Resiliency: let's talk wind and earthquakes

April 26 2022

Robert Jonkman, Vice President, Codes and Engineering
cwc.ca

Canadian Wood Council
Conseil canadien du bois

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Resilience definition

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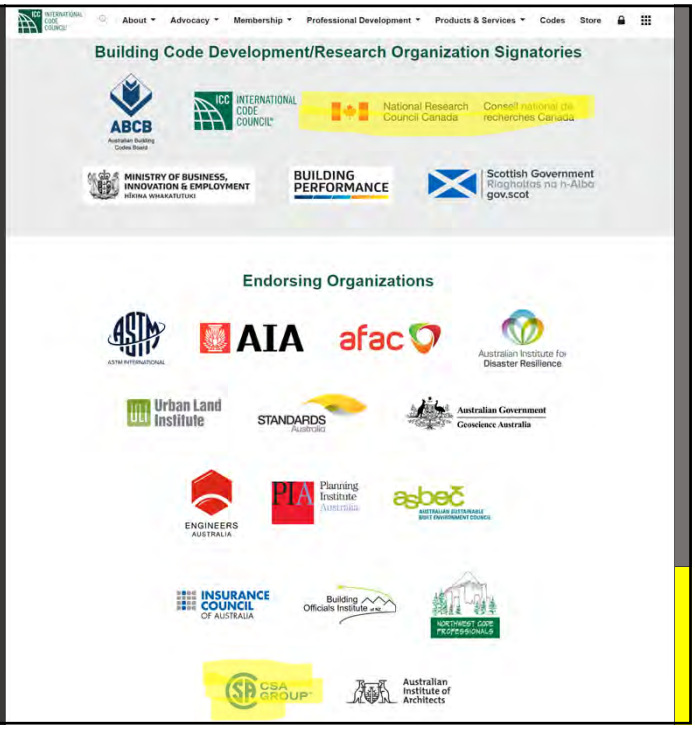
Global Resiliency - ICC (iccsafe.org)



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Resilience definition components

Before: plan, prepare, adapt (to changing conditions)

During: absorb or limit impact, preferably maintain function

After: recover, bounce back, regain function

Symposium on Balancing Resiliency, Safety and Sustainability October 13, 2017, New Orleans, LA
Defining Resilience Martha G. VanGeem, self, Mount Prospect, IL, USA1

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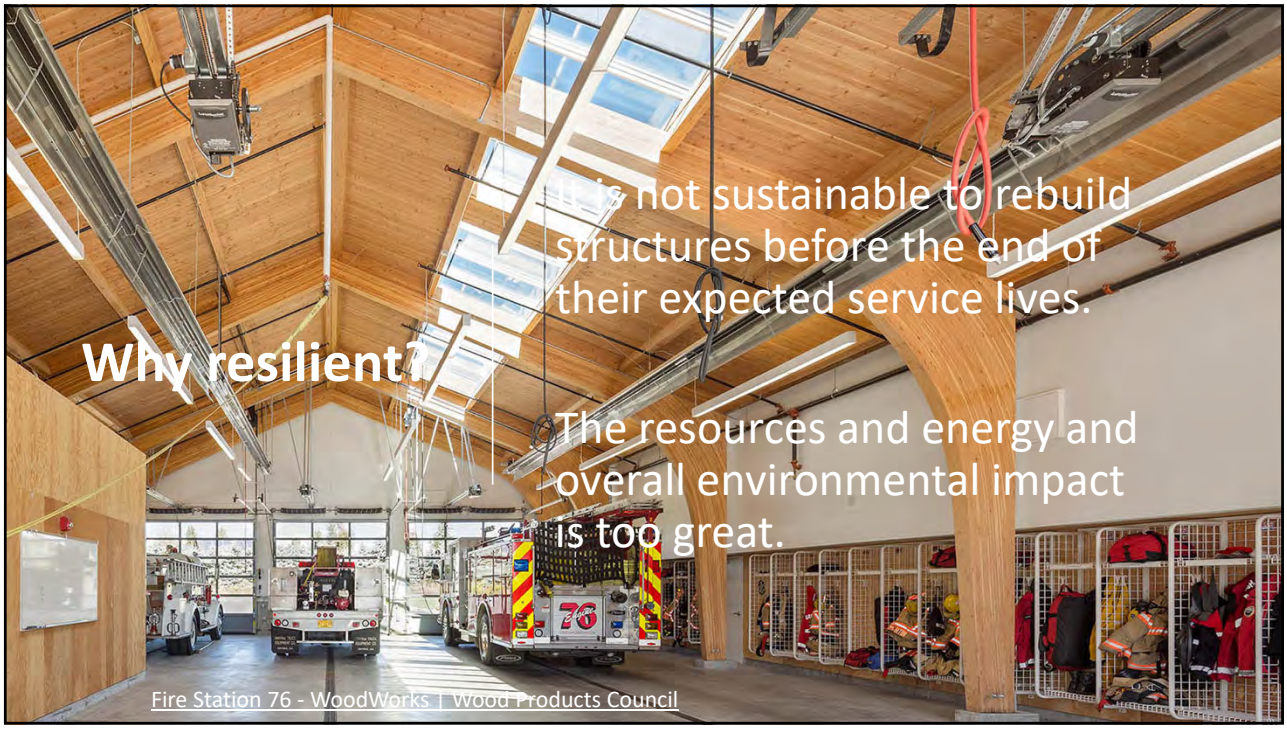
Why resilient?
It is not sustainable to rebuild structures before the end of their expected service lives.
The resources and energy and overall environmental impact is too great.
Fire Station 76 - WoodWorks | Wood Products Council

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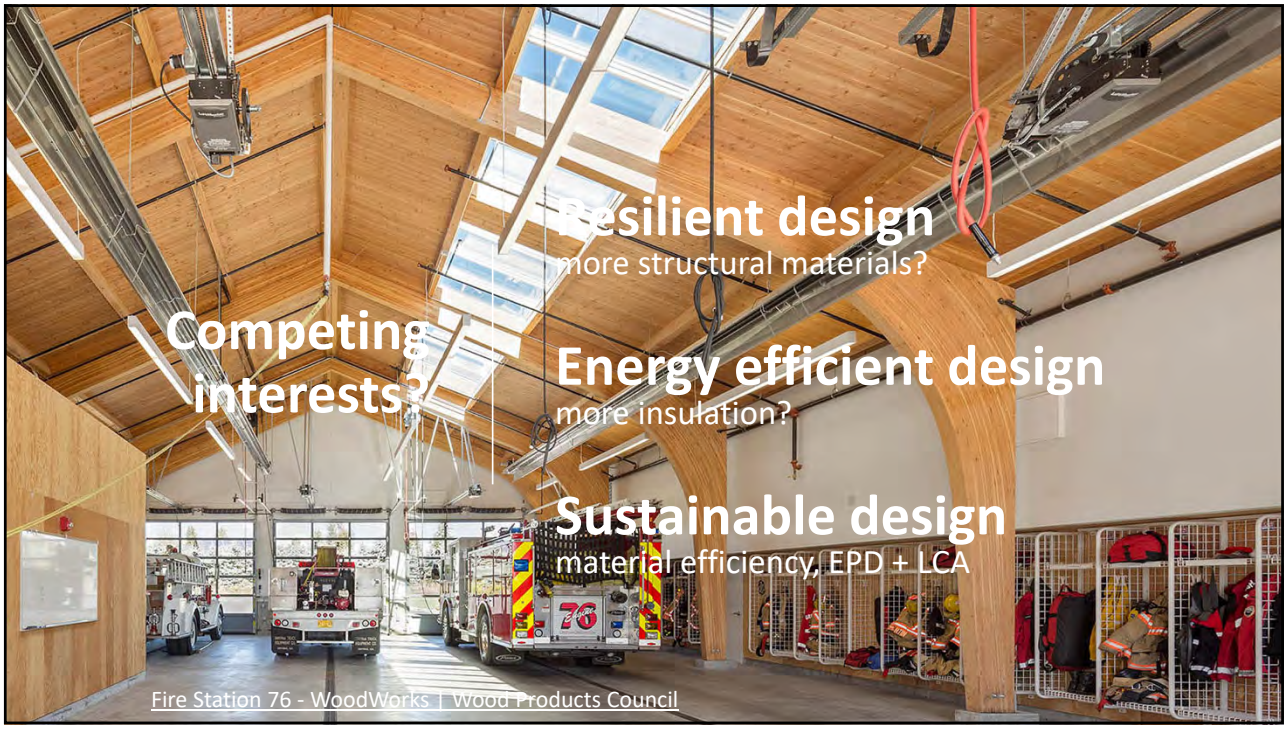
Competing interests?
Resilient design
more structural materials?
Energy efficient design
more insulation?
Sustainable design
material efficiency, EPD + LCA
Fire Station 76 - WoodWorks | Wood Products Council

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Fire Station 76 - WoodWorks | Wood Products Council

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Wind
+ seismic
resilient
design
Fire Station 76 - WoodWorks | Wood Products Council

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How to build wind-resilient buildings
• CSA S520:21 (expected July 2022)
• Dunrobin tornado Sept 21, 2018

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Dunrobin
EF3
Kinburn
Dunrobin tornado Sept 21, 2018
Map: Sarah Stevenson UWO

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How to build wind-resilient buildings

CSA S520:21

- **EF 2** tornado (enhanced fujita scale)
- **180-220** km/h wind speeds

95% of tornadoes in Canada + US are EF 2 or lower

The principles in S520 apply to all wind events

Source: The Northern Tornadoes Project (NTP) - Western University (uwo.ca)

