NUMERICAL MODELING OF CHAR LAYER FALLING OFF IN CROSS-LAMINATED TIMBER (CLT)

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Cross-laminated timber (CLT) is widely acclaimed in modern construction for its structural prowess, aesthetics, and sustainability. Architects, engineers, and designers increasingly favour this versatile material. Nonetheless, an in-depth exploration of CLT's thermal properties is essential. These properties, including heat transfer, charring, and insulation, significantly impact CLT structures' fire resistance and thermal efficiency. The thermal characteristics of timber, which encompass properties like density, thermal conductivity, and heat capacity, significantly influence its response to fire. As timber undergoes heating, it undergoes pyrolysis, leading to chemical and physical transformations that impact its ignition, combustion, and extinguishing behaviour. Therefore, understanding how thermal properties like thermal conductivity, specific heat, and thermal diffusivity evolve as timber is exposed to elevated temperatures is of utmost importance. While prior research has addressed these thermal properties and integrated them into Eurocode 5, their applicability to CLT is not straightforward. CLT exhibits distinctive behaviour at high temperatures, deviating from traditional timber types. In CLTs, a unique phenomenon arises under elevated temperatures, characterised by the delamination of CLT panels. Delamination occurs when the temperature within the panel exceeds the glass transition temperature of the adhesive, resulting in adhesive softening and a loss of strength. Consequently, the internal layers of CLT become exposed to the fire, lacking the protective char layer characteristic of other timber types. This intricacy necessitates dedicated research on CLTs' thermal properties and behaviour under extreme heat conditions.

This study is dedicated to unravelling the intricacies of CLT panels' thermal behaviour when subjected to high temperatures, explicitly focusing on delamination and its repercussions on thermal properties. Leveraging advanced finite element method (FEM) modelling, developed using SAFIR 2016 software, the study orchestrates simulations replicating CLT panels' response to various high-temperature scenarios. To benchmark these simulations and derive meaningful insights, the study juxtaposes the thermal properties stipulated in Eurocode 5-1-2 (2004) with newly derived properties. This rigorous analysis reveals a misalignment between Eurocode data and the real-world behaviour of CLT, especially in the post-fall-off phase of the fire. Consequently, the study introduces a novel thermal property tailored explicitly for CLT under standard fire conditions (ISO-834).

Crucially, the simulations validate the fidelity of the newly derived thermal properties in replicating the actual thermal behaviour of CLT, as substantiated by experimental data. These findings rectify prior inaccuracies and lay the foundation for developing more precise fire-resistant design strategies for CLT structures. Ultimately, this research significantly enhances the safety and performance of contemporary timber buildings operating within high-temperature environments.

Keywords: Cross Laminated Timber, Fire Performance, Delamination, Charring, Thermal properties

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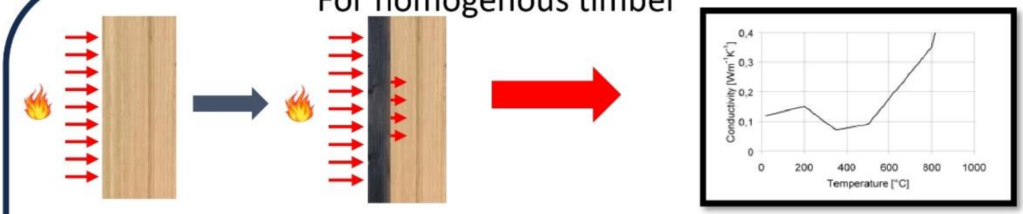
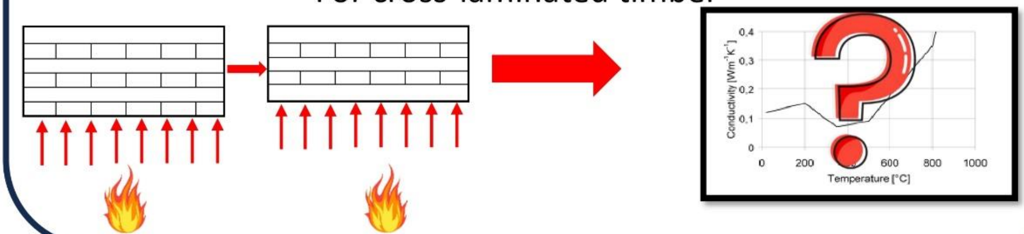
Problem Statement

For homogenous timber



For cross-laminated timber



Methodology

Conclusions