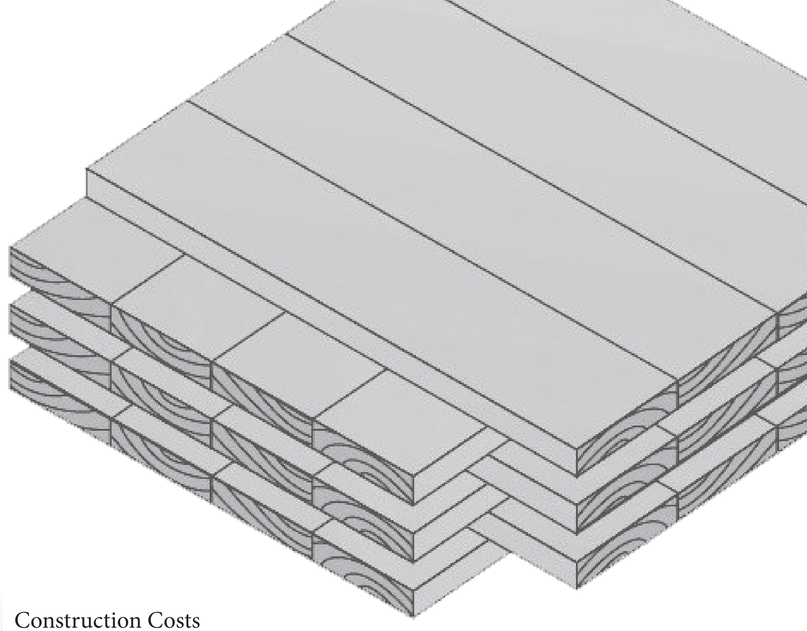
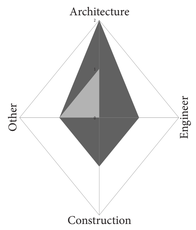
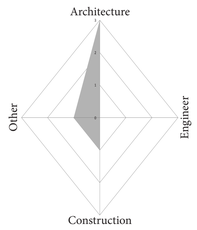
Barriers in the implementation of Cross-Laminated Timber as a Sustainable Alternative Structural System in Multi-Family Multi-Story Housing

Cross-Laminated Timber (CLT) was first developed in the early 1990s in Austria and Germany and has been gaining popularity in residential and non-residential applications, mainly in Europe. Currently, panels are being manufactured in a limited number of places in North America, which allows CLT to be used in a few projects while trade organizations and governmental agencies adopt specifications and codes for its use. CLT is being used in Europe as the structural system for eight and nine story buildings with proposals up to seventeen stories. CLT is an engineered wood product consisting of glue laminated wood boards, approximately 20-60mm (.79" - 2.36") in thickness, with each layer set at right angles to the next layer. This cross lamination creates panels, ranging from a 3-layer 57mm (2.24") panel to as thick as an 11-layer 300mm (11.8") panel, which can span in two directions and be used for load-bearing walls and spans. Cross-Laminated Timber (CLT) has both positive and negative attributes. The most positive attributes include seismic response and sustainability. CLT performs extremely well seismic events. There have been shake table test done on 5-7 story buildings using the same settings as record seismic events. In all cases, the building survived completely, and would need minor repairs to be re-occupied. Wood structures have a significantly lower embodied energy and associated carbon emissions than equivalent steel and concrete structural systems. Wood is also a carbon sink, removing carbon dioxide from the atmosphere and storing it in building components. There is also the increased construction speed and reduced amount of labor on site. An eight story CLT building in London, had the structure completely assembled in 29 days by four carpenters. One of the potential barriers to using CLT as a structural system is its nature of being a solid wall system. This means the systems that typically hid inside a wall cavity will now need extra attention in their integration with the structure. Since the product is made up of wood, this requires special consideration in construction as well as fire protection. The system is unable to get wet during construction so measures to protect it from the elements are necessary. Timber is self-protecting in the sense that it will char on the outside, preventing heat build-up at the center and allowing it to retain its strength during exposure to fire. CLT panels are designed to resist fire by calculating charring rates.