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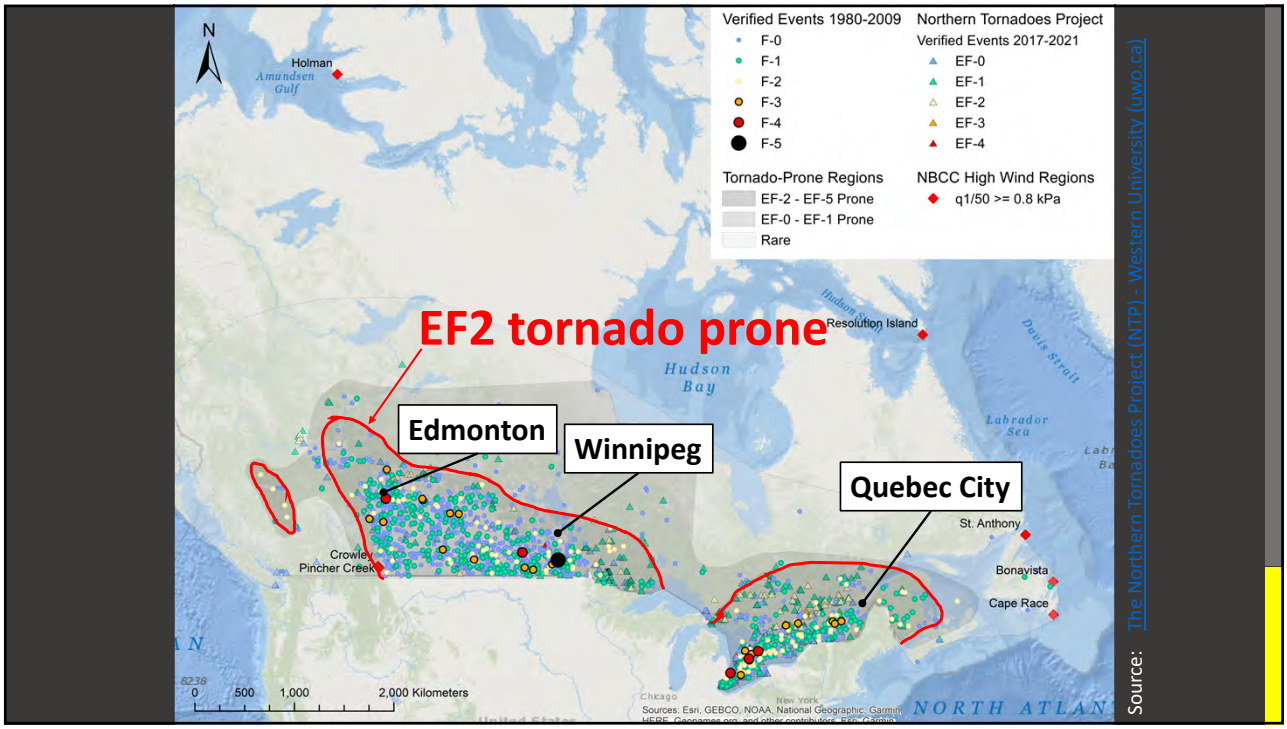

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How to build wind-resilient buildings

1. Highest priority – keep the roof sheathing on

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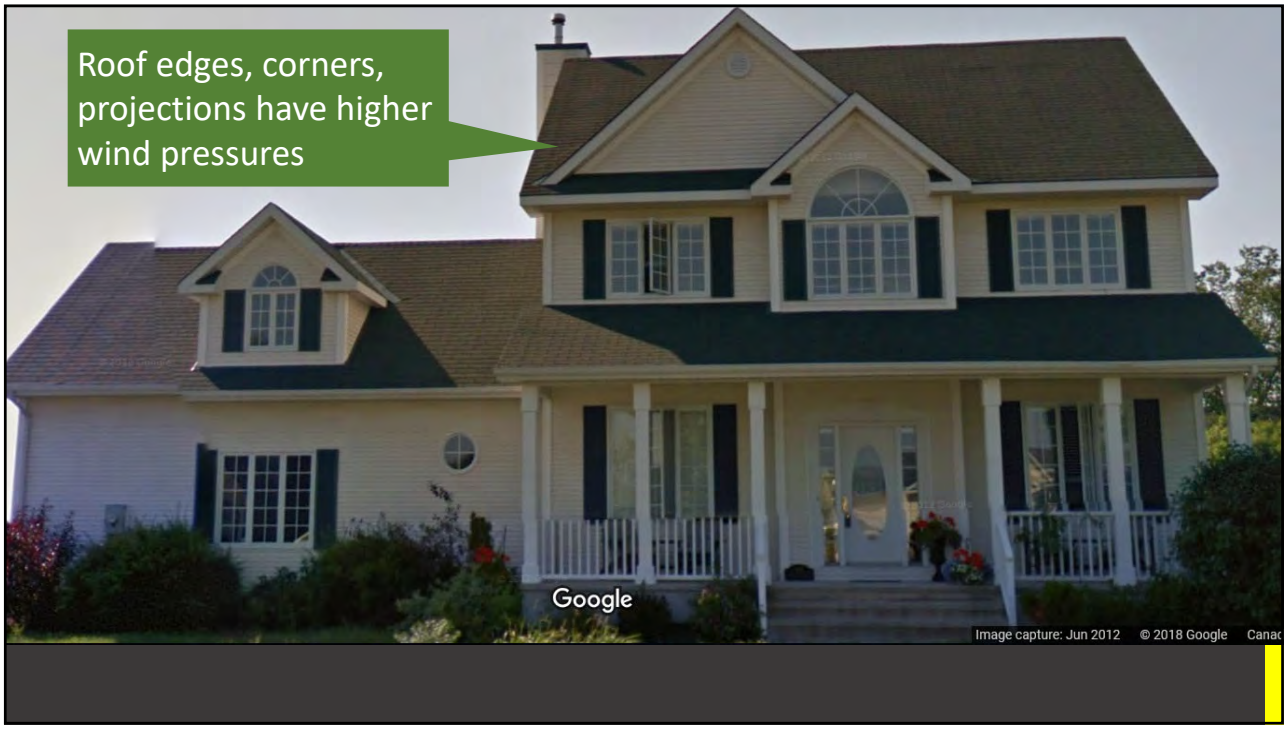
Roof edges, corners, projections have higher wind pressures
Google
Image capture: Jun 2012 © 2018 Google

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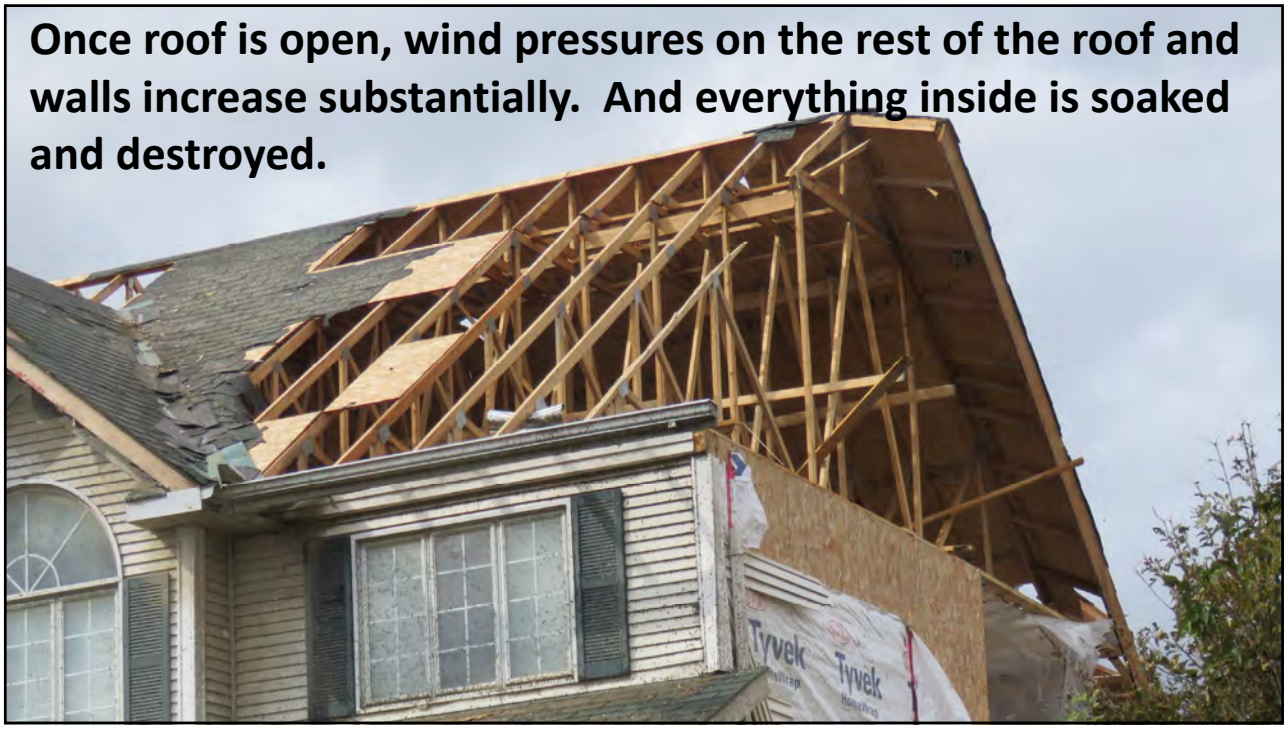
Once roof is open, wind pressures on the rest of the roof and walls increase substantially. And everything inside is soaked and destroyed.
Tyvek
Tyvek

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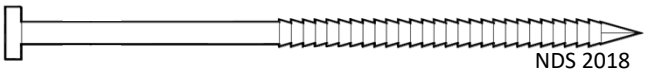
"Roof Sheathing - Ring Shank" nails



Superior withdrawal resistance; head-pull through governs

RSRS nails permitted to be spaced further than common nails

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How to build wind-resilient buildings

2. Beef up the gable ends

Image: APA Building for High-Wind Resilience in Light-Frame Wood Construction – Design Guide M310F 2021

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Gable end walls…
• high wind loads
• often with no interior GWB
• less well fastened as exterior structural sheathing
Hip roofs perform better than gable roof styles, but additional bracing can provide similar benefits.
Stronger attachment of the gable end studs and overhangs to supporting framing is also imperative.
Image: APA M310F 2021

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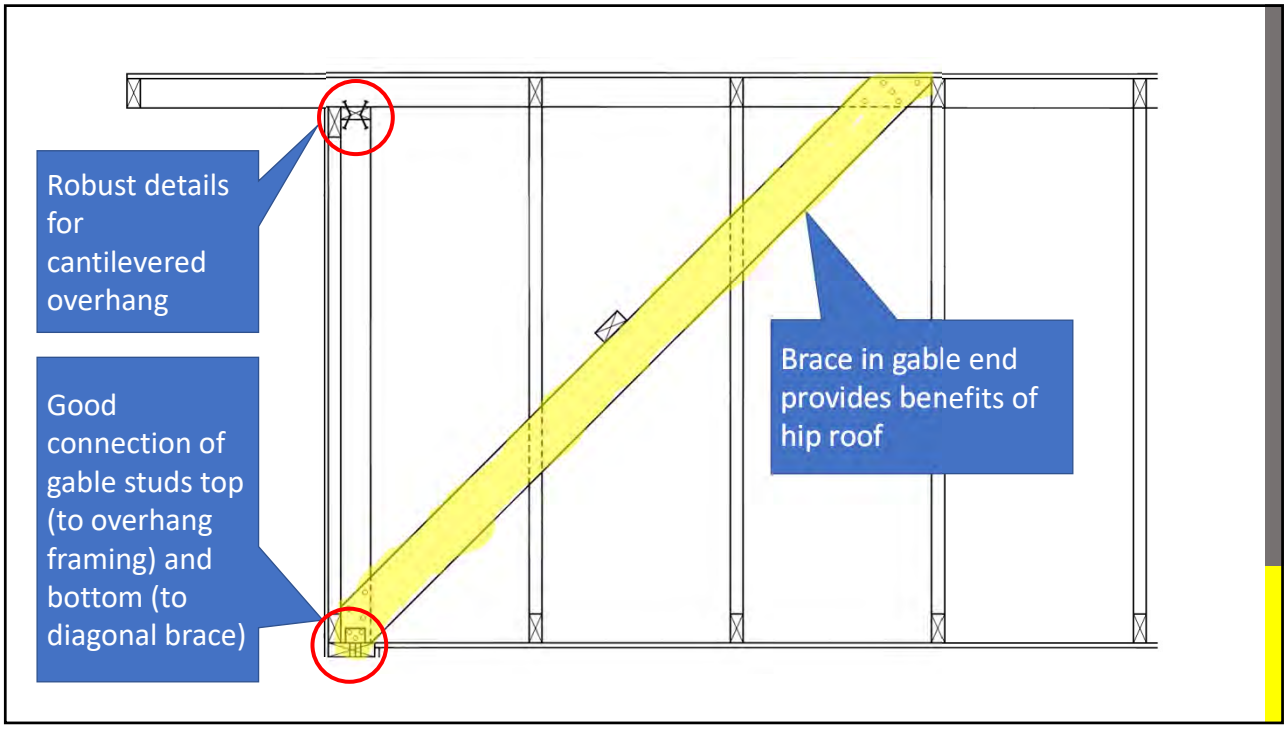
Robust details for cantilevered overhang
Good connection of gable studs top (to overhang framing) and bottom (to diagonal brace)
Brace in gable end provides benefits of hip roof

