

Design of floor diaphragms in multi-storey timber buildings

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ABSTRACT: This paper discusses the design of timber diaphragms, in response to the growing interest in multi-storey commercial timber structures, and the lack of guidance or regulations regarding the seismic design of timber diaphragms.

Proper performance of floor diaphragms is required to transfer all lateral loads to the vertical systems that resist them, but design for earthquake loads can be more complex than design for wind loads. This paper confirms that the seismic design of a diaphragm is intimately linked to the seismic design of the whole building. Diaphragm failure, even if restricted to a limited diaphragm portion, can compromise the behaviour of the whole building. It is therefore necessary to design and detail diaphragms for all possible load paths and to evaluate their influence on the load distribution within the rest of the structure. It is strongly recommended that timber diaphragms be designed as elastic elements, by applying dynamic amplification and overstrength factors derived from the lateral load resisting system.

This paper shows that some current design recommendations for plywood sheathing on light timber framing can be applied to massive wood diaphragms, but for more complex floor geometries an equivalent truss method is suggested. Diaphragm flexibility and displacement incompatibilities between the floor diaphragms and the lateral resisting systems also need to be accounted for.

1 INTRODUCTION

Recent years have seen a growing interest in engineered multi-storey timber buildings around the world. A number of tall timber buildings have been built in Europe, followed by a 10 storey building in Melbourne (Binational Softwood Lumber Council et al. 2014). Both Canada and the US have set up design competitions in order to promote timber as the construction material for tall buildings. The New Zealand construction sector is part of this trend, with a number of commercial timber buildings already built (Ministry for Primary Industries 2014) or in the design process. The local availability of glued laminated timber (glulam), Cross Laminated Timber (CLT), Laminated Veneer Lumber (LVL) as well as prefabricated Light Timber Frame (LTF) elements and the soon to be released new NZ Timber Structures Standard are all encouraging the use of timber for new multi-residential, commercial and industrial buildings.

This new global interest in medium to high-rise multi-storey timber buildings creates the need for a more rigorous approach in design. Furthermore, the presence of some of these structures in seismically active countries has highlighted knowledge gaps regarding their performance under earthquake loading and especially in the design of diaphragms.

1.1 Role of diaphragms

Independently of the construction material used, diaphragms have a multiple role in the structural behaviour of a building. Aside from acting as slabs under gravity loads, diaphragms tie all other structural elements together and transfer horizontal loads to the vertical Lateral Load Resisting System (LLRS). Being the first element to resist most gravity and horizontal forces, a loss of diaphragm action will likely compromise the behaviour of the whole structure.

Design Of Floor Diaphragms In Multi Storey Timber Buildings

Scott C. Dulebohn



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Floor Diaphragms in Multi-storey Timber Buildings Daniel Moroder, 2016 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 Designers' Guide to Eurocode 5: Design of Timber Buildings Jack Porteous, Alexander Porteous, Peter Ross, Haig Gulvanessian, 2013-04-26 Interprets and assists in the use of EN 1995 1 1 structural timber This guide shows typical material properties and dimensions modifiers and structural responses It also explains relationships with other Eurocodes particularly those for EN 1990 Basis of Design **Buildings and Structures under Extreme Loads** Chiara Bedon, Flavio Stochino, Daniel Honfi, 2020-11-25 Exceptional loads on buildings and structures may have different causes including high strain dynamic effects due to natural hazards man made attacks and accidents as well as extreme operational conditions severe temperature variations humidity etc All of these aspects can be critical for specific structural typologies and or materials that are particularly sensitive to external conditions In this regard dedicated and refined methods are required for their design analysis and maintenance under the expected lifetime There are major challenges related to the structural typology and material properties with respect to the key features of the imposed design load Further issues can be derived from the need for risk mitigation or retrofit of existing structures as well as from the optimal and safe design of innovative materials systems Finally in some cases no appropriate design recommendations are available and thus experimental investigations

can have a key role within the overall process In this Special Issue original research studies review papers and experimental and or numerical investigations are presented for the structural performance assessment of buildings and structures under various extreme conditions that are of interest for design

PRO 8: 1st International RILEM Symposium on Timber Engineering Lars Boström,1999

Seismic Retrofit of Existing Buildings Matthew Fox,Weng Yuen Kam,Damian Grant,2024-09-19 Seismic Retrofit of Existing Buildings is a concise and easy to use guideline for practising engineers to assess and design successful seismic retrofit interventions for existing vulnerable buildings It offers readers guidance on both conceptual design strategies and relevant detailed design considerations

18th International Probabilistic Workshop José C. Matos,Paulo B. Lourenço,Daniel V. Oliveira,Jorge Branco,Dirk Proske,Rui A. Silva,Hélder S. Sousa,2021-05-07 This volume presents the proceedings of the 18th International Probabilistic Workshop IPW which was held in Guimar es Portugal in May 2021 Probabilistic methods are currently of crucial importance for research and developments in the field of engineering which face challenges presented by new materials and technologies and rapidly changing societal needs and values Contemporary needs related to for example performance based design service life design life cycle analysis product optimization assessment of existing structures and structural robustness give rise to new developments as well as accurate and practically applicable probabilistic and statistical engineering methods to support these developments These proceedings are a valuable resource for anyone interested in contemporary developments in the field of probabilistic engineering applications

Cross-Laminated Timber Design: Structural Properties, Standards, and Safety Mustafa Mahamid,2020-03-27 Publisher s Note Products purchased from Third Party sellers are not guaranteed by the publisher for quality authenticity or access to any online entitlements included with the product Master the practice of designing structures with cross laminated timber This comprehensive guide explains the design standards safety protocols and codes and regulations engineers need to know to use cross laminated timber as a structural building material Featuring contributions from experts in the field Cross Laminated Timber Design Structural Properties Standards and Safety introduces the material properties of CLT and goes on to cover the recommended lateral and vertical design techniques You will get clear explanations of all relevant NDS ASCE 7 and IBC provisions along with real world examples and case studies Sustainability and environmental issues are discussed in full detail Coverage includes An introduction to cross laminated timber Product standards for cross laminated timber Structural design gravity Structural design lateral Structural connections Building envelope design with cross laminated timber Acoustics for CLT projects Fire for CLT projects Environmental aspects of CLT as a construction material Sustainability of cross laminated timber

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Use of Timber in Tall Multi-Storey Buildings Ian Smith,Andrea Frangi,2014-01-01 Since the dawn of civilization timber has been

a primary material for achieving great structural engineering feats Yet during the late 19th century and most of the 20th century it lost currency as a preferred material for construction of large and tall multi storey building superstructures This Structural Engineering Document SED addresses a reawakening of interest in timber and timber based products as primary construction materials for relatively tall multi storey buildings Emphasis throughout is on holistically addressing various aspects of performance of complete systems reflecting that major gaps in knowhow relate to design concepts rather than technical information about timber as a material Special consideration is given to structural form fire vulnerability and durability aspects for attaining desired building performance over lifespans that can be centuries long **Wood Design**

Focus ,1992 **Timber Construction Manual** American Institute of Timber Construction,2005 Publisher Description

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