

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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Structural Behaviour Of Timber

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Structural Behaviour of Timber Borg Madsen, Lauge Fuglsang Nielsen, 1992 *Structural Behaviour of Timber Constructions in Seismic Zones* A. Ceccotti, 1990 *Connections for 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 Engineering deals not only with the structural aspects of timber construction structural components joints and systems based 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 aspects on timber structures and Joints and structural assemblies this book focuses on key issues in the understanding of timber as a modern engineered construction material with controlled and documented properties the background for design of structural systems based on timber and engineered wood products the background for structural design of joints in structural timber systems Furthermore this invaluable book contains advanced teaching material for all technical schools and universities involved in timber engineering It also provides an essential resource for timber engineering students and researchers as well as practicing structural and civil engineers An Investigation of the Structural Behaviour of a Traditional Timber Joint Subject to Short Term Load G. W. T. Mngara, Civil and Structural Engineering, 1992 Structural Behaviour of Timber Constructions in Seismic Zones A. Ceccotti, 1990 **The Structural Behaviour of Timber Joints Made with Fully Overlapping Nails** Alexander Porteous, Napier University, 2003 **Modelling the Structural Behaviour of OSB Webbed Timber I-beams** Enchun Zhu, University of Brighton, 2003 **High Performance and Optimum Design of Structures and Materials III** W. P. De Wilde, S. Hernandez, S. Kravanja, 2018-12-03 Papers presented at the 2018 International Conference on High Performance and Optimum Design of Structures and Materials are contained in this volume These papers address issues involving advanced types of structures particularly those based on new concepts or new materials and their system design The use of novel materials and new structural concepts nowadays is not restricted to highly technical areas like aerospace aeronautical applications or the automotive industry but affects all engineering fields including those such as civil engineering and architecture Most high performance structures require the development of a generation of new materials which can more easily resist a range of external stimuli or react in a non conventional manner Particular emphasis is placed on intelligent structures and materials as well as the application of computational methods for their modelling control and management

Optimisation problems discussed in this book involve those related to size shape and topology of structures and materials Optimisation techniques have much to offer to those involved in the design of new industrial products The development of new algorithms and the appearance of powerful commercial computer codes with easy to use graphical interfaces has created a fertile field for the incorporation of optimisation in the design process in all engineering disciplines The latest developments in design optimisation manufacturing and experimentation are highlighted in this book Structural Studies, Repairs and Maintenance of Heritage Architecture X C. A. Brebbia,2007 This volume contains papers presented at the Ninth International Conference on Structural Studies Repairs and Maintenance of Heritage Architecture The conference provides an ideal forum for professionals in the area to discuss problems and solutions and exchange opinions and experiences

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Engineering De Proft, K.,Brebba, 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

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web module 3 the reproductive systems unit b assignment 3a use the following information to answer questions 29 30 and 31 human papillomavirus hpv human papillomavirus hpv is the most common type of sexually transmitted infection in the world