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How to build wind-resilient buildings

3. Connect upper roof framing and components to lower roof framing robustly

Piggy-backed trusses
Lumber over-framing
Dormers to roof
Chimneys

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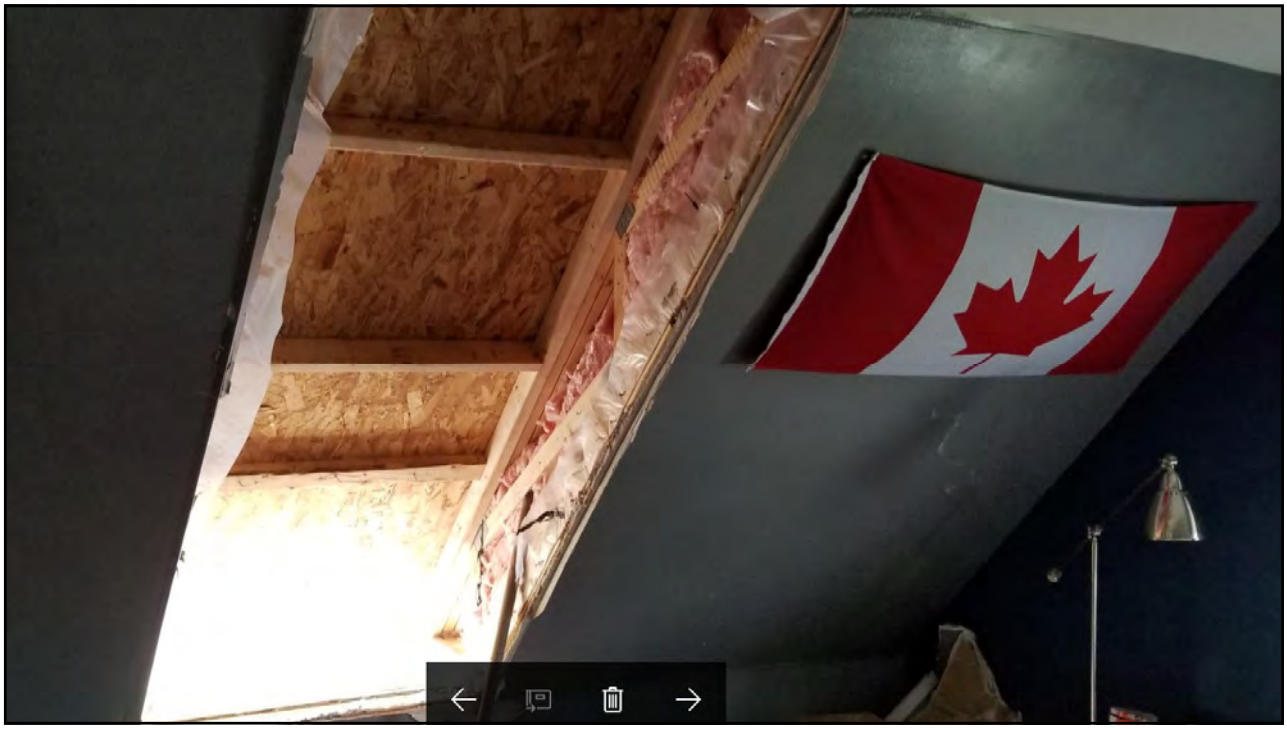

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Source: The Northern Tornadoes Project (NTP) - Western University (uwo.ca)

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How to build wind-resilient buildings

4. **Ensure wall sheathing is adequately attached to resist suction**

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Abrupt corners and larger bump-outs require more robust fastening

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5. Ensure enough wall sheathing is adequately attached to resist lateral movement (NBC Part 9)

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<u>Enough</u> sheathing is needed to resist lateral loads

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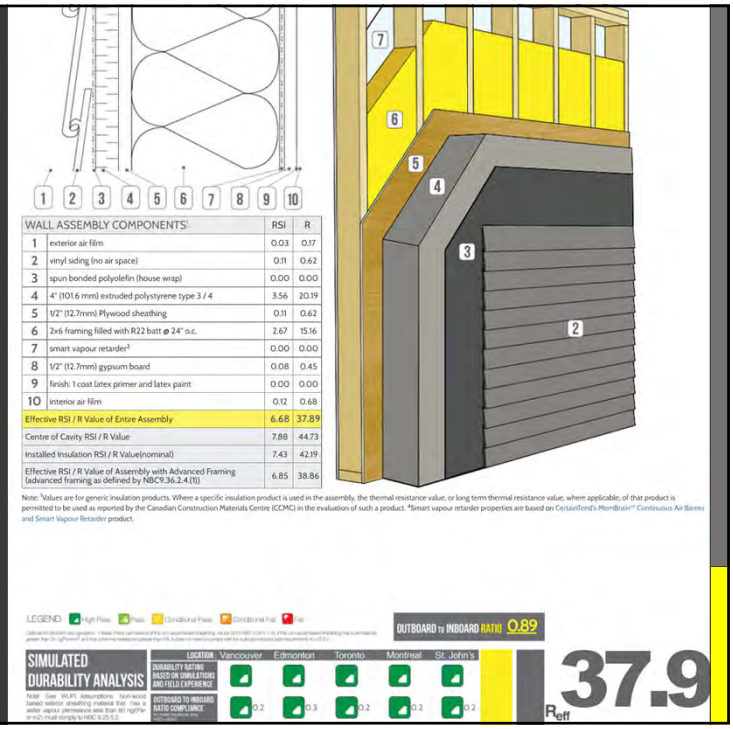
Continuous insulation and wood sheathing work well together…

…Ensure the wood sheathing is fastened directly to the studs.



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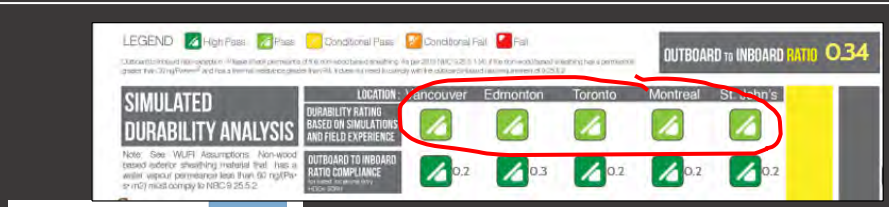
Use EffectiveR.ca to compare wall durability

Best, most resilient

Watch out: read the notes



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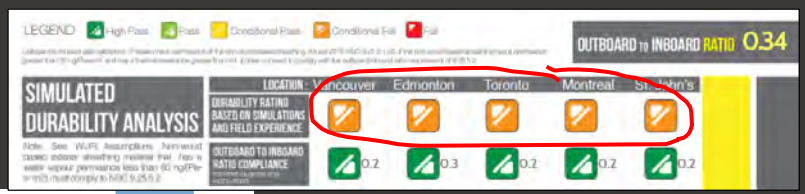

ID of this Wall: 436 Saved

EffectiveR.ca

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Project Team

Project Initiator	Robert Jonkman	Canadian Wood Council
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WUFI Expert Panelist	Graham Finch	RDH Consulting
WUFI Expert Panelist	Chris Schumacher	RDH Consulting

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How to build wind-resilient buildings

6. Use wall sheathing or other methods to bridge assemblies to resist uplift

FORTIFIED Home - Homepage - FORTIFIED - A Program of IBHS

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(384) How Does A Wind Damage Test Work? - YouTube

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Sheathing can be used to resist uplift

Attach sheathing to common framing of adjacent assemblies enhances the uplift resistance.

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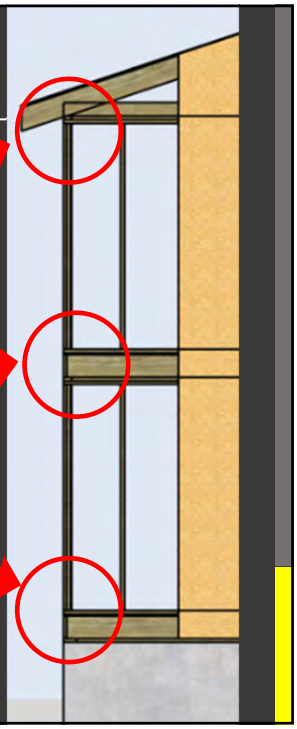
How to build wind-resilient buildings

7. Check the entire uplift load path:



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Roof-to-wall uplift resistance

