# A Life Cycle Assessment of the Environmental Impacts of Cross-Laminated Timber

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Global warming caused by greenhouse gases generated by human activities pose a great threat to the modern world. A 1, 5℃ global temperature increase will affect the planet in numerous ways. The consequences of global warming are for example deforestation, starvation, severe weather and species extinction. Both new and existing buildings impact the environment. The construction materials used to build new buildings demand energy and release greenhouse gases. Existing buildings use energy for heating and cooling which often lead to greenhouse gas emissions. To be able to reduce global warming it is important to increase sustainability among both new and existing buildings.

A life cycle assessment is a tool to measure the environmental impacts of buildings. In a life cycle assessment, the environmental impacts generated by construction materials throughout their existence, from cradle to grave is presented. The data in a life cycle assessment can be used to evaluate how environmentally sustainable a construction material is. Life cycle assessments can be used as a part of sustainable building certifications. Sustainable building certifications aims to encourage the building sector to build sustainable buildings. Sustainable building certifications provides a grading system for different critical aspects of buildings, such as indoor air quality, energy use and moisture safety.

There are many different sustainable building certifications available and different certification systems focus and emphasize different aspects of sustainability. Miljöbyggnad is a Swedish environmentally sustainable building certification while the Danish version of DGNB is a sustainable building certification used in Denmark. Depending on the complexity of developed LCA tools, the life cycle assessments are different and evaluate different aspects of construction materials' life cycles. Miljöbyggnad only regards the parts of construction materials' manufacturing stages as well as the transport from manufacturing to construction site. DGNB on the other hand, also consider end of life stages, where the construction materials can be considered as waste. There are different end of life scenarios depending on the type of construction material. The construction material can after its usage in a building be deconstructed and reused. The material can also be recycled, whereas the material is reworked. If there is no possibility to reuse or recycle, the material can be disposed of as landfill or be incinerated.

Regarding heavy construction materials that are being used as structural construction material, the most regular construction materials are steel and concrete. In recent years it has not been very common to use wood for massive structural constructions, mainly because of the varying load-bearing properties of wood. However, a wood material called cross-laminated timber was developed to compete with steel and concrete. Cross-laminated timber is a construction material that is produced by

gluing together wood panels in one direction and later gluing together even more panels facing the opposite direction of the previous section. By doing this, the irregular properties of wood decreases and a massive wooden construction material is formed.

When comparing different construction materials, it is important that the building system studied is the same for each construction material. For instance, if wood, concrete and steel are being compared as structural construction solution for different buildings, it is important that the buildings are about the same size and have the same floor area in the building. When comparing the different environmental impacts and greenhouse gases from cross-laminated timber, concrete and steel, the following results were obtained for Miljöbyggnad:

- Cross-laminated timber has the lowest global warming potential followed by concrete and steel for the lowest grade in Miljöbyggnad.
- By including global warming potential due to effects from road transports from manufacturer to construction site, concrete has the lowest global warming potential followed by cross-laminated timber and steel.

Regarding DGNB, there are more aspects linked to how environmentally sustainable cross-laminated timber is considered. DGNB evaluates seven environmental impacts including greenhouse gases. Miljöbyggnad only evaluates greenhouse gas emissions. Therefore, cross-laminated timber is not always in all aspects considered a more environmentally sustainable construction material compared to steel and concrete.

For cross-laminated timber to be considered as an alternative construction material, its environmental properties within life cycle assessment needs to be beneficial. The environmental sustainability of cross-laminated timber is highly dependable on the decided end of life scenario, how the used wood is taken care of when it is demolished. The most environmentally beneficial end of life scenario is reuse, followed by recycling and incineration. The amount of avoided greenhouse gas emissions by reusing cross-laminated timber can be regarded as a way to reduce global warming.

There are differences between Miljöbyggnad and the Danish version of DGNB. When evaluating cross-laminated timber in Miljöbyggnad, it is only the global warming potential that is being regarded. In DGNB there are other environmental aspects that is being used, in all types of evaluations of construction materials.

Wood and forests are renewable sources of material. Forest growth results in storage of greenhouse gases from the atmosphere in trees. There are different assessment methods for the environmental effects of wood products, between Miljöbyggnad and DGNB. The positive effects of reducing excessive greenhouse gases in the atmosphere by storing carbon in wood and forests are debated. The positive effects of carbon storage needs to be further researched, to decide which approach is appropriate.