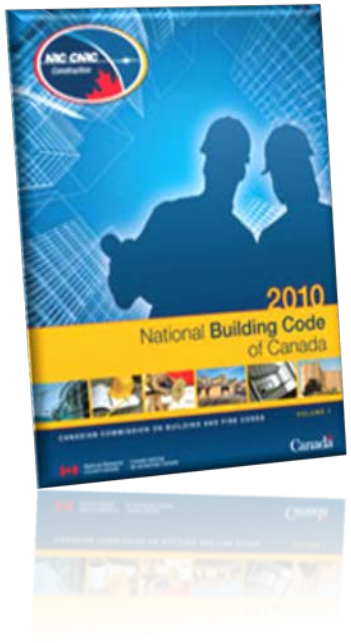
Fire Rating and Fire Performance for Wood Buildings



Wood Works Atlantic Information Session

St. John's, NL

February 3, 2015

AGENDA

- Introductions
- Fire Ratings
  - Background
  - Where are They Needed
  - How are they Achieved
- Fire Performance
  - Historical Perspective/Statistics
  - Emerging Methods
- Questions … AND ALTERNATIVE EXAMPLES

INTRODUCTION

RJ Bartlett Engineering Ltd

Established 1987

Fredericton & Halifax

23 Staff with 10 P.Eng

- Fire Protection Engineering
- Building & Fire Code Consulting
- Fire Safety Planning
- Forensic Investigations

WOODWORKS! ATLANTIC

RJ Bartlett Engineering Ltd

INTRODUCTION

RJ Bartlett Engineering Ltd

Provinces include:

Newfoundland
Nova Scotia
Prince Edward Island
New Brunswick
Quebec
Ontario
Manitoba
Saskatchewan
Alberta
British Columbia

Territories include:

Nunavut
Northwest Territories

States include:

Maine
Pennsylvania
Maryland
New York
Massachusetts
New Hampshire
Georgia
Florida
Washington DC
Illinois
California
North Carolina
Seattle

International:

Barbados
Bermuda
United Kingdom
Germany

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INTRODUCTION

Ben Coles, M.Sc.E., MBA, P.Eng., PE
Project Coordinator

- Fire Protection Engineering
- Building & Fire Code Consulting
- 12 years experience

B.Sc. Mechanical Engineering (UNB 2003)
M.Sc. Fire Protection Engineering (WPI 2009)
MBA in Engineering Management (UNB 2011)

INTRODUCTION

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INTRODUCTION

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Fire Protection

- Fire Separations
- Egress and Exiting
- Suppression System
- Smoke Control /Pressurization/HVAC
- Fire Detection / Alarm / Notification
- Emergency Signage / Lighting
- Structural Integrity and Passive Protection
- Fire Department Access

Fire and Life Safety Approach

INTRODUCTION

www.rjbartlett.com

@RJBEL87

RJ Bartlett Engineering Ltd.

AGENDA

- Introductions
- Fire Ratings
  - Background
  - Where are They Needed
  - How are they Achieved
- Fire Performance
  - Historical Perspective/Statistics
  - Emerging Methods
- Questions

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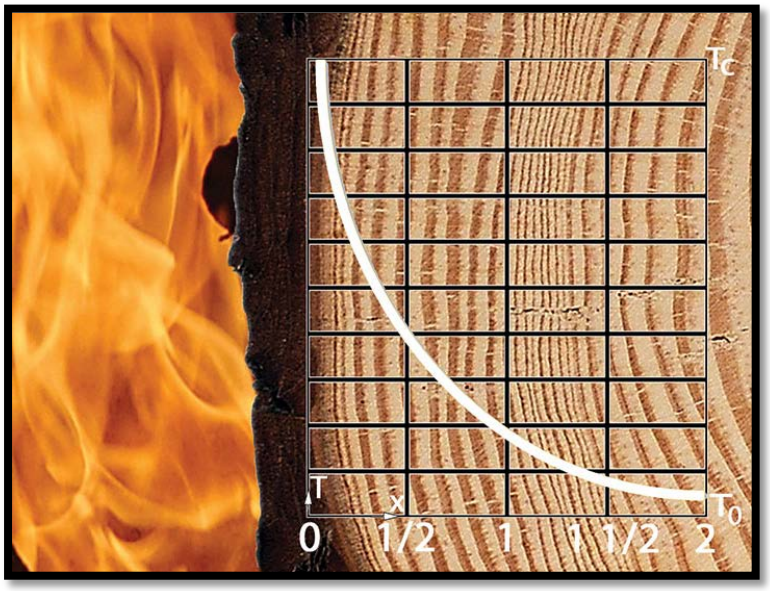
Fire Ratings – What?

Fire-Resistance Rating

The time that a material or assembly of materials will withstand the passage of flame and the transmission of heat when exposed to fire under specified conditions of test and performance criteria



Fire Ratings – What?

Fire Separation

- A construction assembly that acts as a *barrier against the spread of fire.*

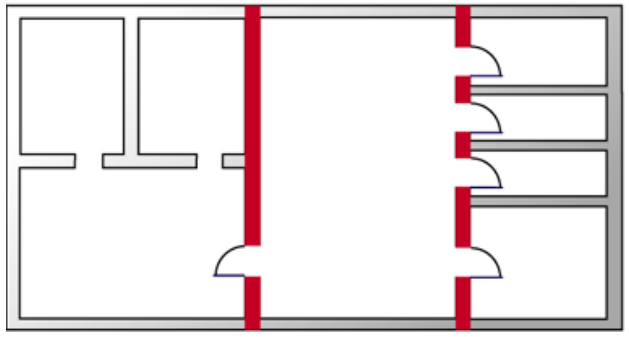
- Commonly used fire-resistance ratings:

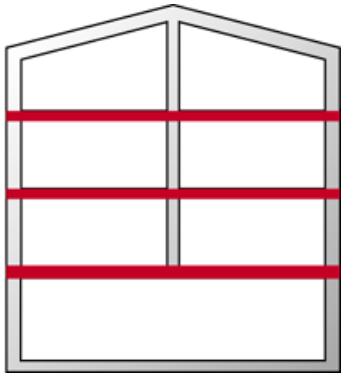
Non-rated | ¾ h | 1 h | 1.5h | 2 h | 3 h | 4 h

FIRE RATINGS – WHAT?