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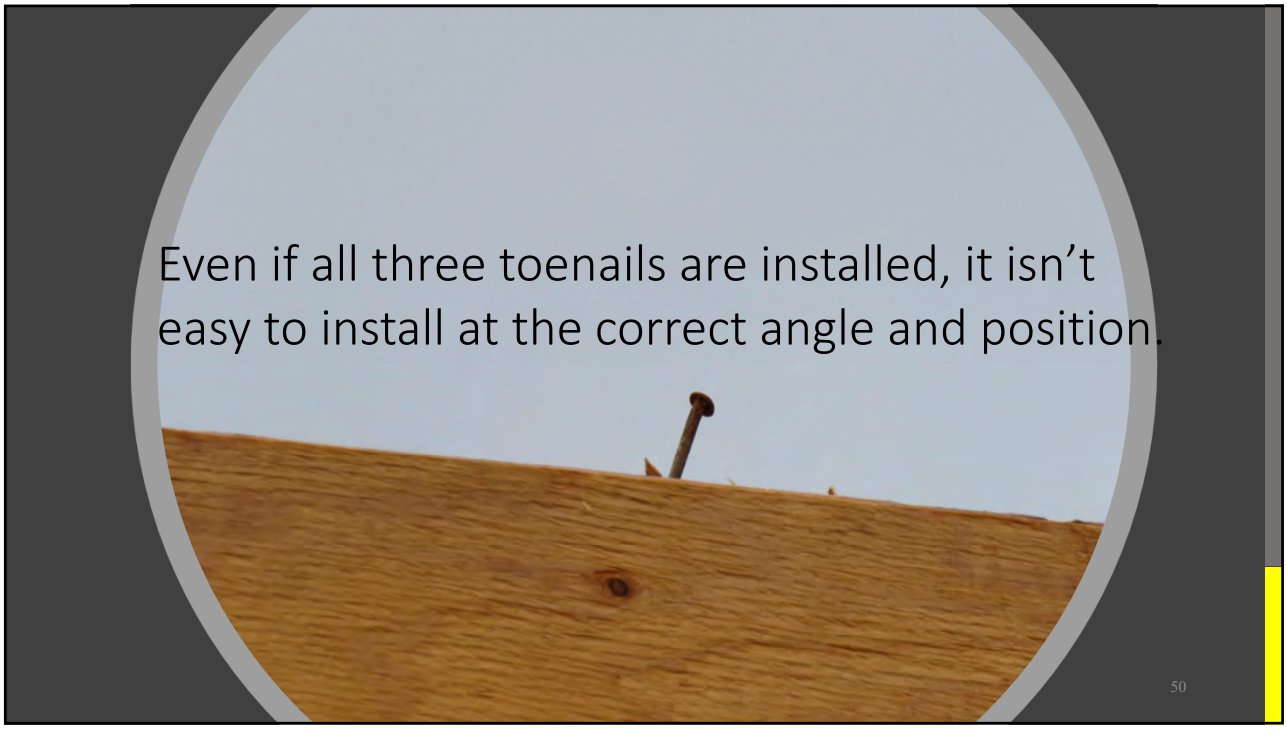
Typical roof framing to top plate

Table 9.23.3.4.
Nailing for Framing
Forming Part of Sentence 9.23.3.4.(1)

Construction Detail	Minimum Length of Nails, mm	Minimum Number or Maximum Spacing of Nails
Roof rafter, roof truss or roof joist to plate – toe nail(3)	82	3

3 toenails

49


Even if all three toenails are installed, it isn't easy to install at the correct angle and position.
50

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Sheathing can be used to resist uplift

APA 330

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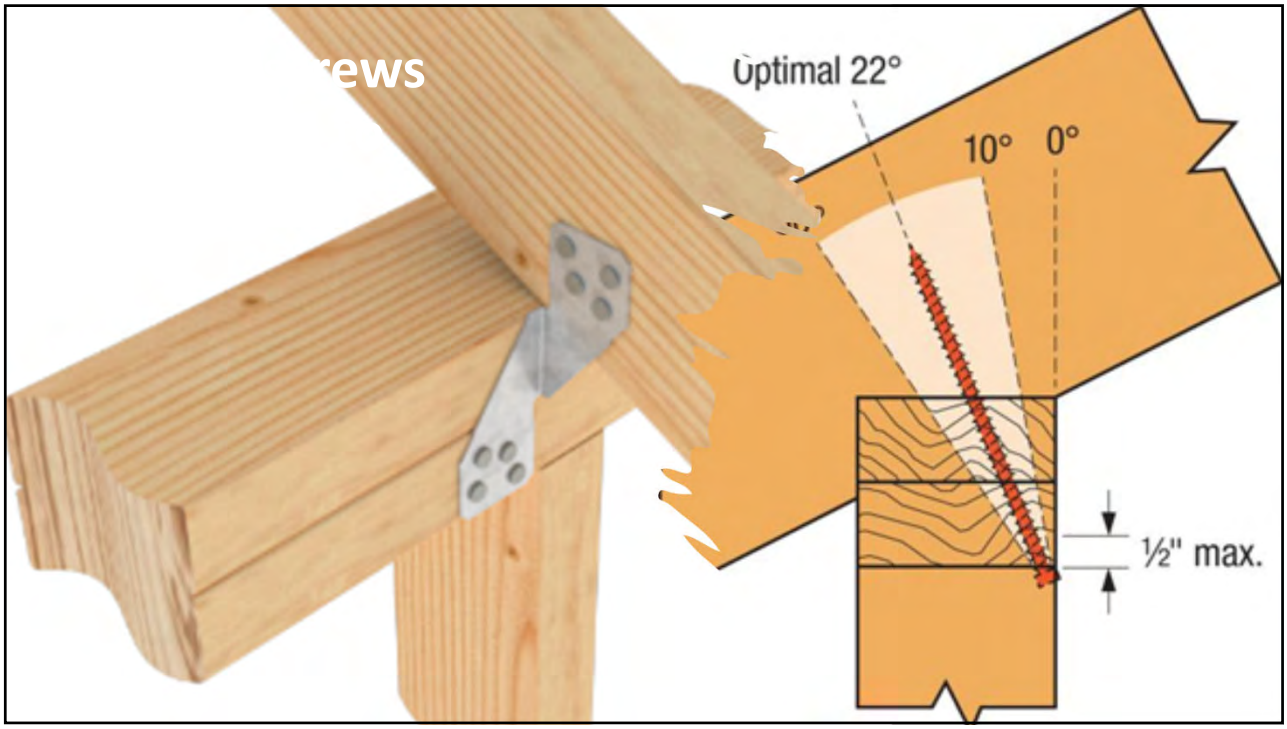

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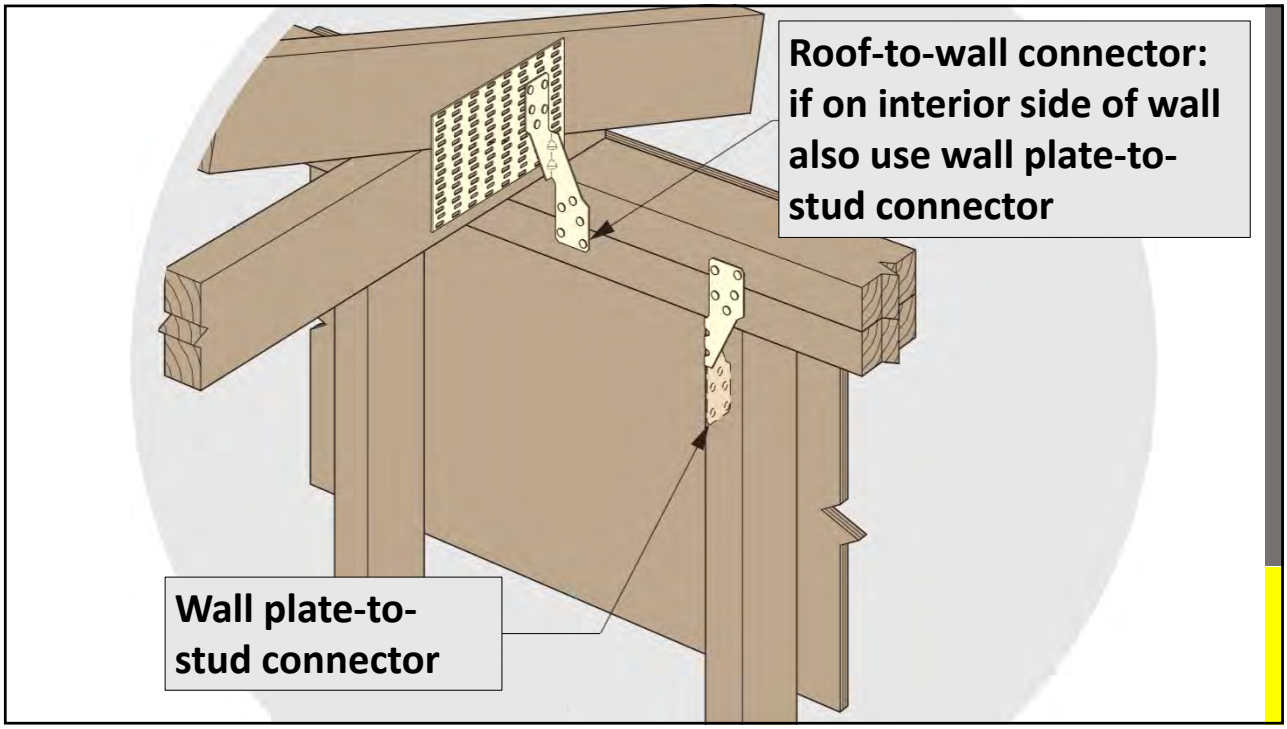
Roof-to-wall connector: if on interior side of wall also use wall plate-to-stud connector
Wall plate-to-stud connector

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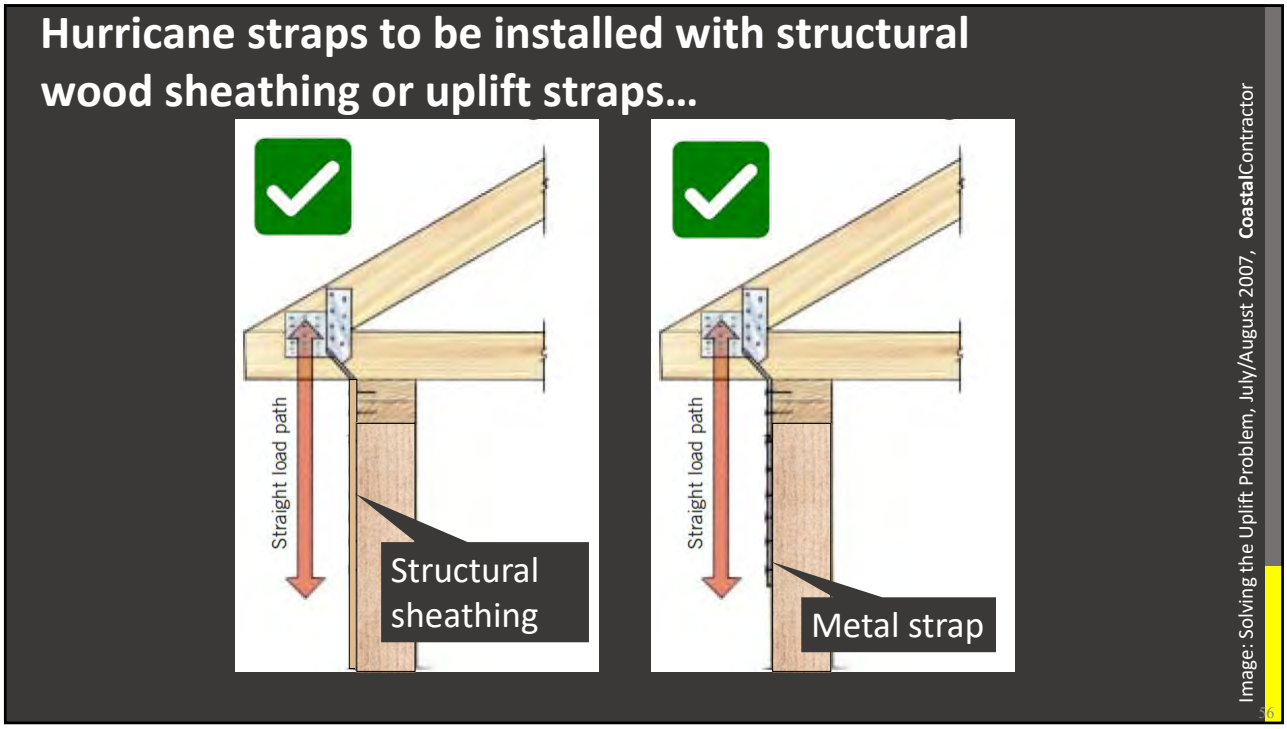
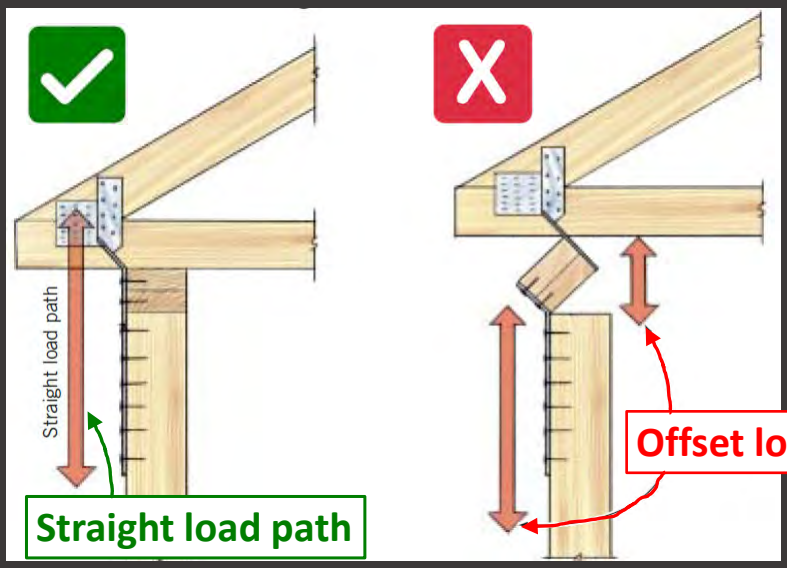

