Fabricating CLT Using Low-grade/Low-value Lumber: Investigation of factors affecting product performance

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Introduction:
Currently, the building industry is a major consumer of the nonrenewable materials, many obtained in unsustainable ways. The construction industry is responsible for a significant part of green house emission and anthropogenic environmental impact (Khan et al., 2017). Wood, as a renewable material with high specific strength, is a promising material to address this issue (Green, 2013). Mass timber constructions contribute to reducing the carbon dioxide footprint of the building industry by storing carbon in buildings instead of releasing it to the environment. In the early 1990s, cross-laminated timber (CLT) was invented in Austria and Germany (Karacabey et al., 2013). CLT is a composite panel consisted of three or more odd number of orthogonally arranged layers of boards. Since the introduction of CLT to North America in early 2000’s it is the interest to use this product as a construction material is steadily grown, but it is not a common practice yet (Petz, 2014).

National forest restoration programs aim to reduce wildfire spread rate by selectively removing small diameter trees to preserve larger and superior trees; These operations are also called thinning programs. Many of the harvested trees are either dead or diseased which can be fuel for wildfire and pest outbreaks. Currently, the market for these low-value lumber is limited, it is important to find a value-added market for this material to offset the high costs of thinning operations. CLT can be a promising solution since the layered structure of CLT decreases the impact of inhomogeneities on individual boards and results in a more uniform, homogenized panel. Due to this characteristic, CLT helps through spreading the impact of defects in low-grade lumber over the panel.

ANSI PRG 320, “Standard for Performance-Rated CLT” is developed in the United States in 2011. This standard provides the CLT specifications such as requirements for the components, performance criteria, qualification, and quality assurance. PRG 320 allows the usage of visually graded lumber of No.2 or better in strong direction and grade No.3 or better in weak direction. Custom layup CLT is also permitted if the product meets the criteria. Several researches were developed to assess the feasibility of using low-grade lumber for fabrication of CLT. This poster aims to find the guidelines and holdbacks of fabricating CLT using low-grade lumber by investigating previous studies in this field to be applied to the current research.

Materials and Methods:
An study on the previous publications conducted to identify the holdbacks of fabricating CLT by low-value lumber. As shown in figure 1, a large portion of the studies reported satisfying results for strength and stiffness of the CLT panel. But only a few of them were able to successfully meet the bond integrity requirements. More specifically, they mostly failed due to delamination test. In each case of failure the reason of delamination is investigated, and compared as a variation factor for the current research at table 2.

Given the importance of delamination test, the work flow of the project designed as shown in figure 2. The research as a whole includes the steps shown in the figure. First, small blocks of 2 inches by 2 inches would be fabricated individually and subjected to the delamination and block shear tests. In the next steps the specimens would be obtained from larger CLT panel. Fabricating and testing samples in variety of scale ensures that fabricated individually and objected to the delamination and block shear tests. In the next steps the specimens were successfully tested the delamination criteria (lower than 5% of delamination on all bond lines of each sample). The all samples are tested in the same condition mentioned in figure 3. A set of samples were successfully passed the delamination criteria (lower than 5% of delamination on all bond lines of each sample). The results are consistent with the research on the margins would result in a strong bond, further research is necessary to optimize the fabrication process.

Done the delamination test as the first step of the research helps to make sure that the adhesive selected for the CLT generates a satisfactory bonding strength which directly affects durability and mechanical properties of the CLT panel.

Conclusion:
It is important to offset the high costs of the thinning program by finding a value-added market for the logs obtained from operations. Previous studies showed that CLT can be a promising solution to address this issue. ANSI PRG 320 requires a series of performance tests to certify a custom CLT layup for structural purposes. Delamination test is one of the most challenging criterions to fulfill; hence it is selected as the first stage of the research. Various fabrication factors affect the final bonding properties. The most important ones are close assembly time, moisture content, temperature, press time, and adhesive spread rate. The allowable margins for these factors are assessed based on several sets of tests. However it is validated that making specimens based on the margins would result in a strong bond, further research is necessary to optimize the fabrication process.

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