Continuity

The *continuity* of a fire separation shall be *maintained* where it abuts another fire separation, a floor, a ceiling, a roof, or an exterior wall assembly.





Fire Ratings – What?

Closures

A device or assembly for closing an opening through a fire separation or an exterior wall, such as a door, shutter, wired glass or glass block, and includes components such as hardware, closing devices, frames and anchors

FIRE RATINGS – WHAT?

Fire Stop

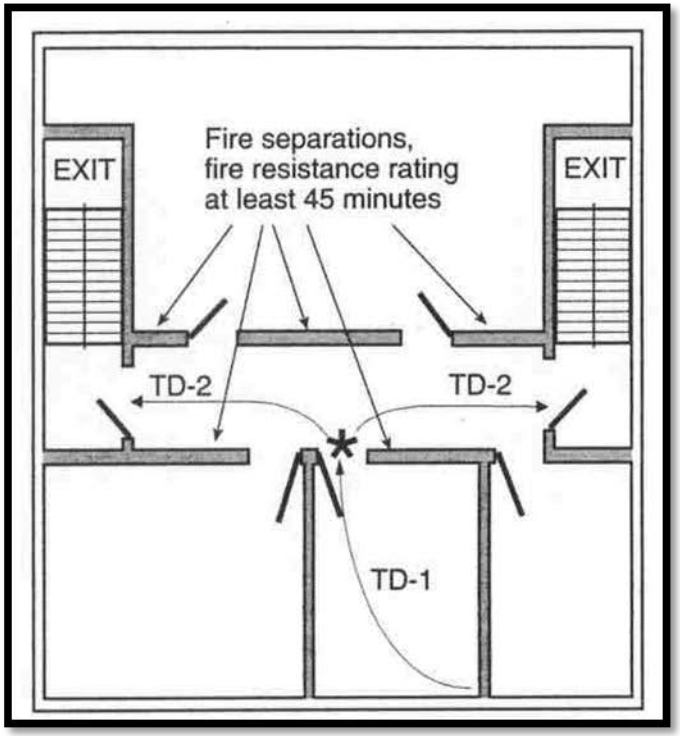
A ***system*** consisting of material, component and means of support, used to fill gaps between fire separations or between fire separations and other assemblies, or used around items that wholly or partially ***penetrate a fire separation***, to restrict the spread of fire and often smoke thus maintaining the ***integrity*** of a fire separation.

FIRE RATINGS – WHAT?

Fire Stop

A ***system*** consisting of material, component and means of support, used to fill gaps between fire separations or between fire separations and other assemblies, or used around items that wholly or partially ***penetrate a fire separation***, to restrict the spread of fire and often smoke thus maintaining the ***integrity*** of a fire separation.

FIRE RATINGS – WHAT?



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Fire Ratings – What?

Fire Wall Construction

Specifications

- A fire separation of noncombustible construction
- Sub-divides a building or separates adjoining buildings
- Has a fire-resistance rating as prescribed in the NBC (2 or 4 h), and
- Maintains structural stability

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FIRE RATINGS – WHAT?

CAN/ULC-S101

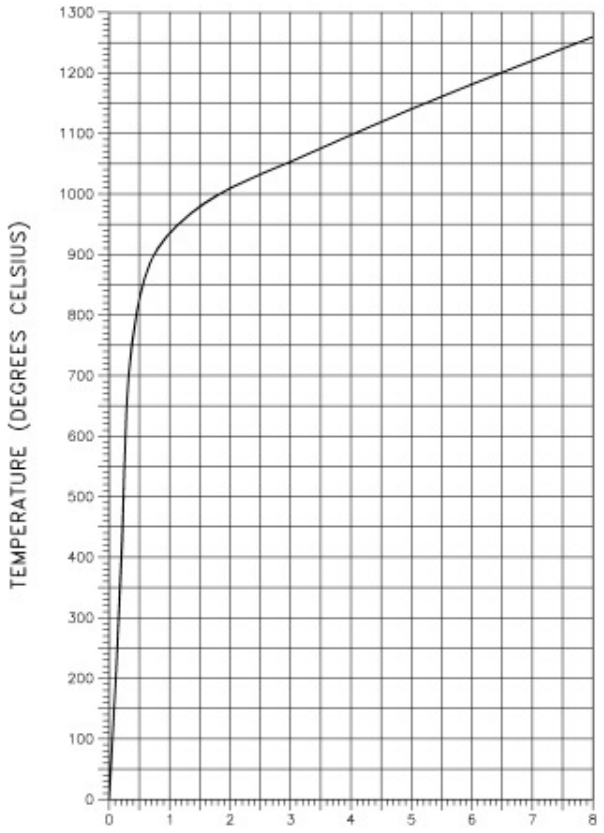
"Standard Methods of Fire Endurance Tests of Building Construction and Materials"

- The standard by which fire-resistance ratings are established.
- Applicable to walls, partitions, floors, ceilings, columns, beams, and girders, as well as some components of building subassemblies.

FIRE RATINGS – WHAT?

CAN/ULC-S101

- First recorded testing was in 1890.
- ASTM adopted in first decade of the 1900's.
- Considered *relatively severe* fire condition



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FIRE RATINGS – WHAT?

