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Alternate Load-Path Analysis for Mid-Rise Mass-Timber Buildings

https://research.thinkwood.com/en/permalink/catalogue1233

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Organization:	Structures Congress
Publisher:	American Society of Civil Engineers
Year of Publication:	2018
Country of Publication:	United States
Format:	Conference Paper
Material:	CLT (Cross-Laminated Timber)
Application:	Floors
	Wood Building Systems
Topic:	Design and Systems
	Seismic
Keywords:	Alternate Load-Path Analysis
	Disproportionate Collapse
	Lateral Loads
Language:	English
Conference:	Structures Conference 2018
Research Status:	Complete
Notes:	April 19–21, 2018, Fort Worth, Texas

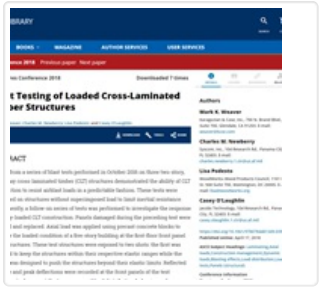
Summary:

This paper presents an investigation of possible disproportionate collapse for a nine-storey flat-plate timber building, designed for gravity and lateral loads. The alternate load-path analysis method is used to understand the structural response under various removal speeds. The loss of the corner and penultimate ground floor columns are the two cases selected to investigate the contribution of the cross-laminated timber (CLT) panels and their connections, towards disproportionate collapse prevention. The results show that the proposed building is safe for both cases, if the structural elements are removed at a speed slower than 1 sec. Disproportionate collapse is observed for sudden element loss, as quicker removal speed require higher moments resistance, especially at the longitudinal and transverse CLT floor-to-floor connections. The investigation also emphasises the need for strong and stiff column-to-column structural detailing as the magnitude of the vertical downward forces, at the location of the removed columns, increases for quicker removal.

Online Access:	Payment Required

Resource Link

https://doi.org/10.1061/9780784481349.017



Blast Testing of Loaded Cross-Laminated Timber Structures

https://research.thinkwood.com/en/permalink/catalogue1234

Author:	Weaver, Mark
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Organization:	Structures Congress
Publisher:	American Society of Civil Engineers
Year of Publication:	2018
Country of Publication:	United States
Format:	Conference Paper
Material:	CLT (Cross-Laminated Timber)
Application:	Wood Building Systems
Topic:	Mechanical Properties
	Design and Systems
Keywords:	Blast Tests
	Airblast Loads
	Axial Load
	Panels
	Load Distribution
	Quasi-Static
Language:	English
Conference:	Structures Conference 2018
Research Status:	Complete
Notes:	April 19–21, 2018, Fort Worth, Texas

Summary:

Results from a series of blast tests performed in October 2016 on three two-story, single-bay cross-laminated timber (CLT) structures demonstrated the ability of CLT construction to resist airblast loads in a predictable fashion. These tests were performed on structures without superimposed load to limit inertial resistance. Subsequently, a follow-on series of tests was performed to investigate the response of axially-loaded CLT construction. Panels damaged during the preceding test were removed and replaced. Axial load was applied using precast concrete blocks to simulate the loaded condition of a five-story building at the first-floor front panel of the structures. These test structures were exposed to two shots: the first was designed to keep the structures within their respective elastic ranges while the second was designed to push the structures beyond their elastic limits. Reflected pressure and peak deflections were recorded at the front panels of the test structures to document the two-way panel load distribution behavior under a dynamic load event and the clearing of the shock wave. Prior to conducting the blast tests, a small number of tests were performed on a load tree test apparatus to aid in test planning by investigating the post-peak response of individual CLT panels of various lengths to quasi-static out-of-plane and axial loads applied simultaneously. This paper provides an overview of the results obtained from both the quasi-static and blast tests of axially-loaded CLT. Additionally, the paper compares CLT structure, component, and connection response across the suite of data. Conclusions are offered to assist engineers in the design of load bearing CLT construction exposed to airblast loads.

