# Technology of cross-laminated timber

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# 1 Abstract

*English*

Cross-laminated timber is an advanced product, designed for increased dimensional stability and strength in framing systems. Cross-laminated timber is made of multiple layers of wood (in general tree, five, seven or even more) with each layer oriented crosswise to the next.

By crosswise gluing of individual board layers from the straightened raw wood,a material is formed with board or panel like properties that allow application as wall, ceiling or roof construction components and cross-laminated timber can be prefinished,which reduces labour onsite. In fact cross-laminated timber opens new horizons in timber engineering thanks to its laminar structure which makes it well suited for use in constructions of that type which had been subject to mineral building materials like concrete and masonry so far.

*Bosanski*

U radu je pokazana dijagnostika vibracija sa osnovnim ciljem da se odredi utjecaj visine rezanja, broja okretaja radnog vratila (nosača alata) i vlažnosti drveta (obratka) na srednju vrijednost ubrzanja vibracije alatne mašine ravnalice (blanjalice).

Za određivanje konkretnog oblika zakona vibriranja u pravcu vertikalne ose potrebno je eksperimentalno odrediti pomak u funkciji od vremena, tako da nije potrebno poznavati krutost i masu sistema. Zakon vibriranja alatne mašine ravnalice se dobiva na osnovu opće diferencijalne jednačine za prisilne vibracije, ima oblik trigonometrijske funkcije i u dobroj mjeri odgovara eksperimentalnim rezultatima. Pri tome se smatra da je prisilno vibriranje zbog harmonijske sile pobude.

# 2 Introduction

Wood products from responsible sources are a good choice for most green building projects, both now construction and renovations. Wood grows naturally, using energy from the sun, is renewable, sustainable and recyclable. It is an affective insulator and uses far less energy to produce than concrete or steel. Therefor new wood products and new building systems, like cross laminated timber (CLT), since more than ten years, had experienced considerable popularity with architects and civil engineers, CLT became interesting in green building because of its many positive characteristics.

Figure 1, cross laminated timber

Figure 2, wall of cross laminated timber

Figure 3, cross laminated timber construction

Cross-laminated timber (CLT) is an advanced product, developed in Switzerland in the early 1990s, designed for increased dimensional stability and strength in framing systems
Its elements have a considerable number of positive properties than other construction materials. Cross laminated timber allows for a very high grade of prefabrication, thus building shells can be erected in the shortest possible time. The construction components are dry and therefore do not bring any moisture into the structure. The layered construction allows for the asembly of decorative, or also sound and fire protection technically adapted protective layers. Because of the crosswise arrangements of the CLT layers, humidity changes in the panels only lead to minor swellings and deformations. CLT in comparison to other construction materials, has a very low thermal conductivity, therefor climate in living spaces can be effortlessly regulated. Cross laminated timber is manufactured using softwood from sustainably managed forests. Compared to other solid construction methods the manufacture of cross laminated timber components requires very little energy. At the end of its use cross laminated timber can be, materially or thermally, recycled.Cross laminated timber is not just substitute for conventional materials; it's an innovation that vastly improves the entire construction process.
The majority of CLT is manufactured in Austria, Deutschland and imported to other countries of EU, for countries with a large amount of renewable forests, like BiH, CLT can become a substitute material for conventional building materials in near future.

# 3 Innovation

Cross laminated timber (CLT) predominantly uses spruce laminations as a raw material. The use of fir, pine, larch and Douglas fir is also common, but other softwood is acceptable. Other wood types can be used as decorative non-load bearing top layers. The surface is sanded or planed. Cross laminated timber consists exclusively of softwood originating from European, sustainably managed forests. A major proportion of renewable energy is used for drying the timber. The amount of energy required for processing is very low due to the good workability. Therefore cross laminated timber has an excellent eco balance. Natural and healthy structural materials are an important requirement for modern projects. Cross laminated timber is dried to very low timber moisture values and has the capacity to absorb and buffer moisture from the surrounding room air. It therefore plays its part in a healthy room climate

The manufacturer frequently offers special surface qualities, thus fire protection technology are also available, and requires usage of top layers. The manufacturing of cross laminated timber includes several work stages like shown in the pictures.