Photo courtesy of Bill Hendricks (photo taken at Southwest Research, San Antonio, TX)

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Fire Ratings – What?

Exposure Conditions for Ratings

Floor, roof, and ceiling assemblies are to be rated for exposure from the underside.

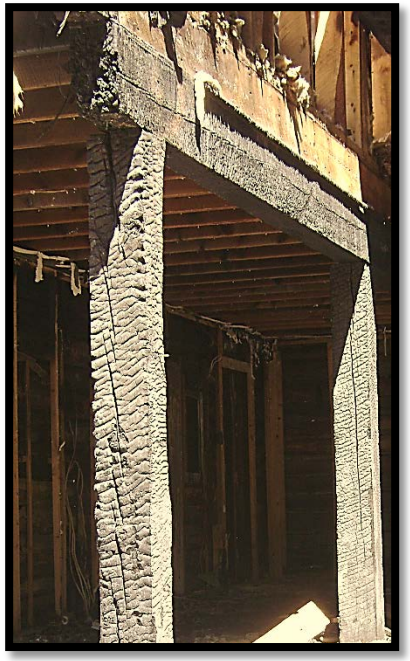
Firewalls and interior vertical fire separations are to be rated for exposure on each side.

Exterior walls are to be rated for exposure from the inside.

Fire Ratings – What?

Rating of Supporting Construction

Loadbearing walls, columns and arches in a storey immediately below a floor or roof assembly required to have a fire-resistance rating are to have a fire-resistance rating no less than that required of the assembly that is supported.



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NBC Assumptions

Occupants are incapable of fighting fires through portable extinguishers and standpipe

NBC Assumptions

Once the safety of building occupants has been secured, the life safety intent has been met

NBC Assumptions

Fire alarm systems provide occupants with an awareness that an emergency situation may exist and a response may be necessary

NBC Assumptions

Fires can start anywhere in a building

NBC Assumptions

Awake, ambulatory occupants can evacuate a two storey building before structural problems arise

NBC Assumptions

Three – six storeys and those under three storeys with sleeping occupants / non ambulatory need additional level of structural fire protection

NBC Assumptions

> six storeys require greatest degree of structural fire protection

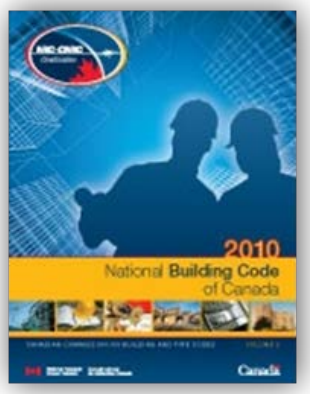
FIRE RATINGS – WHAT?

Intents and Objectives

Example: Article 3.2.2.24. *"Group A, Division 2, up to 2 Storeys"*

- The building to be sprinklered throughout,
- The building to be of noncombustible construction,
- Floor assemblies to be constructed as fire separations with a fire-resistance rating ***not less than 1 h***, and
- Loadbearing members and mezzanines are to have a fire-resistance rating ***not less than that required for the assembly being supported***.

Fire Ratings – What?

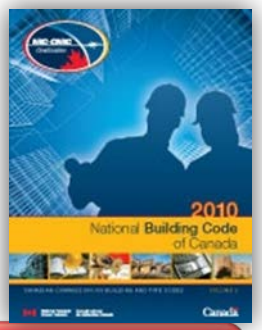


Intents and Objectives

Objective: Fire Protection of the Building

An objective of this Code is to limit the probability that, as a result of its design or construction, the building will be exposed to an ***unacceptable risk of damage due to fire***. The risks of damage due to fire addressed in this Code are those caused by fire or explosion impacting areas beyond its point of origin.

Fire Ratings – What?



Intents and Objectives

Intent 1/4: … *available online @ Codes-Guides.nrc.ca*

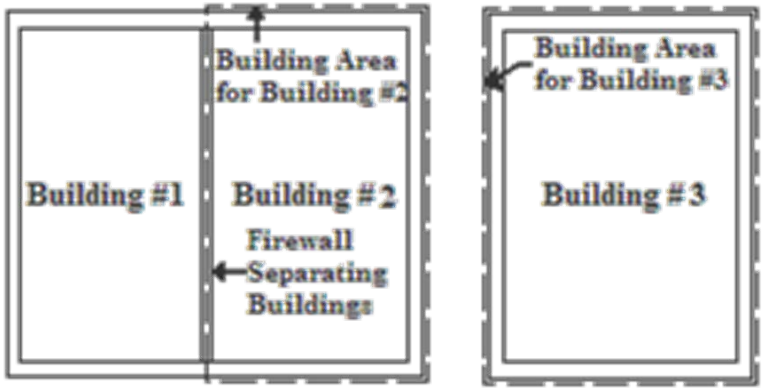
To limit the probability that loadbearing walls or columns and arches exposed to fire will prematurely fail or collapse, which could lead to the failure or collapse of supported floor assemblies during the time required to achieve ***occupant safety*** and for ***emergency responders to perform their duties***, ***which could lead to harm*** of people …

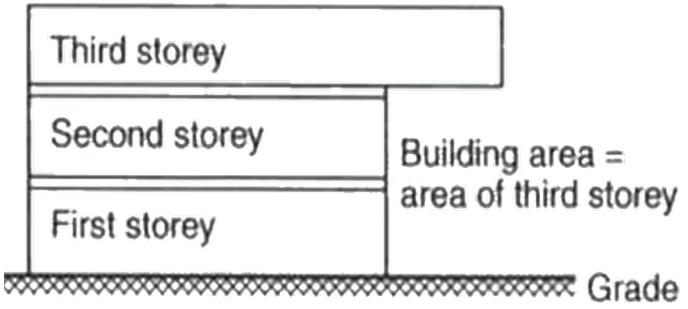
Fire Ratings – Where?

