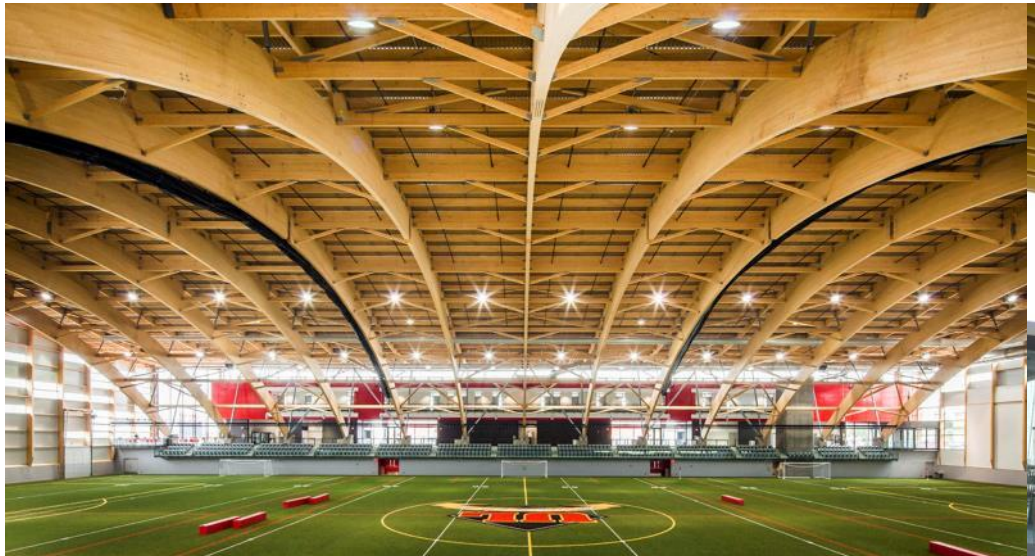
Glulam is a natural structural material that is economical, strong, and attractive looking. Glulam is made with wood from Scandinavian sustainable forests. The trees used are usually spruce, though can sometimes be redwood or Siberian larch. Glulam may also be moulded into different shapes, for example arches. Glulam may be used as the main structure in the same manner as concrete and steel.



Source: glulambeams.co.uk



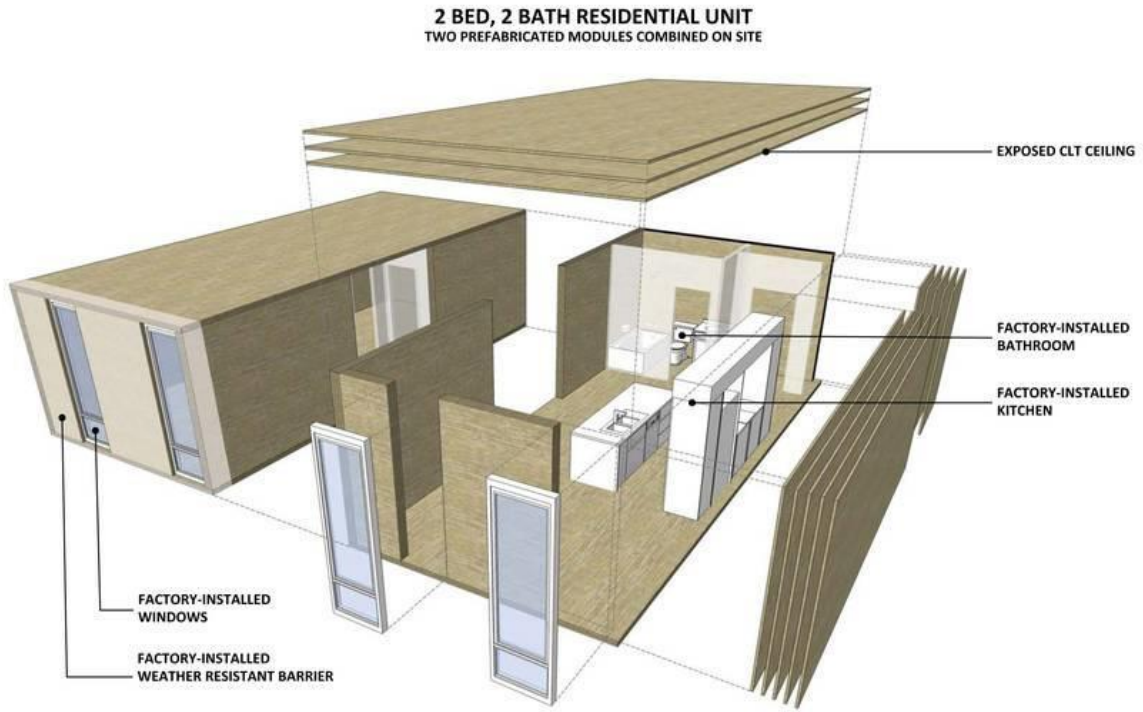
GLULAM EXAMPLES



Modular timber units (box module)

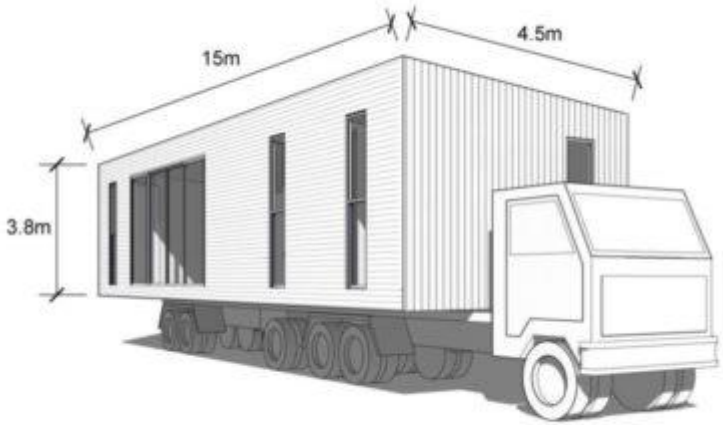
Modular construction is a process in which **a building is constructed off-site**, under **controlled plant conditions.**

Box module production and building processes are not dependent on the weather. The modules are manufactured in large dry and heated warehouses. The production workflow is optimised to ensures short delivery time and a minimal consumption of resources - both in terms of materials and energy. Prefabricated box modules are always placed using a crane. Often the larger boxes can only be transported at night. The modules can be placed side-by-side, end-to-end, or stacked, allowing a variety of configurations and styles.



Source: Weber Thompson

BOX MODULE EXAMPLES



KRONEN, Copenhagen

- Sangberg Architects
- 158 apartments on top of a shopping centre
- 14,100 m²

Source: scandibyg.dk

Timber hybrid (combination)

Finally, you can use engineered timber together with more traditional building materials and methods, to create hybrid structures, that employ the best option for every need.

Kalø Castle, Denmark

Koldinghus Castle, Denmark

Lisbjerg Bakke, Aarhus

- Tegnestuen Vandkunsten
- 34 apartments
- 3.723 m²
- 4 storey timber building
- DGNB Gold Certificate
- Built as social housing estate

The large overhang has a protective effect for the vertical wood cladding made of FSC controlled spruce - which for the same reason is left untreated. In 30 years, which is the estimated lifetime, the planks can be easily replaced, reused or burned and replaced with others. LCA (Life Cycle Assessment) favors wood. But LCC (Life-Cycle Costing) is negative when hardwood and maintenance is used.

Source: arkitekten.dk/2019/01/lisbjerg-bakke


THANK
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ARIGATO
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DANKSCHEEN
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YAQHANYELAY
SUKSAMA
EKHMET
MEHRBANI
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