Advanced methods of encapsulation

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Author:	Osborne, Lindsay
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Contributor:	Forestry Innovation Investment
Date:	November 2016
Edition:	44220
Material Type:	Research report
Physical Description:	66 p.
Sector:	Wood Products
Field:	Sustainable Construction
Research Area:	Building Systems
Subject:	Building construction
	Wood frame
	Design
	Fire
Series Number:	W-3261
Language:	English

Abstract: Neither the National Building Code of Canada (NBCC) [1], nor any provincial code, such as the British Columbia Building Code (BCBC) [2], currently provide “acceptable solutions” to permit the construction of tall wood buildings, that is buildings of 7 stories and above. British Columbia, however, was the first province in Canada to allow mid-rise (5/6 storey) wood construction and other provinces have since followed. As more mid-rise wood buildings are erected, their benefits are becoming apparent to the industry, and therefore they are gaining popularity and becoming more desirable.

Forest product research has now begun to shift towards more substantial buildings, particularly in terms of height. High-rise buildings, typically taller than 6 storeys, are currently required to achieve 2 h fire resistance ratings (FRR) for floors and other structural elements, and need to be of non-combustible construction, as per the “acceptable solutions” of Division B of the NBCC [1]. In order for a tall wood building to be approved, it must follow an “alternative solution” approach, which requires demonstrating that the design provides an equivalent or greater level of safety as compared to an accepted solution using non-combustible construction. One method to achieve this level of safety is by ‘encapsulating’ the assembly to provide additional protection before wood elements become involved in the fire, as intended by the Code objectives and functional statements (i.e., prolong the time before the wood elements potentially start to char and their structural capacity is affected). It is also necessary to demonstrate that the assembly, in particular the interior finishes,

conform to any necessary flame spread requirements.

The Technical Guide for the Design and Construction of Tall Wood

The Technical Guide for the Design and Construction of Tall Wood Buildings in Canada [3] recommends designing a tall wood building so that it is code-conforming in all respects, except that it employs mass timber construction. The guide presents various encapsulation methods, from full encapsulation of all wood elements to partial protection of select elements. National Research Council Canada (NRC), FPInnovations, and the Canadian Wood Council (CWC) began specifically investigating encapsulation techniques during their Mid-Rise Wood Buildings Consortium research project, and demonstrated that direct applied gypsum board, cement board and gypsum-concrete can delay the effects of fire on a wood substrate [4].

There is extensive data on the use of gypsum board as a means of encapsulation for wood-frame assemblies and cold-formed steel assemblies. However, tall wood buildings are more likely to employ mass timber elements due to higher load conditions, requirements for longer fire resistance ratings, as well as other factors. There is little knowledge currently available related to using gypsum board directly applied to mass timber, or in other configurations, for fire protection. Testing performed to date has been limited to direct applied Type X gypsum board using standard screw spacing, and showed promising results [5, 6, 7]. This represents an opportunity for other configurations that might provide enhanced protection of wood elements to be investigated.

Being able to provide equivalent fire performance of assemblies between non-combustible and combustible construction will thus improve the competiveness of tall timber buildings by providing additional options for designers.

Revision of March 2015 edition

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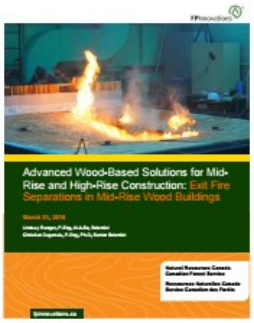

Advanced wood-based solutions for mid-rise and high-rise construction: exit fire separations in mid-rise Wood buildings

https://library.fpinnovations.ca/en/permalink/fpipub49853

Author:	Ranger, Lindsay
	Dagenais, Christian
Contributor:	Natural Resources Canada. Canadian Forest Service
Date:	March 2018
Material Type:	Research report
Physical Description:	91 p.
Sector:	Wood Products
Field:	Sustainable Construction
Research Area:	Advanced Wood Materials
Subject:	Wood
	Fire
	Building code
	Residential construction
Language:	English
Abstract:	In 2015, the National Building Code of Canada (NBCC) [1] adopted prescriptive provisions to allow the construction of mid-rise (5- and 6-storey) buildings using combustible construction. These types of buildings were already permitted under the British Columbia Building Code, as of 2009 [2]. In2014 the Province of Ontario filed an amendment to also allow mid-rise wood buildings, however, it required that the exit fire separations be built using noncombustible construction having a fire resistance rating (FRR) of not less than 1.5-hr, which was an increase from the 1-hr requirement in the NBCC. The Québec Construction Code has also filed amendments to allow mid-rise wood construction and also limits exit stairwells to use noncombustible construction.