Building Size and Height

Building Area (Footprint)

- Greatest horizontal area,
- Above grade,
- Within the outside surface, or
- Within the outside surface and the center line.





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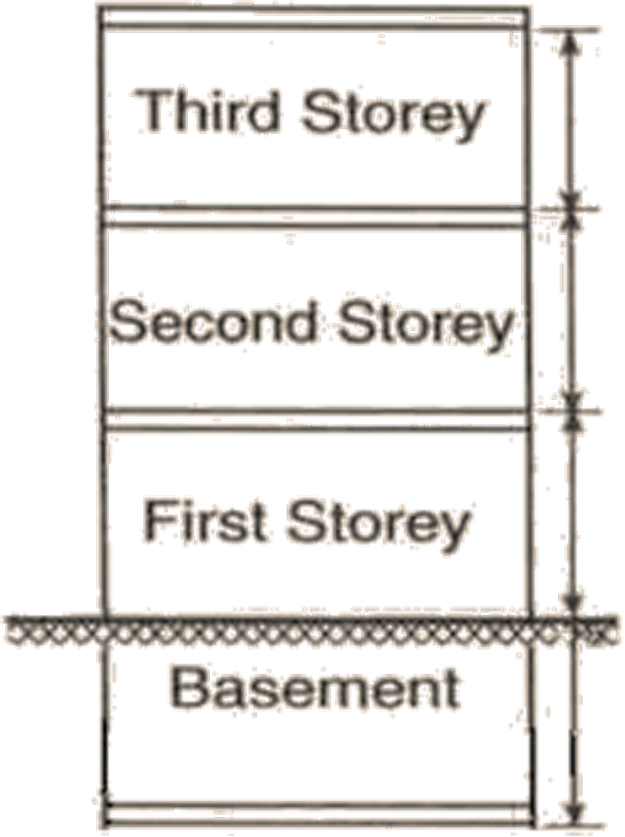
Fire Ratings – Where?

Building Size and Height

Building Height

- The number of storeys contained between the roof and the floor of the first floor.
- 2.0 m threshold



Fire Ratings – Where?

Occupancy Classification

Three options for occupancy classification:

Major	Multiple Major	Subsidiary
		

FIRE RATINGS – WHERE?

Occupancy Classification

Our Hotel Today ???

C

Residential

Major

C and A2

Residential / Assembly

Multiple Major

A2

Assembly

Subsidiary

Fire Ratings – Where?

- A-1 → Theatres
- A-2 → Museums, restaurants
- A-3 → Arenas
- A-4 → Grandstands
- B-1 → Prisons
- B-2 → Hospitals
- B-3 → Assisted living facilities
- C → Apartments
- D → Offices
- E → Supermarkets
- F-1 → Rubber processing plants
- F-2 → Aircraft hangars
- F-3 → Power plants

Group	Division	Description of Major Occupancies
A	1	Assembly occupancies intended for the production and viewing of the performing arts.
A	2	Assembly occupancies not elsewhere classified in Group A.
A	3	Assembly occupancies of the arena type.
B	1	Detention occupancies.
B	2	Treatment occupancies.
B	3	Care occupancies.
C	---	Residential occupancies
D	---	Business and personal services occupancies
E	---	Mercantile occupancies
F	1	High hazard industrial occupancies
F	2	Medium hazard industrial occupancies.
F	3	Low hazard industrial occupancies.

FIRE RATINGS – WHERE?

Table 3.1.3.1.
Major Occupancy Fire Separations[1]
Forming Part of Sentence 3.1.3.1.(1)

Major Occupancy	Minimum *Fire-Resistance Rating* of *Fire Separation*, h												
	Adjoining *Major Occupancy*												
	A-1	A-2	A-3	A-4	B-1	B-2	B-3	C	D	E	F-1	F-2	F-3
A-1	—	1	1	1	2	2	2	1	1	2	[2]	2	1
A-2	1	—	1	1	2	2	2	1	1	2	[2]	2	1
A-3	1	1	—	1	2	2	2	1	1	2	[2]	2	1
A-4	1	1	1	—	2	2	2	1	1	2	[2]	2	1
B-1	2	2	2	2	—	2	2	2	2	2	[2]	2	2
B-2	2	2	2	2	2	—	1	2	2	2	[2]	2	2
B-3	2	2	2	2	2	1	—	1	2	2	[2]	2	2
C	1	1	1	1	2	2	1	—	1	2[3]	[2]	2[4]	1
D	1	1	1	1	2	2	2	1	—	—	3	—	—
E	2	2	2	2	2	2	2	2[3]	—	—	3	—	—
F-1	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	3	3	—	2	2
F-2	2	2	2	2	2	2	2	2[4]	—	—	2	—	—
F-3	1	1	1	1	2	2	2	1	—	—	2	—	—

Fire Ratings – Where?