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Resource Link

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Capacity-Based Design for Cross-Laminated Timber Buildings

https://research.thinkwood.com/en/permalink/catalogue1255

Author:	Shahnewaz, Md
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	Alam, Shahria
	Popovski, Marjan
Organization:	Structures Congress
Publisher:	American Society of Civil Engineers
Year of Publication:	2017
Country of Publication:	United States
Format:	Conference Paper
Material:	CLT (Cross-Laminated Timber)
Application:	Wood Building Systems
	Shear Walls
Topic:	Mechanical Properties
	Connections
Keywords:	In-Plane Stiffness
	Strength
	Non-Linear Springs
	Finite Element Analysis
	Hysteretic Behaviour
	Cyclic Loading
Language:	English
Conference:	Structures Congress 2017
Research Status:	Complete
Notes:	April 6–8, 2017, Denver, Colorado

Summary:

The use of cross-laminated timber (CLT) in residential and non-residential buildings is becoming increasingly popular in North America. While the 2016 supplement to the 2014 edition of the Canadian Standard for Engineering Design in Wood, CSAO86, provides provisions for CLT structures used in platform type applications, it does not provide guidance for the in-plane stiffness and strength of CLT shearwalls. The research presented in this paper investigated the in-plane stiffness and strength of CLT shearwalls with different connections for platform-type construction. Finite element analyses were conducted where the CLT panels were modelled as an orthotropic elastic material, and non-linear springs were used for the connections. The hysteretic behaviour of the connections under cyclic loading was calibrated from quasi-static tests; the full model of wall assemblies was calibrated using experimental tests on CLT shearwalls. A parametric study was conducted that evaluated the change of strength and stiffness of walls with the change in a number of connectors. Finally, a capacity-based design procedure is proposed that provides engineers with guidance for designing platform-type CLT buildings. The philosophy of the procedure is to design the CLT buildings such that all non-linear deformations and energy dissipation occurs in designated connections, while all other connections and the CLT panels are designed with sufficient over-strength to remain linear elastic.

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Resource Link

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Displacement Design Procedure for Cross Laminated Timber (CLT) Rocking Walls with Sacrificial Dampers

https://research.thinkwood.com/en/permalink/catalogue395

Author: Gu, Mengzhe
Pang, Weichiang
Schiff, Scott

Organization: Structures Congress

Publisher: American Society of Civil Engineers

Year of Publication: 2015

Country of Publication: United States

Format: Conference Paper

Material: CLT (Cross-Laminated Timber)

Application: Walls

Topic: Design and Systems
Seismic

Keywords: Energy Dissipation
Ductile Behavior
U-Shaped Flexural Plates
Self-centering Mechanism

Language: English

Conference: Structures Congress 2015

Research Status: Complete

Notes: April 23–25, 2015, Portland, Oregon, USA

Summary:

This paper presents the preliminary design of a rocking Cross-laminated Timber (CLT) wall using a displacement-based design procedure. The CLT wall was designed to meet three performance expectations: immediate occupancy (IO), life safety (LS), and collapse prevention (CP). Each performance expectation is defined in terms of an inter-story drift limit with a predefined non-exceedance probability at a given hazard level. U-shape flexural plates were used to connect the vertical joint between the CLT panels to obtain a ductile behavior and adequate energy dissipation during seismic motion. A design method for ensuring self-centering mechanism is also presented.

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Experimental Investigations of Post-Tensioned Timber Frames with Advanced Seismic Damping Systems

https://research.thinkwood.com/en/permalink/catalogue464

Author:	Smith, Tobias
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	Pampanin, Stefano
	Buchanan, Andrew
	Nigro, Domenico
Organization:	Structures Congress
Publisher:	American Society of Civil Engineers
Year of Publication:	2012
Country of Publication:	United States
Format:	Conference Paper
Material:	Glulam (Glue-Laminated Timber)
	LVL (Laminated Veneer Lumber)
Application:	Wood Building Systems
Topic:	Mechanical Properties
	Seismic
Keywords:	Damping
	Energy Dissipation
	Full Scale
	Post-Tensioning
Language:	English
Conference:	Structures Congress 2012
Research Status:	Complete
Notes:	March 29-31, 2012, Chicago, Illinois, United States

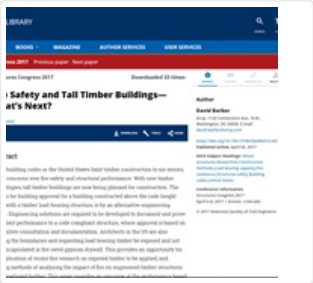
Summary:

This paper describes initial experimental testing to investigate feasible sources of passive damping for the seismic design of post-tensioned glue laminated timber structures. These innovative high performance structural systems extend precast concrete PRESSS technology to engineered wood structures, combining the use of post-tensioning bars or cables with large post-tensioned timber members. The combination of these two elements provides elastic recentering to the structure while the addition of damping using a specialised energy dissipation system gives the desirable `flag shaped' hysteretic response under lateral loading. Testing has been performed on a full scale beam-column joint at the University of Basilicata in Italy in a collaborative project with the University of Canterbury, New Zealand. The experimental testing uses engineered wood products, extending the use of laminated veneer lumber (LVL) structures tested in New Zealand to testing of glue laminated timber (glulam) structures in Italy. Current testing is aimed at further improvement of the system through additional energy dissipation systems.