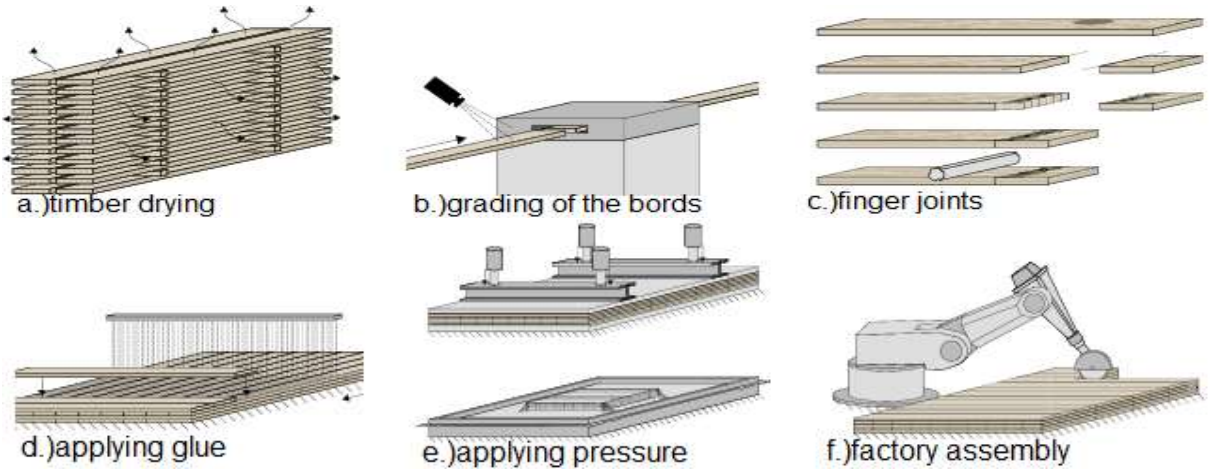


Figure 4, manufaturing of cross laminated timber

These are elements that are made of board sorted to strenght, which correspond too at least the grading class S7/C18, however, as a rule to S10/C24, having widts ranging between 80 and 240mm. Board thiknesses are between 19 and 45mm. Depending on the nomber of layers and individual thiknesses of boards, element thiknesses can be between 57 and 400mm. Typically, 3or 5 layers elements having thiknesses between 80 and 120mm are used for wall components, and 5 or 7 layer elements having thiknesses between 140 and 200mmm are used for floors. Element dimensions depend on production conditions od the respective producers and of transportation menas. Suppliers od large-format panels basically offer standard widhts between 2.4m and 3m and lengths of 12m to 20m. depending on the manufacturing procedure bended and curved elements can also be manufactured. Such shell elements, which are predominantly subject to normal forces or bending, are mainly used for special structures. Cros laminated timber, depending on the moisture content and the gluing method, has a water vapour diffusion ressistance value between $\mu$=30 – 80. For thermal insulation thechnical aspects CLT has a termal conductivity of $\lambda$=0.13 W/(mK), that can be assumed for the uninsulated emements.