Specific Hazards from the NBC and NFC

Janitors' rooms	Exits	Elevator hoistways
Elevator machine rooms	Service rooms	Electrical rooms
Emergency generator rooms	Vertical service spaces	Combustible refuse storage

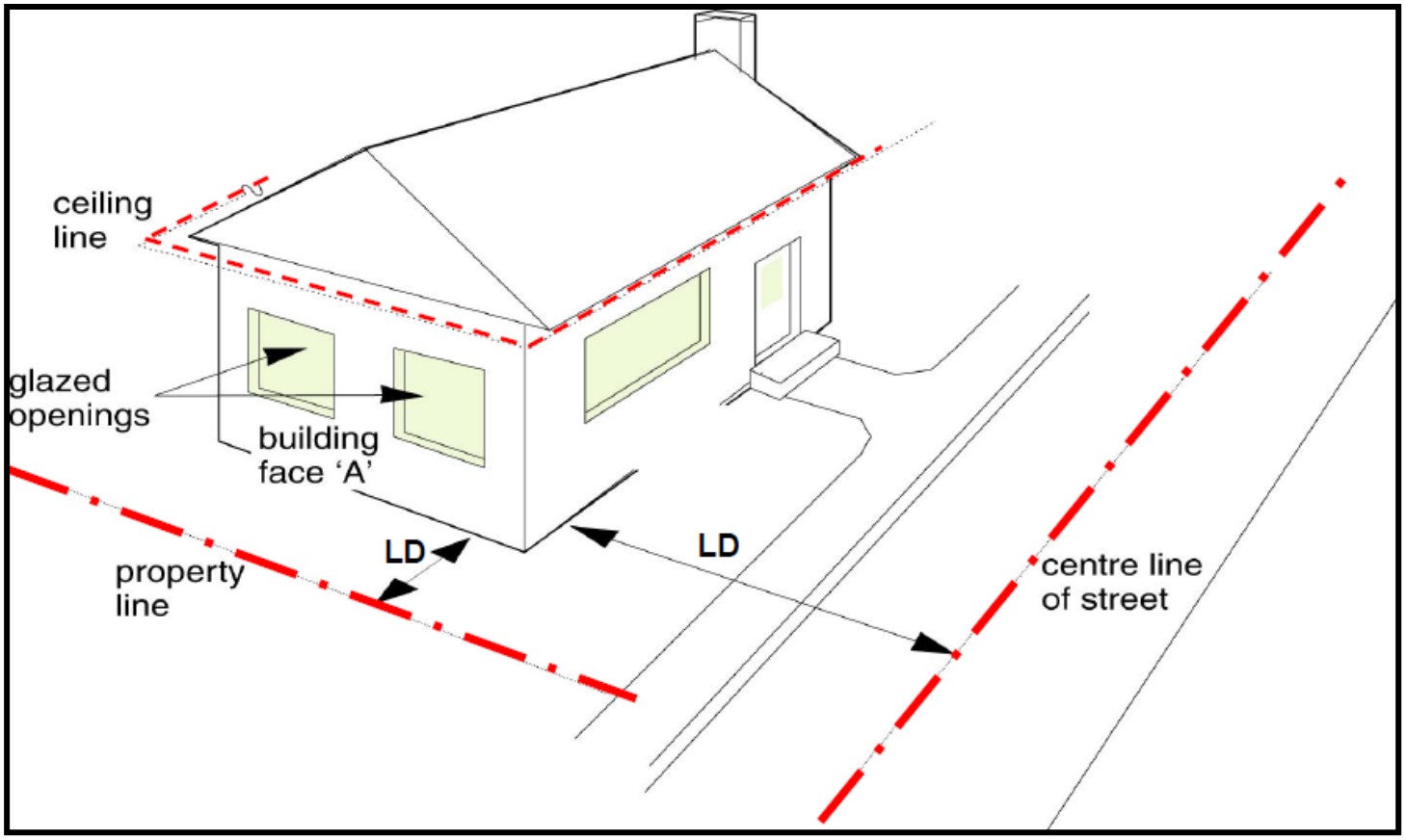
Fire Ratings – Where?

Spatial Separation

Limiting Distance:

The distance from an exposing building face to property line, center line of street, or imaginary line between 2 buildings or fire compartments on the same property measured at right angles to exposing building face.

FIRE RATINGS – WHERE?



FIRE RATINGS – WHERE?

Occupancy Classification of *Building or Fire Compartment*	Maximum Area of *Unprotected Openings* Permitted, % of *Exposing Building Face* Area	Minimum Required *Fire-Resistance Rating*	Type of Construction Required	Type of Cladding Required
Group A, B, C, D, or Group F, Division 3	0 to 10	1 h	*Noncombustible*	*Noncombustible*
	> 10 to 25	1 h	*Combustible or Noncombustible*	*Noncombustible*
	> 25 to 50	45 min	*Combustible or Noncombustible*	*Noncombustible*
	> 50 to < 100	45 min	*Combustible or Noncombustible*	*Combustible or Noncombustible*
Group E, or Group F, Division 1 or 2	0 to 10	2 h	*Noncombustible*	*Noncombustible*
	> 10 to 25	2 h	*Combustible or Noncombustible*	*Noncombustible*
	> 25 to 50	1 h	*Combustible or Noncombustible*	*Noncombustible*
	> 50 to < 100	1 h	*Combustible or Noncombustible*	*Combustible or Noncombustible*

Fire Ratings – Where?

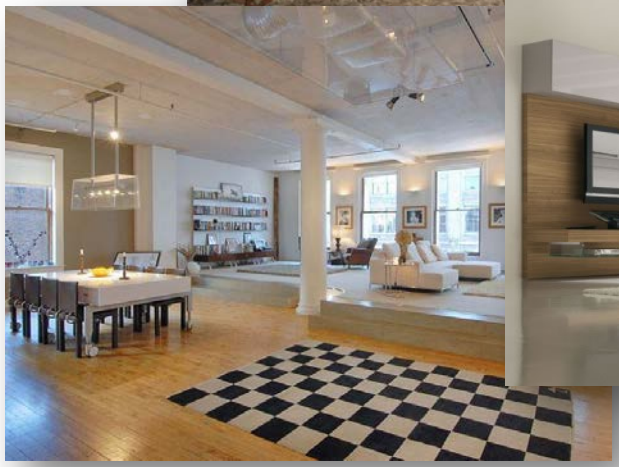
St Lawrence Burns vs Today's Homes

- Winter 1958 in Aultsville, Ontario
- 8 abandoned buildings for seaway construction
- Radiation, tenability, ventilation
- Non rated walls

Fire Ratings – Where?