Online Access:	Payment Required

Resource Link

http://dx.doi.org/10.1061/9780784412367.154



Fire Safety and Tall Timber Buildings—What's Next?

https://research.thinkwood.com/en/permalink/catalogue1253

Author:	Barber, David
Organization:	Structures Congress
Publisher:	American Society of Civil Engineers
Year of Publication:	2017
Country of Publication:	United States
Format:	Conference Paper
Material:	Glulam (Glue-Laminated Timber)
Application:	Wood Building Systems
Topic:	Design and Systems
	Market and Adoption
Keywords:	Fire Safety
	Exposed Load Bearing Timber
	Concealed Connections
Language:	English
Conference:	Structures Congress 2017
Research Status:	Complete
Notes:	April 6–8, 2017, Denver, Colorado

Summary:

Model building codes in the United States limit timber construction to six stories, due to concerns over fire safety and structural performance. With new timber technologies, tall timber buildings are now being planned for construction. The process for building approval for a building constructed above the code height limits with a timber load-bearing structure, is by an alternative engineering means. Engineering solutions are required to be developed to document and prove equivalent performance to a code compliant structure, where approval is based on substantive consultation and documentation. Architects in the US are also pushing the boundaries and requesting load-bearing timber be exposed and not fully encapsulated in fire rated gypsum drywall. This provides an opportunity for the application of recent fire research on exposed timber to be applied, and existing methods of analyzing the impact of fire on engineered timber structures to be developed further. This paper provides an overview of the performance based fire safety engineering required for building approval and also describes the engineering methodologies that can be utilized to address specific exposed load-bearing timber issues; concealed connections for glulam beams; and the methodology to address areas of exposed timber.

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Resource Link

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Investigation into the Failure of a Long-Span Glued Laminated Beam

https://research.thinkwood.com/en/permalink/catalogue1251

Author:	Shuck, Andrew
	Porto, Jason
	Sasaki, Kent
Organization:	Structures Congress
Publisher:	American Society of Civil Engineers
Year of Publication:	2017
Country of Publication:	United States
Format:	Conference Paper
Material:	Glulam (Glue-Laminated Timber)
Application:	Roofs
Topic:	Mechanical Properties
Keywords:	Failure
Language:	English
Conference:	Structures Congress 2017
Research Status:	Complete
Notes:	April 6–8, 2017, Denver, Colorado

Summary:

The failure of wood roof members in older buildings is a fairly common occurrence compared to systems built of steel or concrete. The slow-working detrimental effect of sustained loading at relatively high stress levels (i.e., “creep rupture” or “cumulative damage”) is typically viewed as the predominant failure mechanism, but this is not always the case. The following describes a case study of a glulam beam that failed for other reasons. The subject glulam beam that failed absent a significant atypical loading event was one of many in the roof structure of a large building. Each glulam beam was about five feet deep and 100 feet long. At the time of failure, the subject glulam beam was 41 years old. Through the course of the investigation, significant research was performed into multiple aspects of glulam beam behavior, including revisions to design stresses over time, fabrication technology, and time-dependent properties. Detailed field observations were performed to document the failed beam, the surrounding elements, and the assemblies supported by the roof framing. The cause of the failure was ultimately found to be a fabrication error.

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Resource Link

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Post-Tensioned Mass Timber Systems

https://research.thinkwood.com/en/permalink/catalogue1256

Author:	Iqbal, Asif
	Popovski, Marjan
Organization:	Structures Congress
Publisher:	American Society of Civil Engineers
Year of Publication:	2017
Country of Publication:	United States
Format:	Conference Paper
Application:	Frames
	Shear Walls
Topic:	Design and Systems
	Seismic
Keywords:	North America
	New Zealand
	Post-Tensioning Cables
	Post-Tensioned
	Multi-Story
	Lateral Load Resisting Systems
	High Seismic Regions
Language:	English
Conference:	Structures Congress 2017
Research Status:	Complete
Notes:	April 6–8, 2017, Denver, Colorado