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Advanced wood-based solutions for mid-rise and high-rise construction: Mid-rise wood exit shaft demonstration fire test report

https://library.fpinnovations.ca/en/permalink/fpipub49832

Author:	Ranger, Lindsay
	Dagenais, Christian
	Bénichou, Noureddine
Contributor:	Natural Resources Canada. Canadian Forest Service
Date:	April 2018
Material Type:	Research report
Physical Description:	48 p.
Sector:	Wood Products
Field:	Sustainable Construction
Research Area:	Advanced Wood Materials
Subject:	Wood
	Fire
	Building code
	Residential construction
Language:	English
Abstract:	FPInnovations conducted a research project to study the construction of mid-rise wood exit shafts in Ontario and Québec. The scope of the project included an investigation into the concerns that have been raised in regards to the use of wood exits in mid-rise buildings, an analysis of recent Canadian fire statistics in residential multi-family structures, and a fire demonstration of a mass timber wall and supported light-frame floor. This report describes the fire demonstration completed as part of this project; this report acts as a supplement to the full project report.

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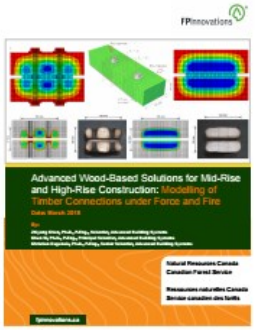
Advanced wood-based solutions for mid-rise and high-rise



construction: modelling of timber connections under force and fire

https://library.fpinnovations.ca/en/permalink/fpipub49851

Author:	Chen, Zhiyong
	Ni, Chun
	Dagenais, Christian
Contributor:	Natural Resources Canada. Canadian Forest Service
Date:	March 2018
Material Type:	Research report
Physical Description:	85 p.
Sector:	Wood Products
Field:	Sustainable Construction
Research Area:	Advanced Wood Materials
Subject:	Cross Laminated Timber
	Fire
	Performance
	Timber
Language:	English

Abstract: FPInnovations carried out a survey with consultants and researchers on the use of analytical models and software packages related to the analysis and design of mass timber buildings. The responses confirmed that a lack of suitable models and related information for material properties of timber connections, in particular under combination of various types of loads and fire, was creating an impediment to the design and construction of this type of buildings. Furthermore, there is currently a lack of computer models for use in performance-based design for wood buildings, in particular, seismic and fire performance-based design.
In this study, a sophisticated constitutive model for wood-based composite material under stress and temperature was developed. This constitutive model was programmed into a user-subroutine and can be added to most general-purpose finite element software. The developed model was used to model the structural performance of a laminated veneer lumber (LVL) beam and a glulam bolted connection under force and/or fire. Compared with the test results, it shows that the developed model was capable of simulating the mechanical behaviour of LVL beam and glulam connection under load and/or fire with fairly good correlation. With this model, it will allow structural designers to obtain the load-displacement curve of timber connections under force, fire or combination of the two. With this, key design parameters such as capacity, stiffness, displacement and ductility, which are required for seismic or fire design, can be obtained.
It is recommended that further verification and calibration of the model be conducted on various types of wood products, such as CLT, glulam, SCL and NLT, and fasteners, e.g. screw and rivet. Moreover, a database of the thermal and structural properties of the wood members and fasteners that are commonly used in timber constructions need to be developed to support and facilitate the application of the model.

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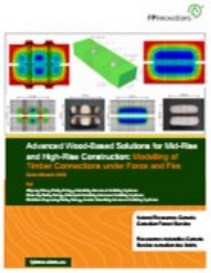

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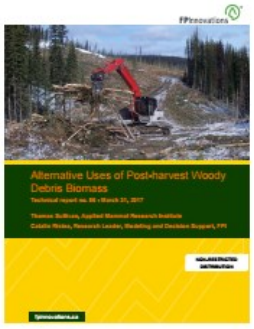

Alternative uses of post-harvest woody debris biomass

https://library.fpinnovations.ca/en/permalink/fpipub49507

Author:	Ristea, Catalin
Date:	March 2017
Material Type:	Research report
Physical Description:	13 p.
Sector:	Forest Operations
Field:	Fibre Supply
Research Area:	Forestry
Subject:	Harvesting
	Logging
	Fire
	Biomass
	Wildlife
	Energy
	FPI TR
Series Number:	Technical Report ; TR 2017 n.56
Language:	English
Abstract:	Current forest management policy in many jurisdictions in North America manages excess woody debris by piling and burning it, mainly as a post-harvest fire hazard abatement obligation. This study highlights three key points to consider regarding utilization and disposal of waste wood piles: 1) Allocate most woody debris waste to the biofuels sector in a cost-effective manner; 2) Allocate a small portion of woody debris (e.g. 10-15%) to implement windrow habitats where necessary to maintain mammalian biodiversity on clearcuts; 3) Limit burning of waste wood to those sites near human activity (potential fire hazard) that do not have an opportunity for biofuels or windrow purposes.