St Lawrence Burns vs Today's Homes

- Contemporary Fuel Loading
- Openness and Ventilation
- Material Properties



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FIRE RATINGS – WHERE?

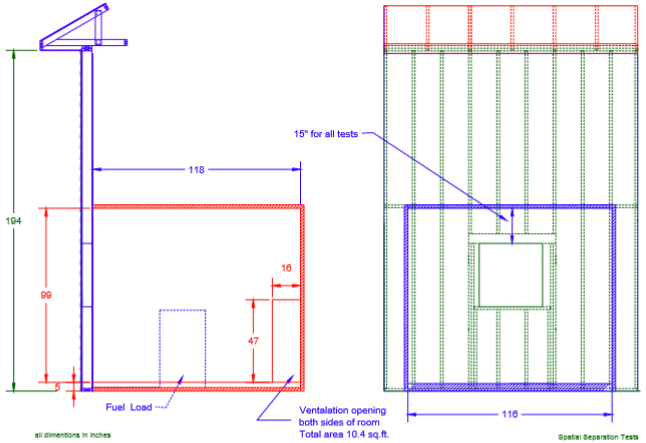

Figure 3. Drawing of fire compartment.

Figure 4. Mixed fuel package of wood cribs and plastic pipes.

NRC·CNRC

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Fire Ratings –

Compliance with Combustible Construction Options

Fire Ratings – How?

Heavy Timber Construction (NBC User's Guide)

- Is a type of combustible construction.
- Permitted where 45 min or less fire-resistance rating is required and combustible construction allowed.
- Wooden elements with large sections for roof and floor assemblies.
- Permitted for roof assemblies of sprinklered buildings where noncombustible would be required.

FIRE RATINGS – HOW?

Table 3.1.4.6.
Heavy Timber Dimensions
Forming Part of Sentence 3.1.4.6.(3)

Supported Assembly	Structural Element	Solid Sawn (width × depth), mm × mm	Glued-Laminated (width × depth), mm × mm	Round (diam), mm
Roofs only	Columns	140 × 191	130 × 190	180
	Arches supported on the tops of walls or abutments	89 × 140	80 × 152	—
	Beams, girders and trusses	89 × 140	80 × 152	—
	Arches supported at or near the floor line	140 × 140	130 × 152	—
Floors, floors plus roofs	Columns	191 × 191	175 × 190	200
	Beams, girders, trusses and arches	140 × 241 or 191 × 191	130 × 228 or 175 × 190	—

Fire Ratings – How?

Fire Retardant Treated Wood

NBC Article 3.1.4.5.

- Wood that is pressure impregnated with fire-retardant chemicals in conformance with CAN/CSA-080 Series, “Wood Preservation,” and
- Have a flame spread rating not more than 25.

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Fire Ratings – How?

Fire Retardant Treated Wood

Decorative Wood Cladding (NBC Article 3.1.5.21.)

- Building req'd to be noncombustible construction,
- On exterior marquee fascias of a storey having direct access to street or access route,
- ASTM 2898, " Accelerated Weathering for Fire Retardant Treated Wood for Fire Testing," and
- CAN/ULC-S102, "Test for Surface Building Characteristics of Building Materials and Assemblies.

Fire Ratings – How?

Fire Retardant Treated Wood

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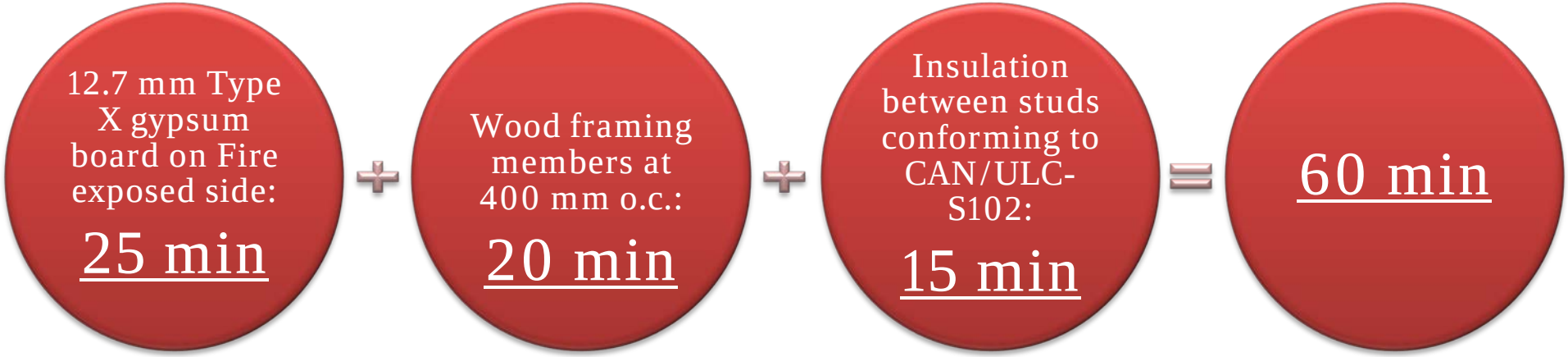
Fire Ratings – How?

Appendix D 2.3 methods

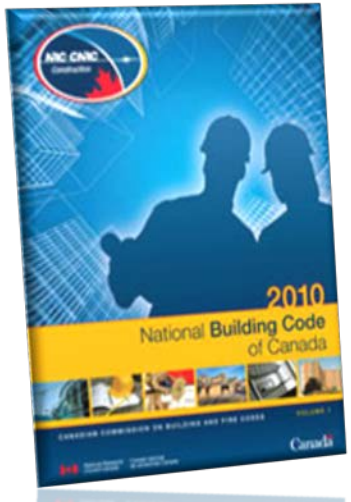
Additive Method Example: 1 h GWB Interior Partition



FIRE RATINGS – HOW?