Hurricane straps to be installed with structural wood sheathing or uplift straps…
Straight load path
Structural sheathing
Straight load path
Metal strap
Image: Solving the Uplift Problem, July/August 2007, CoastalContractor

56

…and installed on the same side as the wall plate to stud connection.



57

…the strength of the load path is important.

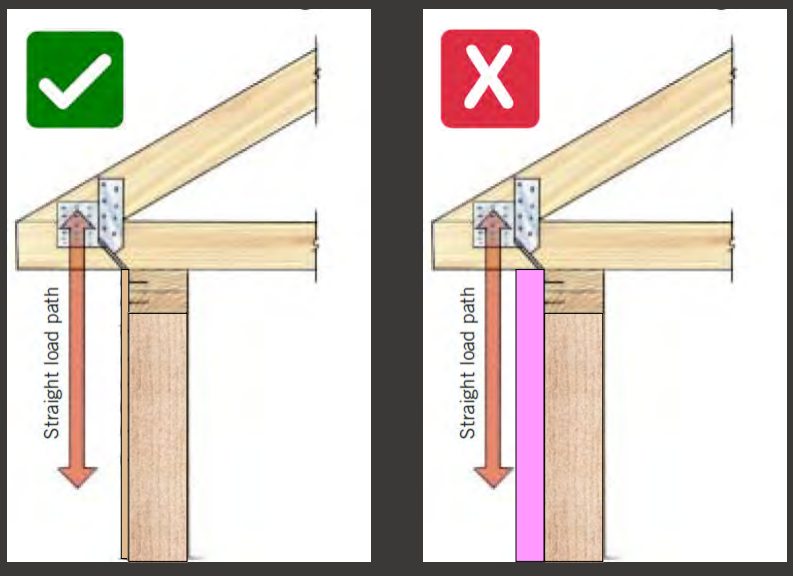


Image: Solving the Uplift Problem, July/August 2007, CoastalContra

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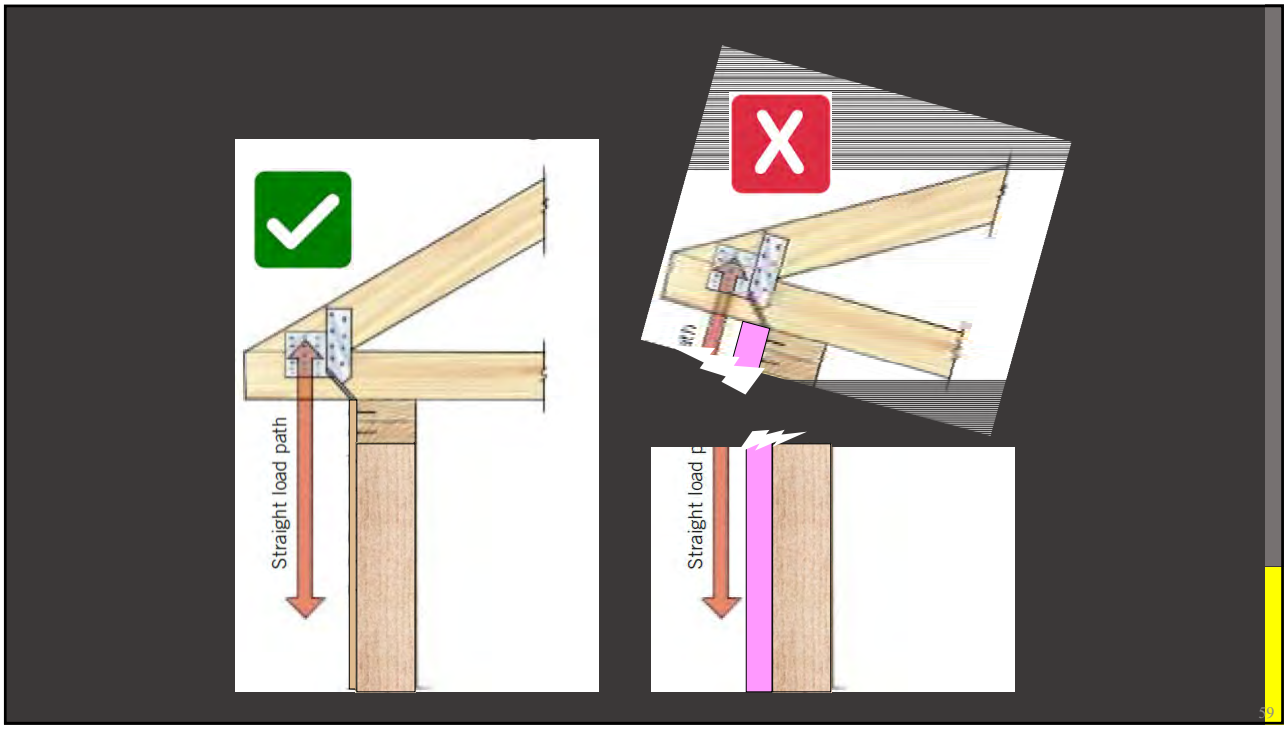

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Wall-to-floor uplift resistance

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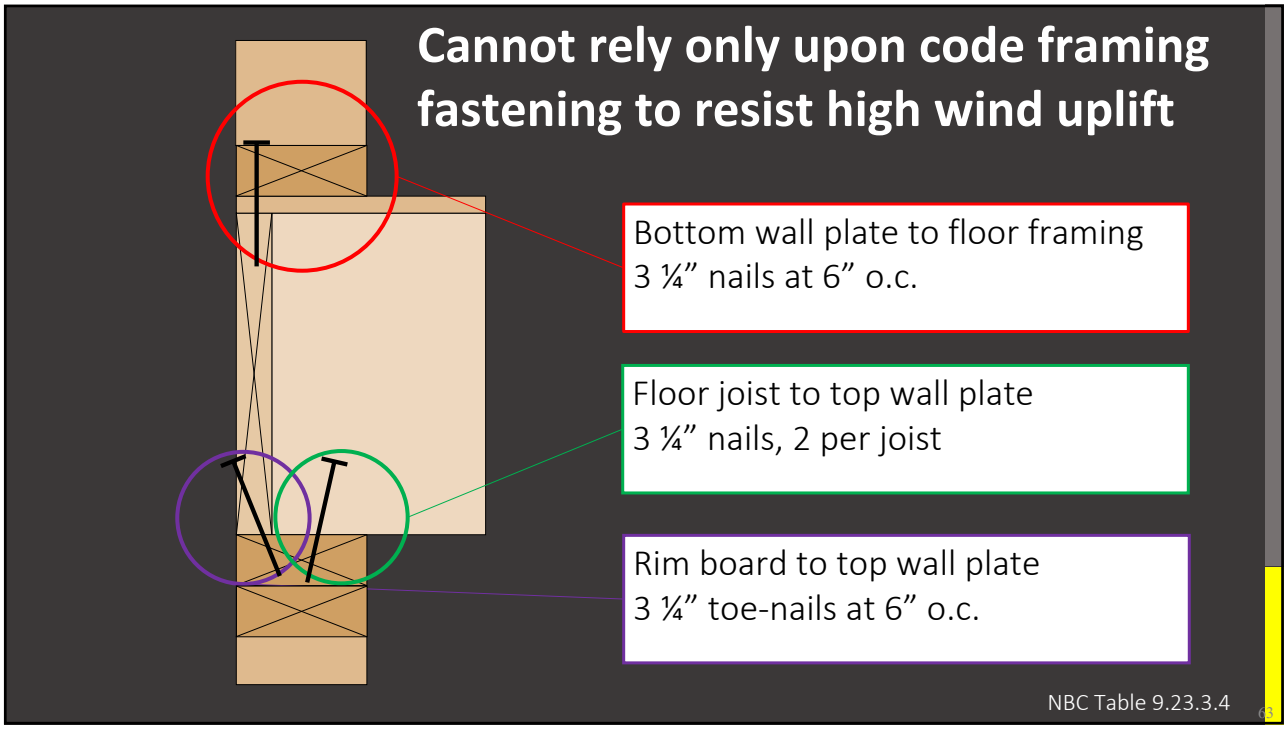
Cannot rely only upon code framing fastening to resist high wind uplift
Bottom wall plate to floor framing
3 ¼" nails at 6" o.c.
Floor joist to top wall plate
3 ¼" nails, 2 per joist
Rim board to top wall plate
3 ¼" toe-nails at 6" o.c.
NBC Table 9.23.3.4