Through the corresponding surface coating or top layers, flame-resistant member surfaces can be achieved. With requirements to the fire resistance of coated or uncoated cross laminated timber elements, a design shall be made on the basis of the technical approval. The basis for this is experimental fire testing or design on the basis of DIN 4102-22 and/or DIN EN 1995-1-2 by means of the charring rates of the construction component cross section. The manufacturer has available a number of tested specific constructional systems for a fire duration of up to 90 minutes.

| Building class | Requirements for fire resistance |
|---|---|
| GK 2 | 30 minutes |
| GK 2 between apartments or operational units in town houses | 60 minutes |
| GK 3 and GK 4 | 60 minutes |
| GK 2, GK 3 und GK 4 components forming fire compartments | 90 minutes |

Table 1, cross laminated timber- fire resistant

Flexible layers which at the same time can serve as installation area come into use. In ceiling construction components to achieve the required footfall sound insulation according to DIN 4109, through constructive measures, the direct structure borne sound transmission via the massive construction components through isolation of the sound input on the ceiling's upper surface from the radiating surface on the underside is minimised. Through combinations of upper floor screeds and footfall sound insulation mats with a lower dynamic rigidity as well as weight suppression integrated into the elements or underside, and then possibly also flexible, ceiling coverings, a very good footfall insulation is achieved that also exceeds the increased requirements of the standard.
In terms of seismic performance, wood buildings in general perform well because they're lighter and have more repetition and ductility than structures built with other materials, which make them effective at resisting lateral and uplift forces. However, the Trees and Timber Research Institute of Italy tested a full-scale seven-story CLT building on the world's largest shake table in Japan with excellent results. Even when subjected to severe earthquake simulation (magnitude of 7.2 and acceleration of 0.8 to 1.2 g), the structure showed no residual deformation after the test. The maximum inter-story drift was 1.5 inches and the maximum lateral deformation at the top of the building was just 11.3 inches.

The benefits of CLT include the fact that it comes from a renewable and sustainable resource. It also has a low carbon footprint—because the panels continue to store carbon absorbed during the tree's growing cycle and because of the greenhouse gas emissions avoided by not using products that require large amounts of fossil fuels to manufacture. The architect of the CLT apartment building in the UK estimated that, between the carbon stored in the panels and emissions avoided by not using concrete, he kept about 300 metric tons of carbon out of the atmosphere. The CLT building was also estimated to weigh four times less than its concrete counterpart, which reduced transportation costs, allowed the design team to reduce the foundation by 70 percent, and eliminated the need for a tower crane during construction. It took four carpenters just nine weeks to erect nine stories—and the entire construction process was reduced from 72 weeks to 49.

This type od wood has also many another positive sides and product advantages as ecologically sustainable building material, it is recommended in terms of building biology, has positive ecobalance, solid wood construction with lasting value, flexible design without a grid pattern, excellent static properties and comfortable room climate . Cross laminated timbet is healthy, compatible with steel, glass and other materials. It increase space thanks to slender construction elements and also gives freedom in architectural implementation.

Figure 5, cross laminated timber family house

Figure 6, The interior rooms of the cross laminated timber house

By 2005 awareness of CLT as a structural building material and sustainable alternative to concrete and brick & block had been established and demand in Europe had increased dramatically. This was predominantly driven by the green building movement, improved distribution channels and enhanced marketing. By 2005 the number of European manufacturers producing CLT had also increased. Today there are 5 main producers all still based in Europe. As the demand for CLT grows over the next 5 – 10 years there will be a huge increase in the number of new entrants to the manufacturing market.

Figure 7, first cross laminated object in UK-Shrewsbury School music

Figure 8, interior of Shrewsbury School music

## 4 Results

Thereby the solid timber construction technique with CLT is not regarded as competitor against the existing timber building sector with focus on linear timber elements. Building technique with CLT has already shown to open and extend the possibilities to realize structures in timber. In fact, meanwhile CLT is in direct competition with mineral based solid building materials, like reinforced concrete and masonry. Further extension of this position is expected. This is in particular enforced by the circumstance that the product CLT has only minor requirements,
regarding the mechanical potential of the basic material. So far minimum principles as mentioned in this contribution are applied. Thus also local timber species can be sustainably utilized and value can be gained regionally, which may lead to the worldwide establishment of CLT. Consequently, the creation of further small and median scaled production lines and companies as well as of some big players worldwide all operating in the field of CLT is expected.

## 5 Literature

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