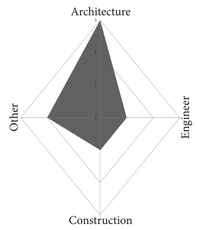




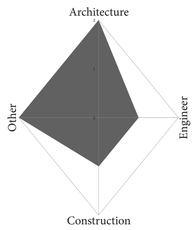
Before taking this survey, had you heard of Cross-Laminated Timber (CLT)?



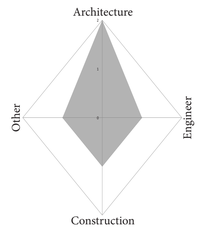
Do you know the various attributes of CLT?



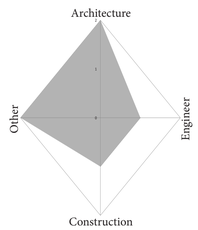
Do you think CLT could be a viable alternative structural system in multi-family housing?



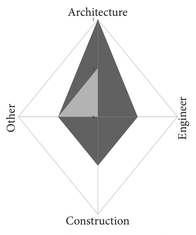
If codes were to be reformed to allow CLT in high-rise construction, do you think it would be an acceptable alternative structural system?



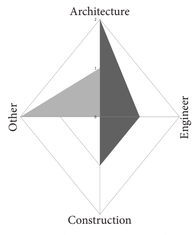
Compared to post-tensioned concrete, do you think CLT will have better acoustical performance?



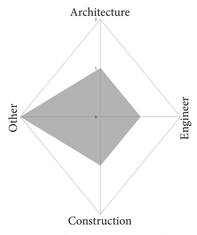
Compared to post-tensioned concrete, do you think CLT will perform better in fire?



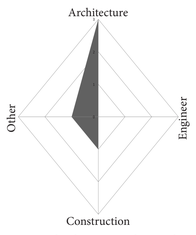
Compared to post-tensioned concrete, do you think CLT will require less labor?



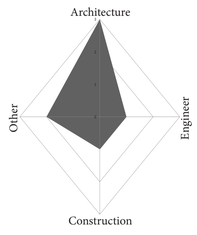
Compared to post-tensioned concrete, do you think CLT will have a lower material cost?



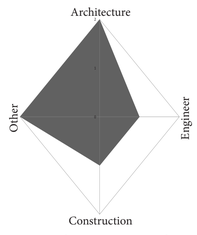
Compared to post-tensioned concrete, do you think CLT will perform better in terms of systems integration?



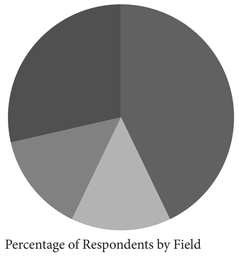
Do you think CLT can be used as an architectural finish similar to post-tensioned concrete?



Compared to post-tensioned concrete, do you think CLT will have a lower embodied energy?



Compared to post-tensioned concrete, do you think CLT will have a lower embodied carbon?



Percentage of Respondents by Field

Fire Ratings

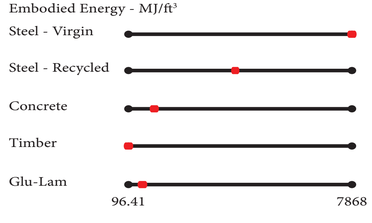
Heavy timber assemblies or solid wood designs are able to reach the necessary fire resistance ratings for buildings types made out of non-combustible materials. The char rate of CLT has been tested at .67mm per min (.02 in per min). Over the course of being exposed to fire for two hours the CLT panels will have experienced a loss of 80mm (2.4in) in panel thickness. If CLT is to be left exposed, adding an extra layer or two to the panel could result in having the equivalent to a two hour fire rating.

