

THE STRUCTURAL BEHAVIOUR OF CROSS-LAMINATED TIMBER RIB PANELS IN FIRE

Miriam Kleinhenz¹, Alar Just², Andrea Frangi³

ABSTRACT

In the frame of a research project, the structural behaviour in fire and the fire resistance of cross-laminated timber rib panels were studied based on experimental and numerical investigations. The floor system consists of cross-laminated timber plates rigidly bonded to glued-laminated timber ribs. The full composite action between the composite components is provided by means of screw-press gluing. The results of the reference tests showed good agreement with results based on the method of rigidly bonded components and the effective width according to the final European draft of cross-laminated timber design [1]. The fire resistance tests resulted in fire resistances up to 120 min and confirmed the assumption that the effect of the composite action was maintained in fire. In this paper, the numerical investigations cover thermal, and uncoupled thermo-mechanical simulations using a 2D FE model of a linear beam system for discussion of the mechanical behaviour under fire exposure. The numerical results of the tested cross-sections are compared with the experimental results of the fire resistance tests. Depending on the modelled cross-section, the influence of the effective width on the numerical results is investigated.

Keywords: Massive timber rib panel; fire resistance; fire tests; finite element; effective width

1 INTRODUCTION

Long-span floor systems are required for building types such as commercial office buildings, residential buildings, schools, and industrial buildings. As a long-span floor system with spans up to 16 m, cross-laminated timber rib panels consist of cross-laminated timber (CLT) plates connected to glued-laminated timber (glulam) ribs (Figure 1). Full composite action is provided by a rigid connection between the composite components by means of screw-press gluing [2]. For ribbed cross-sections, the assumption that the cross-section remains plane is incorrect. The simple beam theory according to Euler-Bernoulli is not applicable because the strains in the flange vary with the distance from the rib due to the in-plane shear flexibility of the flange. This leads to a non-uniform distribution of the longitudinal strains along the flange width. For simplified structural analysis, the effective width defines an equivalent cross-section that provides the same maximum bending stress and effective bending stiffness as the actual cross-section [3]. The final European draft of CLT design [1] for a revised version of EN 1995-1-1 [4] proposes simplified formulae to estimate the effective width for ribbed plates build up from cross-laminated timber plates. In the case of uniformly distributed loads, equation (1) determines the effective width at normal temperature b_{ef} according to prEN 1995-1-1:20xx [1], as explained in Figure 1

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Timber-framed Structures Dan Engström, Chalmers tekniska högskola, 1997 **Timber Engineering** Sven
Thelandersson, Hans J. Larsen, 2003-03-14 Timber construction is one of the most prevalent methods of constructing buildings
in North America and an increasingly significant method of construction in Europe and the rest of the world Timber
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on solid timber and engineered wood products but also material behaviour and properties on a wood element level Produced
by internationally renowned experts in the field this book represents the state of the art in research on the understanding of
the material behaviour of solid wood and engineered wood products There is no comparable compendium currently available
on the topic the subjects represented include the most recent phenomena of timber engineering and the newest development
of practice related research Grouped into three different sections Basic properties of wood based structural elements Design
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Modelling and New Technologies ,1999* The Structural Behaviour of Curved Glued Laminated Timber Beams J. A. Anderson,1976 **Timber Structures and Engineering** De Proft, K.,Brebbia, C. A.,Connor, J.,2018-02-06 This book contains papers presented at the 1st International Conference on Timber Structures which was held in collaboration with the Technical Centre of Wood Industry in Belgium It explores the latest developments in wood products and their application as structural components The focus of the included works is to draw attention to new research and real applications from both researchers and practitioners and to present new and innovative ideas in this significant field Rapid advances have recently been made in the development and processing of innovative ecologically friendly wood products A variation of new structural shapes can now be fabricated and used to construct buildings and bridges which have minimal impact on the environment Wood is particularly appealing since it is renewable and has no carbon footprint when it is harvested in a sustainable way Timber structures are ecologically sound and comparatively low cost The material lends itself to ground breaking designs and new types of composites offer reliable robust and safe materials The content of this book comprises a range of topics Material properties of wood Durability aspects service life modelling Fire safety of timber structures Protection against decay Non destructive inspection and monitoring Glued laminated structures Xlam and CLT Timber joints and connections Vernacular wood and heritage timber structures Timber housing and eco architecture Timber bridges Large span timber roof structures Shell structures in timber Mixed composite and hybrid structures Computational analysis and experimental methods Structural engineering and design Seismic behaviour of timber structures Protection of timber Repaired timber structures Rapidly assembled and transferable timber structures Guidelines codes and regulations Structural failures Art and craftsmanship The Structural Behaviour of Laminated Timber Beams Using Nail Plates Michael James Phillips,Darling Downs Institute of Advanced Education. School of Engineering,1986 *Structural Behaviour of Glued Laminated Timber Beams with Unreinforced and Reinforced Notches* Robert Jockwer,2014 Structural Behaviour of Lateral Load-carrying Capacity of Timber Frame Walls Filled with Hemp Concrete Husam Wadi,2019 Construction projects nowadays face significant challenges to reduce the large amounts of daily energy usage for utilities such as heating electricity and hot water in residential and commercial buildings especially in Europe Many building regulations encourage the use of bio based materials with superior physical properties for energy efficiency in the construction sector The use of low carbon material in structures such as hemp concrete improves the insulation level and sound absorption and simultaneously decreases the weight of the building structure as this natural material provides low density aggregate This study aimed to investigate the mechanical behaviour of timber frame walls against lateral loads Cross laminated timber walls CLT and Oriented Strand Board OSB were used in this study in order to examine the global lateral strength of timber walls A theoretical approach has been proposed to predict the lateral performance of CLT wall against lateral loads and a comparison between the theoretical and experimental results has been conducted Experimental testing was undertaken on a full size example of two different

designs of timber walls to investigate and highlight the parameters that significantly affect the lateral resistance of hemp concrete as infill material. Vertical studs and diagonal bracing elements under compression were used in this study with dimensions of 2.5m height and 1.25m length. The results showed that hemp concrete makes a slight contribution against lateral loads in vertical stud timber wall of length 1.25m, which means that decreasing the length of timber wall significantly decreased the hemp concrete contribution against lateral loads. Three timber walls with different lengths 1.2m, 1.6m and 2.4m filled with hemp concrete have been examined numerically in this study. Based on the numerical results, it was obvious that the length of the timber wall plays a major role in the lateral strength of hemp concrete, as increasing the wall length significantly increased the lateral strength of hemp concrete. Also, the contact and bonding between hemp material and timber studs significantly affected the lateral load carrying capacity of hemp concrete as infill material in timber frame walls.

The Enigmatic Realm of **Structural Behaviour Of Timber**: Unleashing the Language is Inner Magic

In a fast-paced digital era where connections and knowledge intertwine, the enigmatic realm of language reveals its inherent magic. Its capacity to stir emotions, ignite contemplation, and catalyze profound transformations is nothing in short supply of extraordinary. Within the captivating pages of **Structural Behaviour Of Timber** a literary masterpiece penned by a renowned author, readers embark on a transformative journey, unlocking the secrets and untapped potential embedded within each word. In this evaluation, we shall explore the book's core themes, assess its distinct writing style, and delve into its lasting effect on the hearts and minds of people who partake in its reading experience.

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