Appendix D 2.3 methods

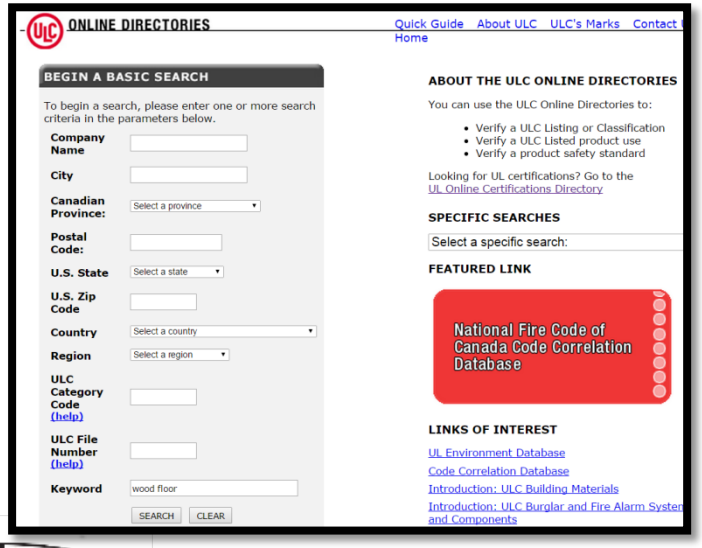
REVAMP FOR 2015

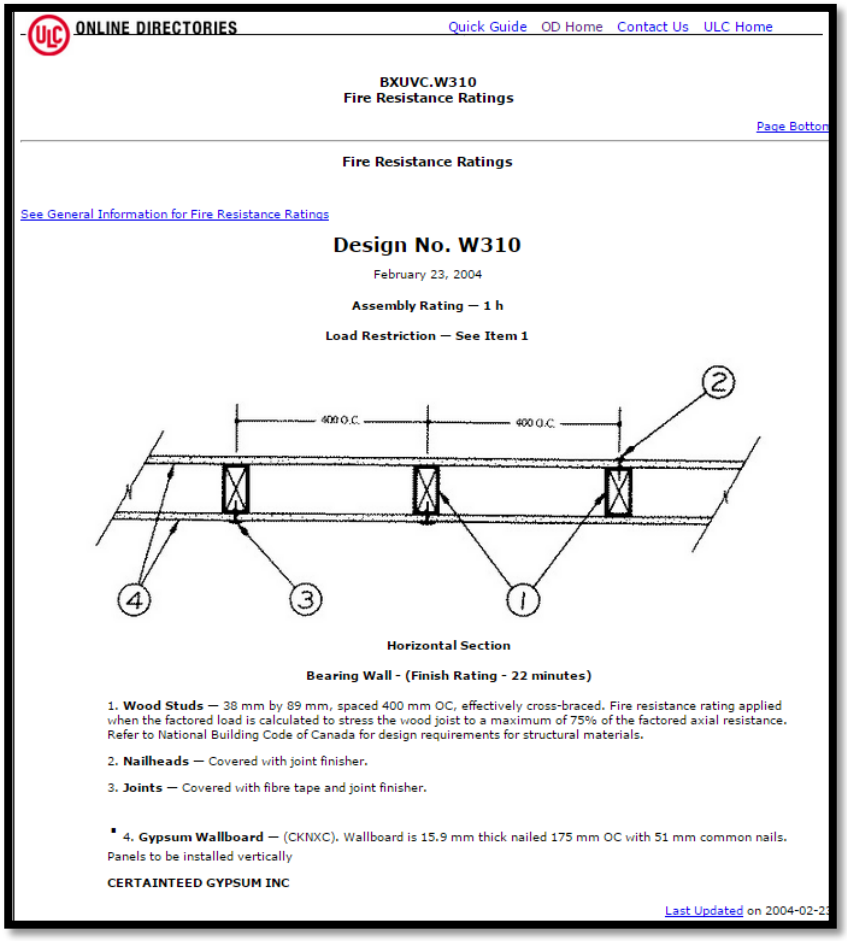


FIRE RATINGS – HOW?

Design References

UL/ULC online Directory





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Fire Ratings – How?

Design References

- Canadian Wood Council
  - 2010 Wood Design Manual
  - Fire Safety Design in Buildings

Fire Ratings – How?

Performance of Wood Components

CLT Handbook

- CLT manufacturing
- Structural design of CLT elements
- Seismic performance of CLT buildings
- Connections in CLT buildings
- Duration of load and creep factors for CLT panels
- Vibration performance of CLT floors
- Fire performance of CLT assemblies
- Acoustic performance of CLT assemblies
- Building enclosure design using CLT
- Environmental performance of CLT

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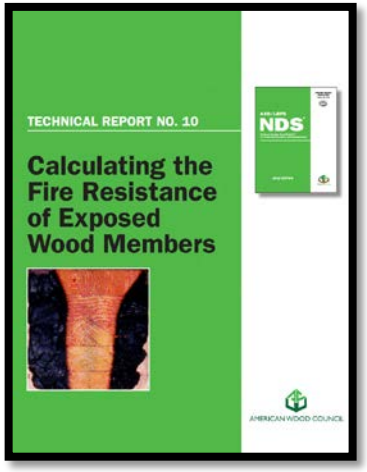
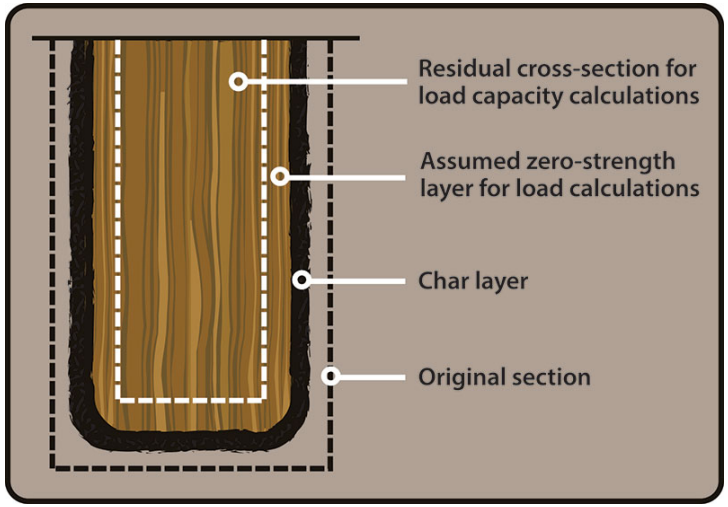
Fire Ratings – How?