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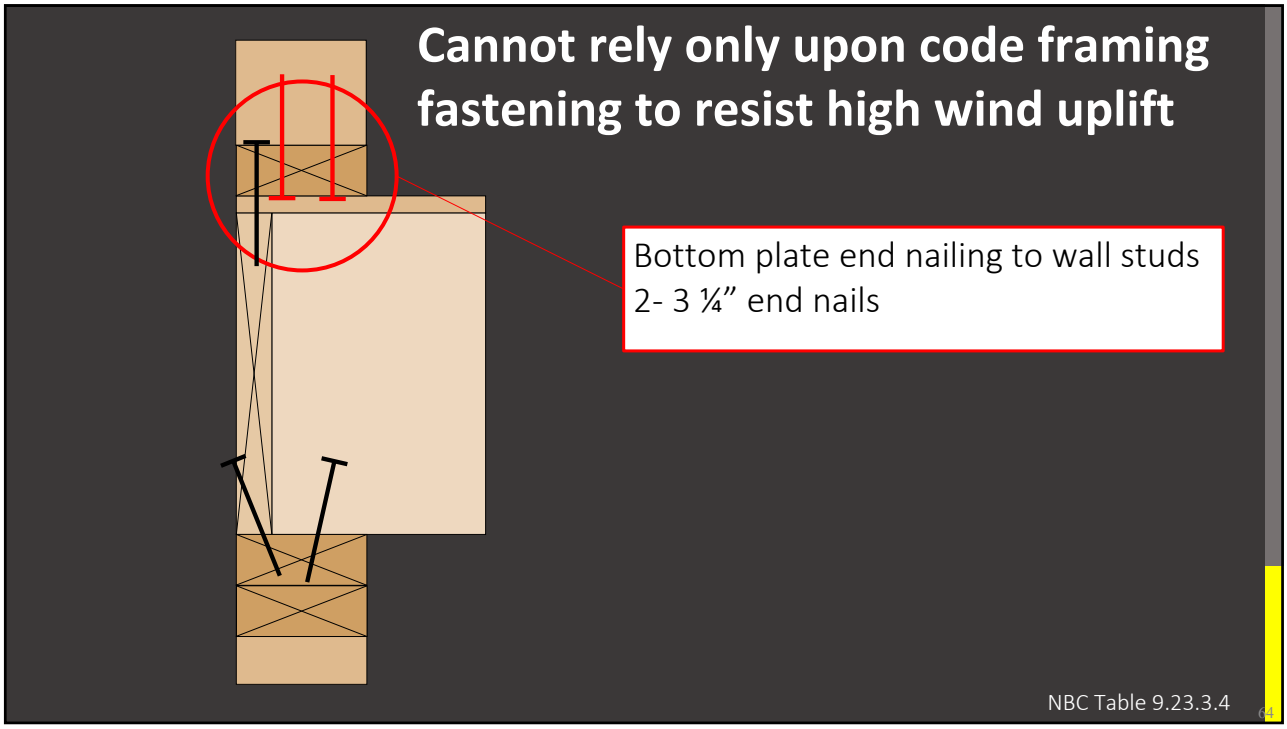
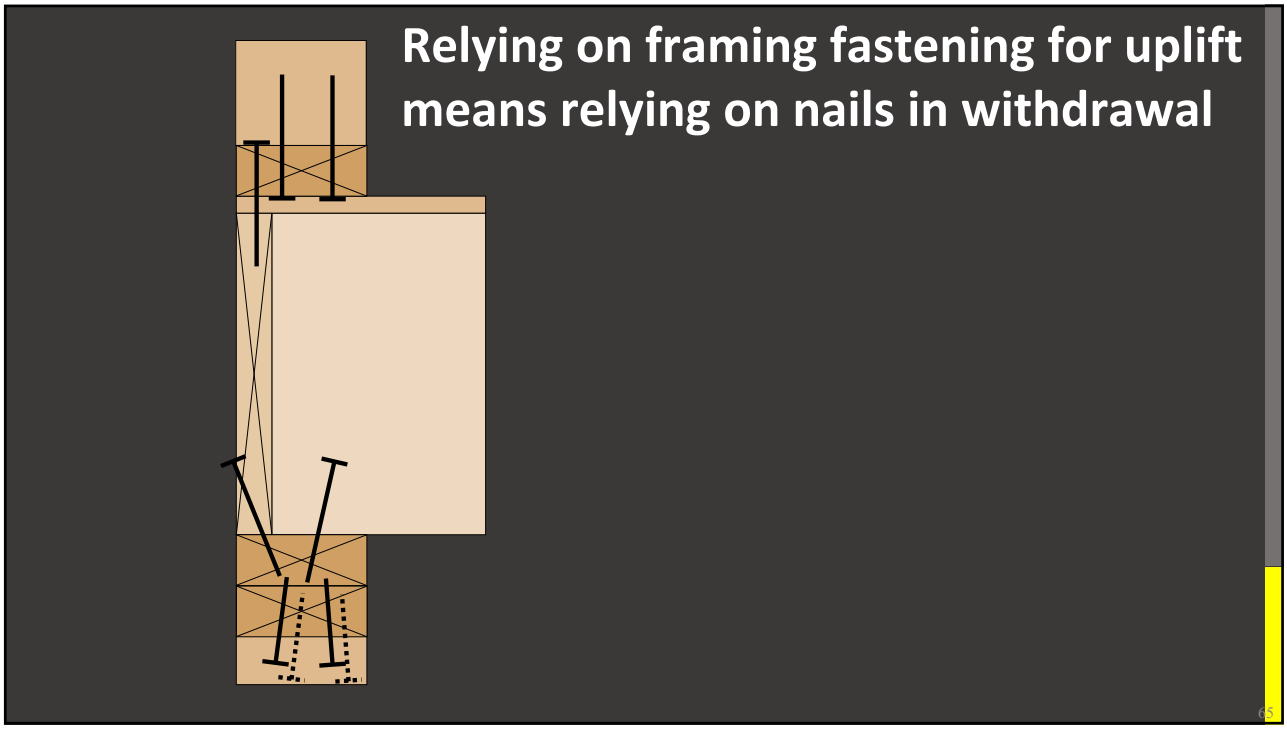
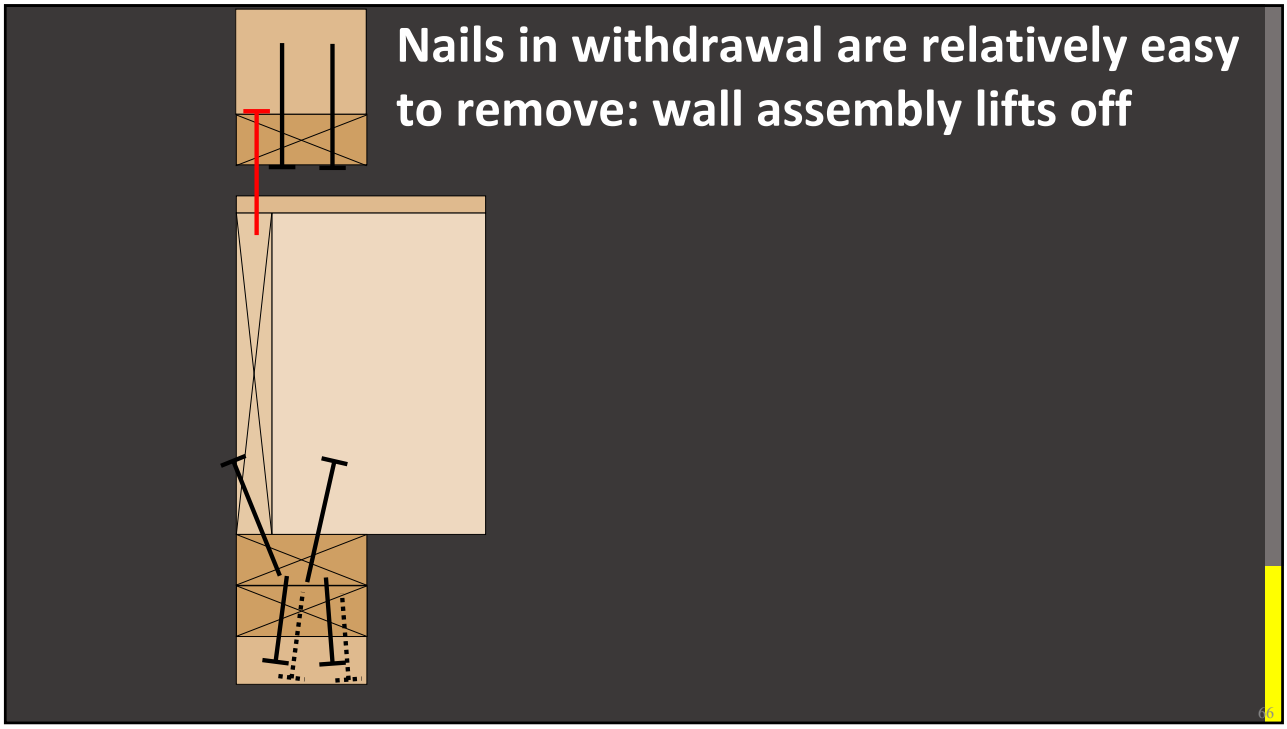

Cannot rely only upon code framing fastening to resist high wind uplift
Bottom plate end nailing to wall studs
2- 3 ¼" end nails
NBC Table 9.23.3.4