Summary:

A new type of mass timber structural system has been developed in New Zealand over the last decade. Timber members made of engineered wood products are used in combination with post-tensioning cables to produce highly efficient structural components suitable for multi-story moment resisting frames or shear wall-based lateral load resisting systems. Both systems are particularly useful in structures designed in high seismic regions. The post-tensioning also ensures self-centering of the components and the structural systems after a seismic event. In addition to the post-tensioning, the systems can use energy dissipating devices within the connections that further enhance the ductility of the systems and make them good candidates for low damage structural applications. Extensive experimental and numerical studies have been conducted to determine the performance of these systems and design procedures have been developed for practical applications. In an effort to bring this system closer to the North American designers, this paper contains a summary of the evolution of the concept and the most important research projects and findings to date. In addition, a number of applications within and outside New Zealand are reviewed to demonstrate the applicability of the concept. Finally, potential and recent initiatives for adoption of the technology in North America are discussed.

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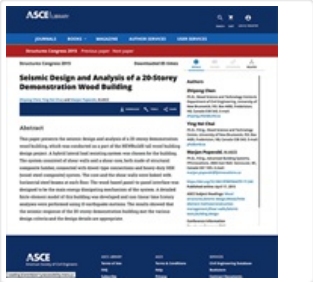

Seismic Design and Analysis of a 20-Storey Demonstration Wood Building

https://research.thinkwood.com/en/permalink/catalogue667

Author:	Chen, Zhiyong
	Chui, Ying Hei
	Popovski, Marjan
Organization:	Structures Congress
Publisher:	American Society of Civil Engineers
Year of Publication:	2015
Country of Publication:	United States
Format:	Conference Paper
Application:	Hybrid Building Systems
Topic:	Design and Systems
	Seismic
Keywords:	Nonlinear time history analysis
	Demonstration Building
	Finite Element Model
	Wood-Steel
Language:	English
Conference:	Structures Congress 2015
Research Status:	Complete
Notes:	April 23–25, 2015, Portland, Oregon, USA

Summary:

This paper presents the seismic design and analysis of a 20-storey demonstration wood building, which was conducted as a part of the NEWBuildS tall wood building design project. A hybrid lateral load resisting system was chosen for the building. The system consisted of shear walls and a shear core, both made of structural composite lumber, connected with dowel-type connections and heavy-duty HSK (wood-steel-composite) system. The core and the shear walls were linked with horizontal steel beams at each floor. The wood-based panel-to-panel interface was designed to be the main energy dissipating mechanism of the system. A detailed finite element model of this building was developed and non-linear time history analyses were performed using 10 earthquake motions. The results showed that the seismic response of the 20-storey demonstration building met the various design criteria and the design details are appropriate.

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Resource Link

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Shear Connections with Self-Tapping-Screws for Cross-Laminated-Timber Panels

https://research.thinkwood.com/en/permalink/catalogue432

Author:	Hossain, Afrin
	Lakshman, Ruthwik
	Tannert, Thomas
Organization:	Structures Congress
Publisher:	American Society of Civil Engineers
Year of Publication:	2015
Country of Publication:	United States
Format:	Conference Paper
Material:	CLT (Cross-Laminated Timber)
Application:	Wood Building Systems
Topic:	Connections
	Mechanical Properties
Keywords:	Ductility
	Self-Tapping Screws
	Stiffness
	Strength
	Vertical Shear Loading
	Mid-Scale
	Quasi-Static
	Shear Tests
Language:	English
Conference:	Structures Congress 2015
Research Status:	Complete
Notes:	April 23–25, 2015, Portland, Oregon, USA

Summary:

Cross-Laminated-Timber (CLT) is increasingly gaining popularity in residential and non-residential applications in North America. To use CLT as lateral load resisting system, individual panels need to be connected. In order to provide in-plane shear connections, CLT panels may be joined with a variety of options including the use of self-tapping-screws (STS) in surface splines and half-lap joints. Alternatively, STS can be installed at an angle to the plane allowing for simple butt joints and avoiding any machining. This study investigated the performance of CLT panel assemblies connected with STS under vertical shear loading. The three aforementioned options were applied to join 3ply and 5-ply CLT panels. A total of 60 mid-scale quasi-static shear tests were performed to determine and compare the connection performance in terms of strength, stiffness, and ductility. It was shown that – depending on the screw layout – either very stiff or very ductile joint performance can be achieved.

Online Access:	Payment Required

Resource Link

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