Design References

American Wood Council

Tr-10: Calculating the Fire Resistance of Exposed Wood Members





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Fire Ratings – How?

Ongoing Research

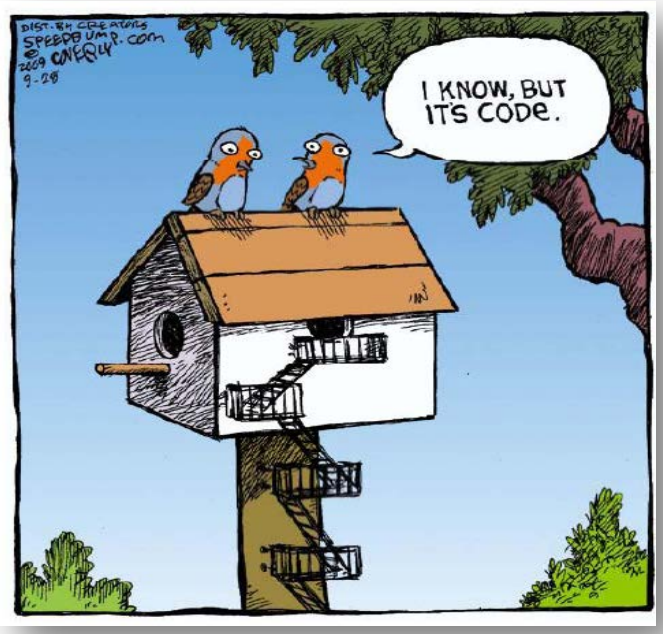
NRC / IRC

- Fire researchers making strides in mid-rise wood research project
- Changes to allow six-storey wood construction under consideration for National Codes

Fire Ratings – How?

Look to Other Jurisdictions

Alternative Solutions



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- Introductions
- Fire Ratings
  - Background
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FIRE PERFORMANCE

Loss History in Canada

Canadian Mortgage and Housing Corporation (CMHC),
"Canadian Housing Fire Statistics" ***… Death by 1000 Cuts …***

- Residential Fires
  - 70-80% deaths
  - 60-70% injuries

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FIRE PERFORMANCE

Loss History

NFPA 557, *"Determination of Fire Loads for Use in Structural Fire Protection Design"*

The purpose of this standard is to provide methods and values for use in the determination of fire loads and fire load densities for design-basis fires, which is done using a ***risk basis framework***.

FIRE PERFORMANCE

Table 5.7.3.2 Fraction of Fires That Are Structurally Significant in Eating and Drinking Establishments

Type of Construction	No Detection or No Alarm (No Sprinklers)	Detection and Alarm Present (No Sprinklers)	No Detection or No Alarm (Sprinklers Present)	Detection and Alarm Present (Sprinklers Present)
Fire resistive	0.16	0.10	0.05	0.03
Protected noncombustible	0.16	0.06	0.04	0.04
Unprotected noncombustible	0.20	0.10	0.08	0.05
Protected ordinary	0.19	0.11	0.06	0.04
Unprotected ordinary	0.24	0.14	0.08	0.05
Protected wood frame	0.22	0.12	0.08	0.05
Unprotected wood frame	0.29	0.19	0.11	0.07

Table 5.7.4.2 Fraction of Fires That Are Structurally Significant in Other Public Assembly Buildings

Type of Construction	No Detection or No Alarm (No Sprinklers)	Detection and No Alarm Present (No Sprinklers)	No Detection or No Alarm (Sprinklers Present)	Detection and Alarm Present (Sprinklers Present)
Fire resistive	0.13	0.05	0.04	0.02
Protected noncombustible	0.16	0.06	0.03	0.05
Unprotected noncombustible	0.20	0.13	0.04	0.06
Protected ordinary	0.21	0.11	0.04	0.03
Unprotected ordinary	0.31	0.15	0.05	0.03
Protected wood frame	0.33	0.18	0.12	0.05
Unprotected wood frame	0.43	0.22	0.10	0.08

Fire Performance

Systems Approach to Fire Safety

… A Holistic Approach

- **Manage the People**
  - Early detection providing early warning
- **Manage the Fire**
  - Active Protection: Sprinklers
  - Passive Protection: Compartmentalization,

FIRE PERFORMANCE

Emerging Methods

Mid-Rise Timber Construction

Fire Performance

Emerging Methods (International Perspective)

- University of Canterbury - Timber Research
  - Multi-storey timber buildings, 2 to 20+ storeys
  - Seismic design
  - Fire safety

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Fire Performance

Emerging Methods

Fire safety

- Fire safety of timber lining and cladding materials
- Fire resistance of pre-stressed timber frames and walls
- Fire resistance of timber-concrete composite floors
- Fire code requirements in target markets

Fire Performance

Emerging Methods

Coatings

Albi

CONTEGO INTERNATIONAL, INC

safecoat

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FIRE PERFORMANCE

Alternative Solutions ....

Questions