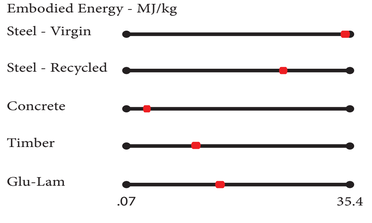
Acoustics

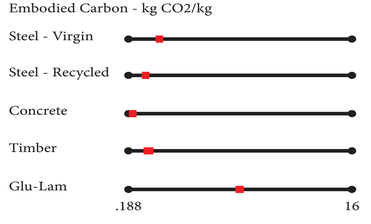
There are multiple wall and floor assemblies, made with CLT, capable of meeting code. Meeting code requires multiple layers of materials to be used in specific assemblies. The assembly increases in thickness with the addition of the multiple layers causing it to become thicker than an equivalent made of post-tensioned concrete as the base material.

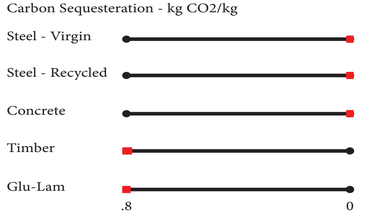
Seismic

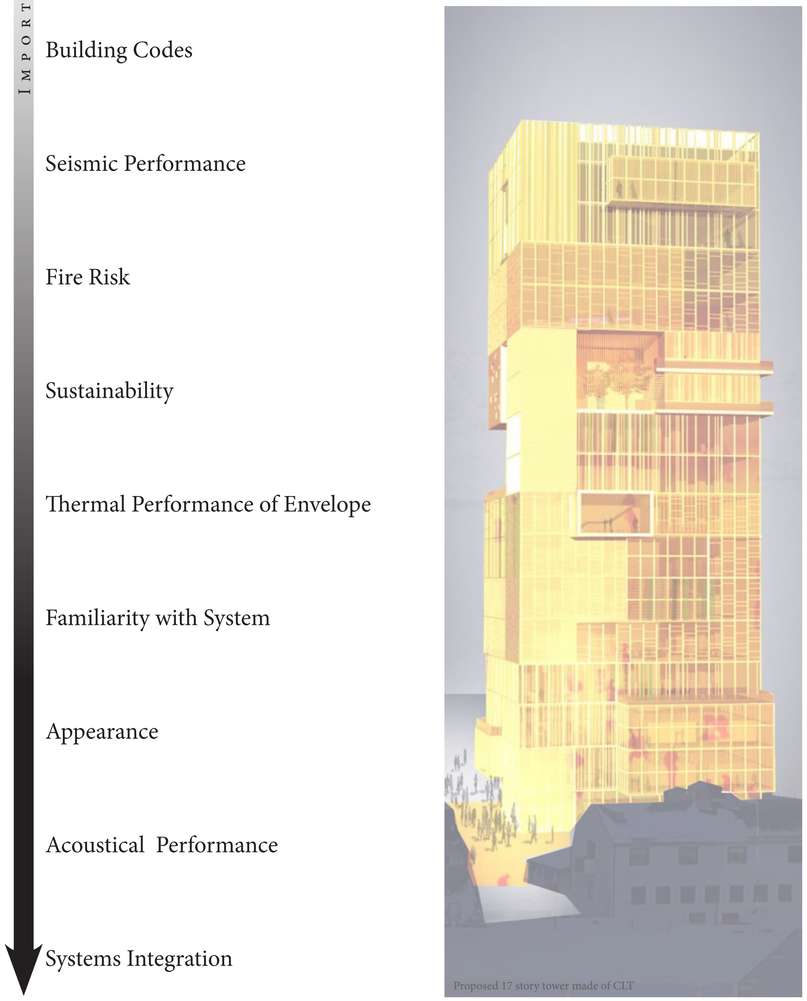
Seismic design with CLT is completely controlled by the connections of the panels. Large scale tests have been performed by IVALSA on a seven story CLT structure in Japan. The structure was exposed to record earthquake simulations including the Kobe earthquake (magnitude of 7.2 and accelerations of 0.8 to 1.2 g) resulting in moderate damage. The extent of the damage was found to be located around the connections. A few of them had failed, but overall the structure withstood the simulations and needed minor repairs for re-occupancy. CLT requires fewer materials for seismic design compared to traditional structural systems, and performs well during seismic testing.











Proposed 17 story tower made of CLT