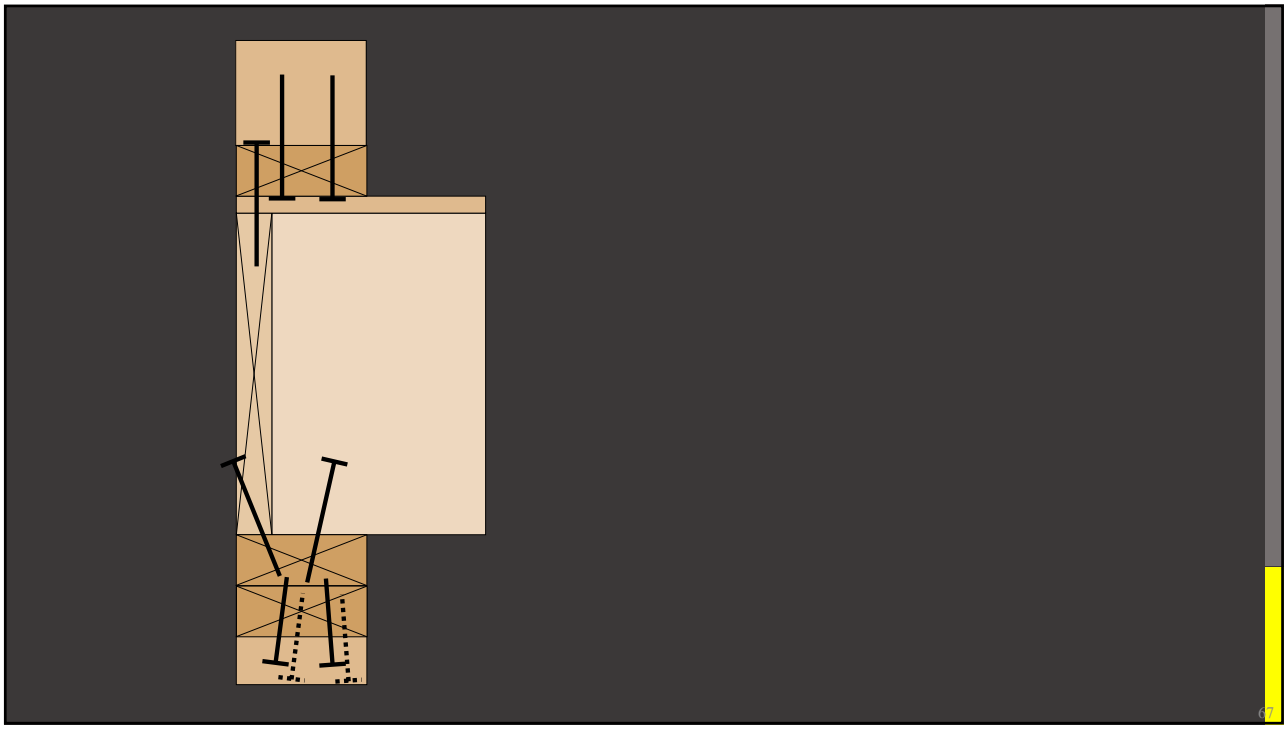
64


Relying on framing fastening for uplift means relying on nails in withdrawal

65


Nails in withdrawal are relatively easy to remove: wall assembly lifts off

66



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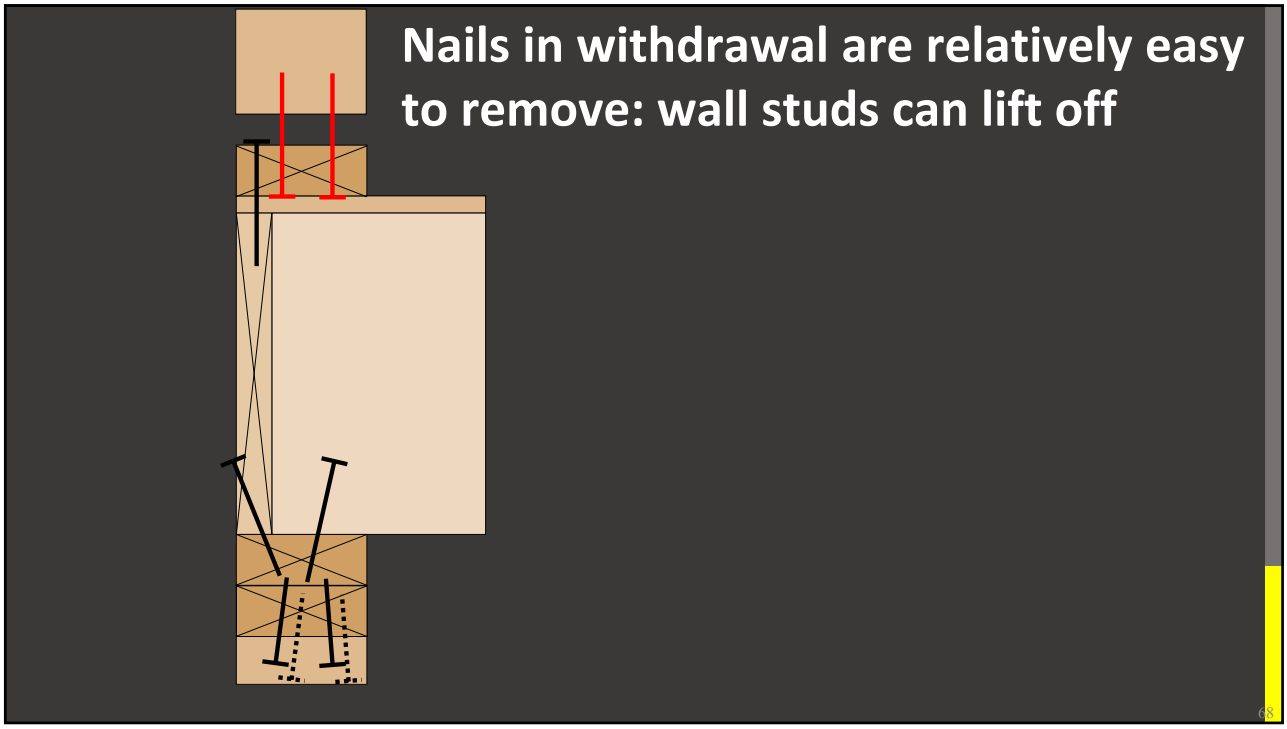
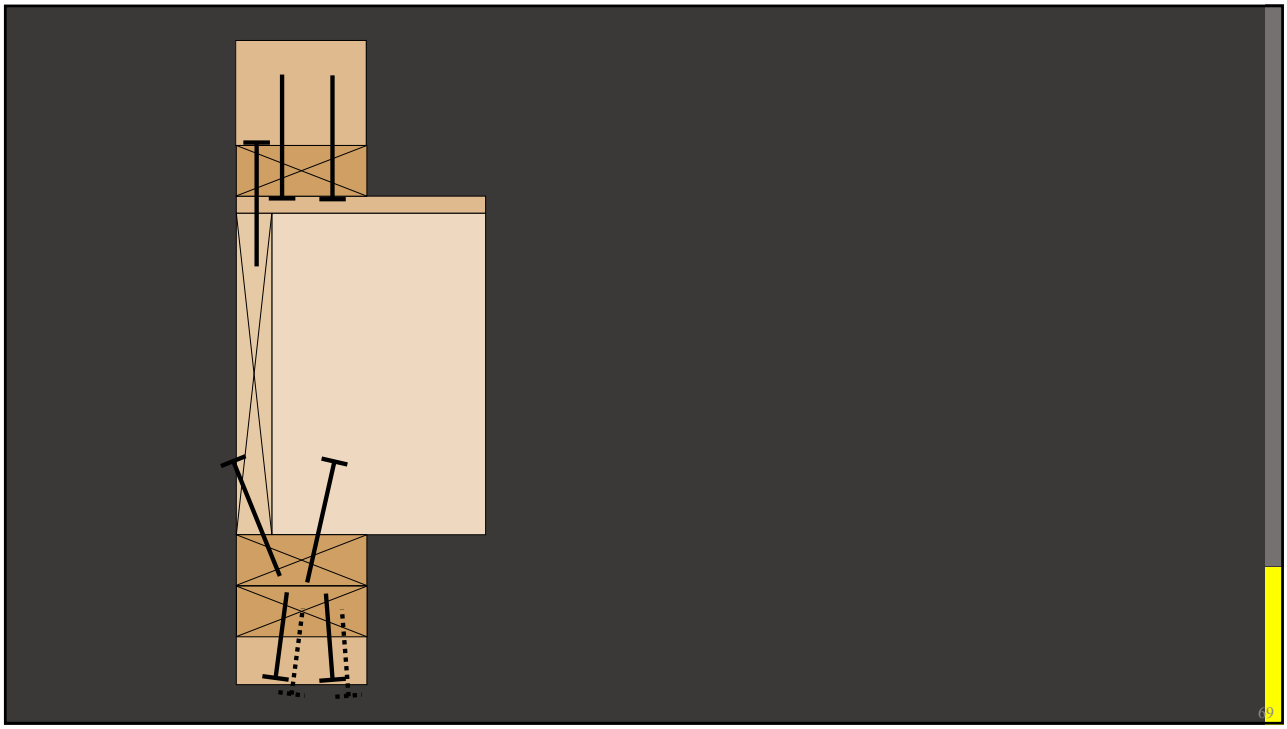

Nails in withdrawal are relatively easy to remove: wall studs can lift off

68



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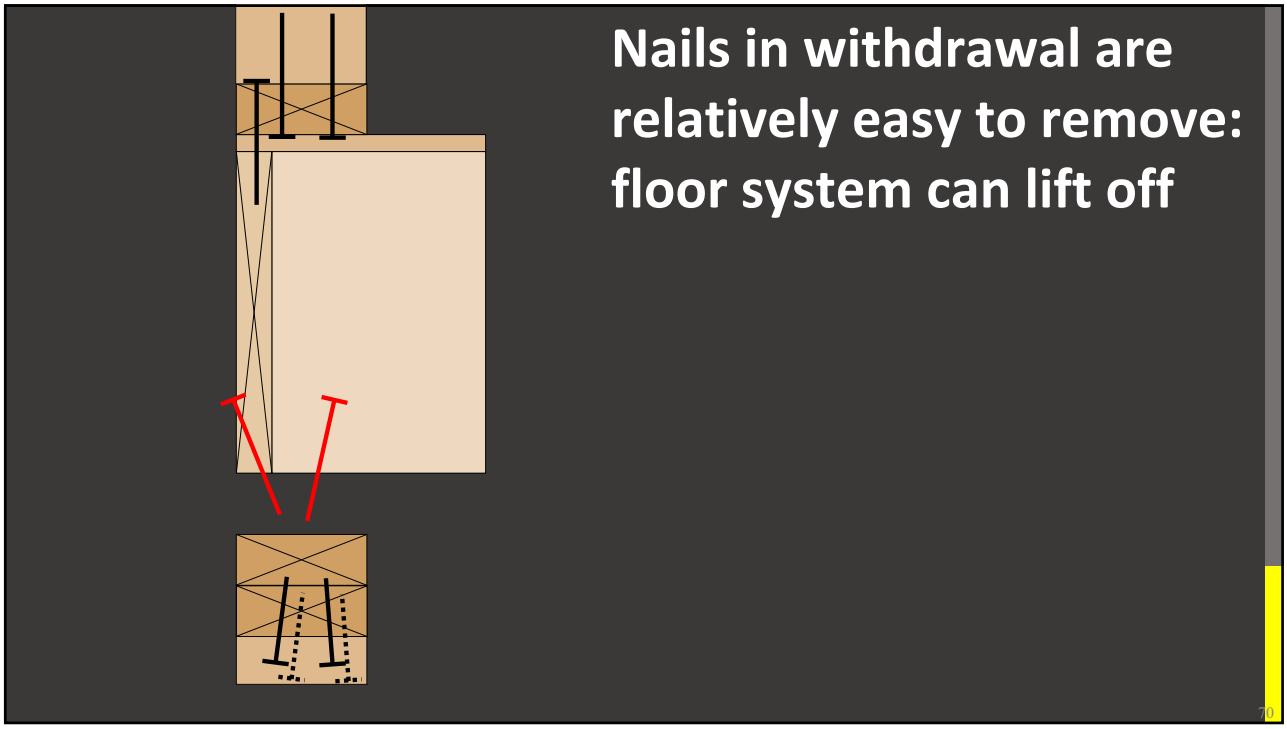
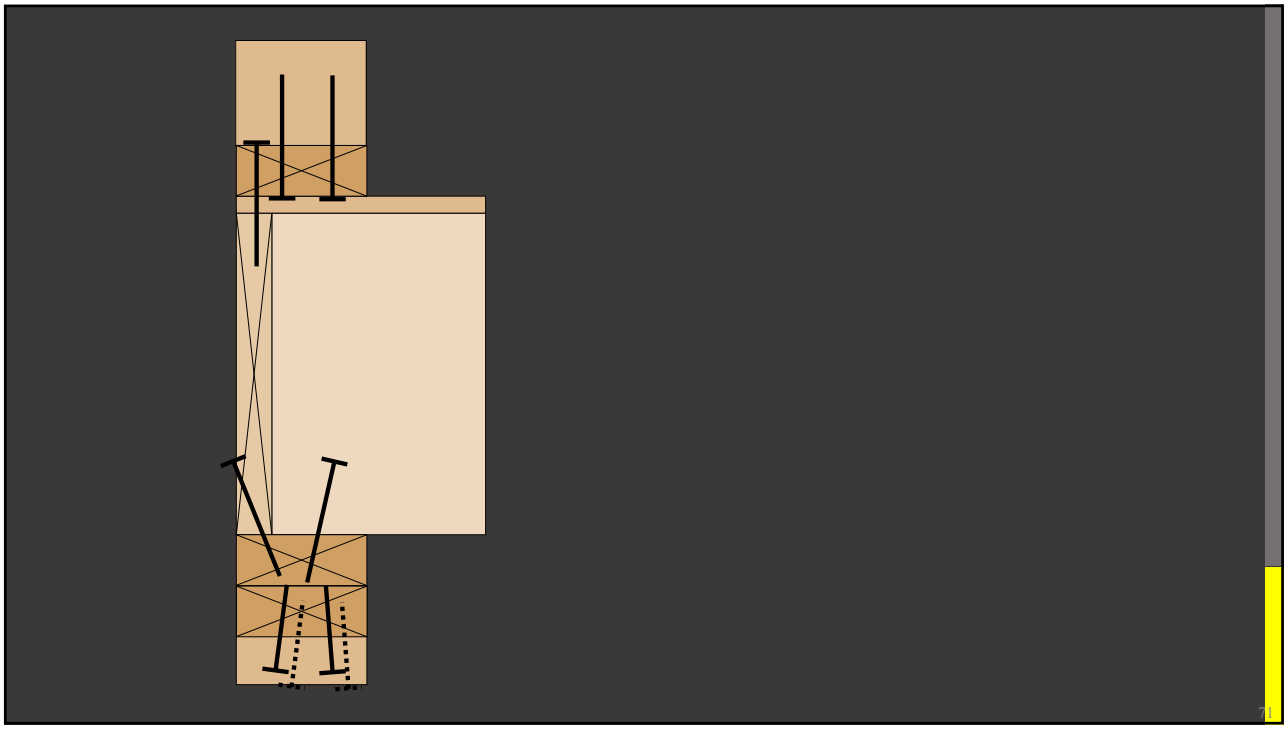