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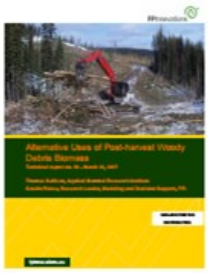

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Analysis of full-scale fire-resistance tests of structural composite lumber beams

https://library.fpinnovations.ca/en/permalink/fpipub3316

Author:	Dagenais, Christian
Contributor:	Canadian Forest Service
Date:	October 2014
Edition:	39980
Material Type:	Research report
Physical Description:	14 p.
Sector:	Wood Products
Field:	Wood Manufacturing & Digitalization
Research Area:	Advanced Wood Manufacturing
Subject:	Fire Resistance Testing Structural composites Beams
Series Number:	E 4914
Location:	Québec, Québec
Language:	English
Abstract:	The key objective of this study is to analyze full-scale fire-resistance tests conducted on structural composite lumber (SCL), namely laminated veneer lumber (LVL), parallel strand lumber (PSL) and laminated strand lumber (LSL). A sub-objective is to evaluate the encapsulation performance of Type X gypsum board directly applied to SCL beams and its contribution to fire-resistance of wood elements. The test data is being used to further support the applicability of the newly developed Canadian calculation method for mass timber elements, recently implemented as Annex B of CSA O86-14. Structural Composites - Properties Beams - Fire resistance

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Area-based water delivery systems. Exploratory research on logistics, water delivery, and its localized impacts

https://library.fpinnovations.ca/en/permalink/fpipub7859

Author:	Refai, Razim
	Hsieh, Rex
Date:	January 2021
Material Type:	Research report
Physical Description:	20 p.
Sector:	Forest Operations
Field:	Fibre Supply
Research Area:	Wildfire Operations
Subject:	Fire retardant
	Retardant
	Spruce
	Water
	FPI TR
Series Number:	Technical Report ; TR 2021 n.1
Location:	Alberta
Language:	English
Abstract:	The aim of this study was to capture data on area-based water delivery systems, specifically in the context of logistics, systems differentiation, water delivery, and its localized effects. FPInnovations successfully collaborated with Fire & Flood to obtain this data. A two-day test was executed during which Fire & Flood set up their 4- and 12-inch systems and carried out sprinkler operations.

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Assessing the flammability of mass timber components, a review

https://library.fpinnovations.ca/en/permalink/fpipub53026

Author:	Mehaffey, J.R. (Jim)
	Dagenais, Christian
Date:	February 2014
Material Type:	Research report
Physical Description:	27 p.
Sector:	Wood Products
Field:	Sustainable Construction
Research Area:	Building Systems
Subject:	Building code
	Fire
	Performance
	Design
	Timber
Language:	English
Abstract:	The report concludes with the recommendation that it would be useful to run an extensive set of cone calorimeter tests on SCL, glue-laminated timber and CLT products. The fundamental data could be most useful for validating models for predicting flame spread ratings of massive timber products and useful as input to comprehensive computer fire models that predict the course of fire in buildings. It is also argued that the cone calorimeter would be a useful tool in assessing fire performance during product development and for quality control purposes.

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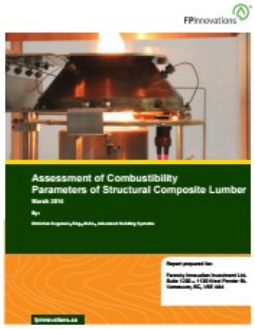
Assessment of combustibility parameters of structural composite lumber

https://library.fpinnovations.ca/en/permalink/fpipub3149



Author:	Dagenais, Christian
Contributor:	Forestry Innovation Investment
Date:	March 2014
Edition:	39807
Material Type:	Research report
Physical Description:	16 p.
Sector:	Wood Products
Field:	Wood Manufacturing & Digitalization
Research Area:	Advanced Wood Manufacturing
Subject:	Structural composites
	Lumber
	Fire
Location:	Québec, Québec
Language:	English
Abstract:	The present work aims at evaluating the combustibility characteristics (i.e. reaction to fire) of structural composite lumber (SCL) when tested in compliance with the cone calorimeter standard ISO 5660 [7, 8, 9]. More precisely, this study evaluates the heat release rate, total heat release, mass loss, effective heat of combustion, smoke obscuration as well as the presence of toxic gases when SCL products are tested in conformance with ISO 5660. Moreover, this study is solely focused on SCL elements that are thick enough to act as semi-infinite solids (thermally thick solids), as opposed to typical thin combustible finish products. Tests data are also compared to those obtained for visually-graded solid wood specimens of the SPF species group.
	Combustibility
	Composite Lumber
	Laminated products - Fire resistance
	Structural Composites - Properties
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Bridges & wildfire event: identifying information gaps in bridge protection in the context of resistance to wildland fire events

https://library.fpinnovations.ca/en/permalink/fpipub8006

Author:	Refai, Razim
Contributor:	Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD)
Date:	March 2020
Material Type:	Research report
Physical Description:	15 p.
Sector:	Forest Operations
Field:	Sustainable Construction
Research Area:	Building Systems
Subject:	Bridge Fire Protection Structures FPI TR Wildfires
Series Number:	Technical Report ; TR 2020 n.14
Language:	English
Abstract:	The Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) has asked FPInnovations to investigate current information and knowledge for bridge fire impact mitigation opportunities and strategies. The extent of the investigation includes reaching out to domestic and international contacts to find directly applicable information and literature on strategies to mitigate fire impacts to bridge structures. This will include review of academic journals and reports, products and methods, to find

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