Nails in withdrawal are relatively easy to remove: floor system can lift off

70



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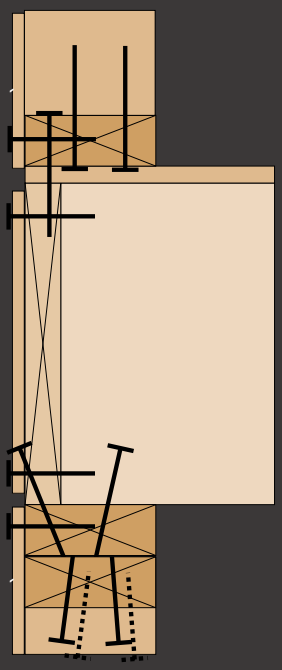
Discrete wood sheathing…

Provides racking strength, but doesn't create continuous uplift resistance if discontinuous



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Discontinuous sheathing good for lateral resistance but still means total reliance on connections for uplift
Source: APA
73

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Sheathing that does not overlap assemblies does not help resist uplift
74

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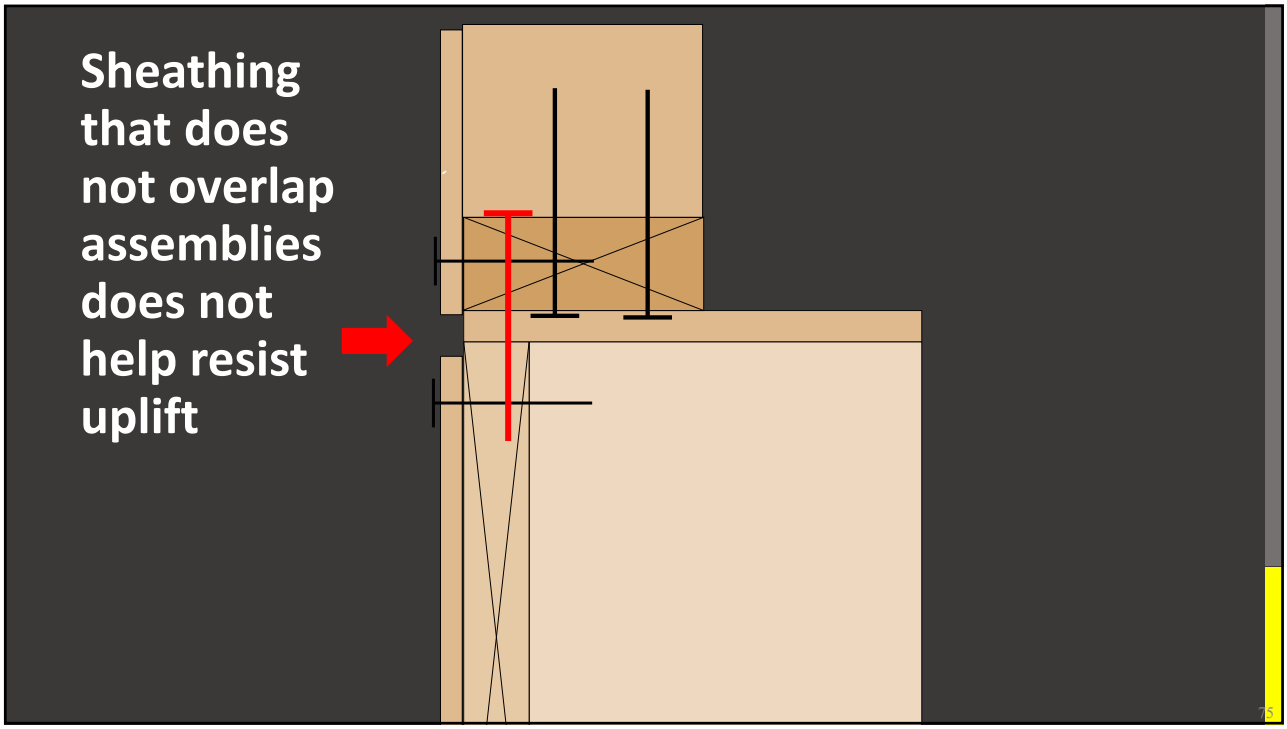
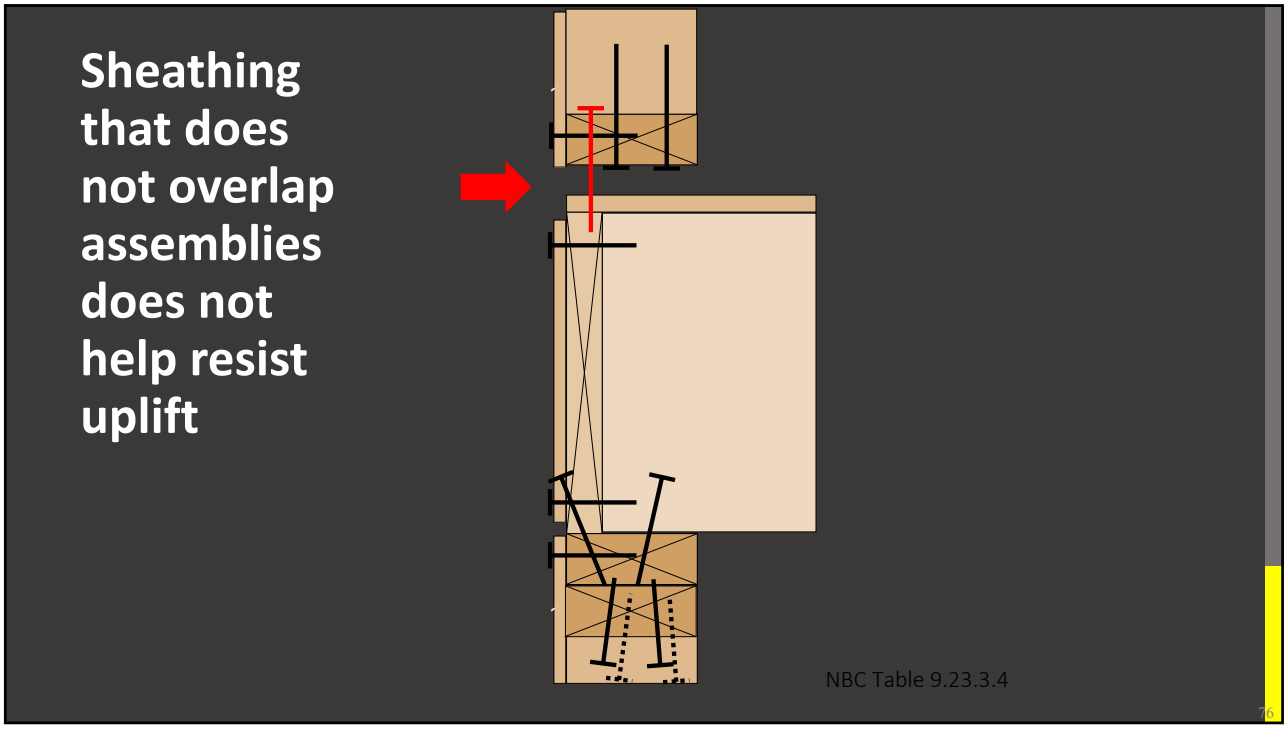

Sheathing that does not overlap assemblies does not help resist uplift

75


Sheathing that does not overlap assemblies does not help resist uplift
NBC Table 9.23.3.4

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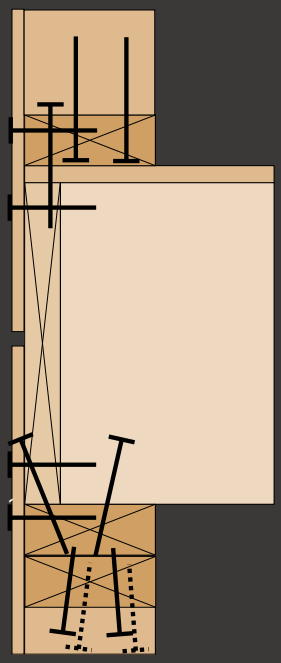
Overlap the sheathing across assemblies.



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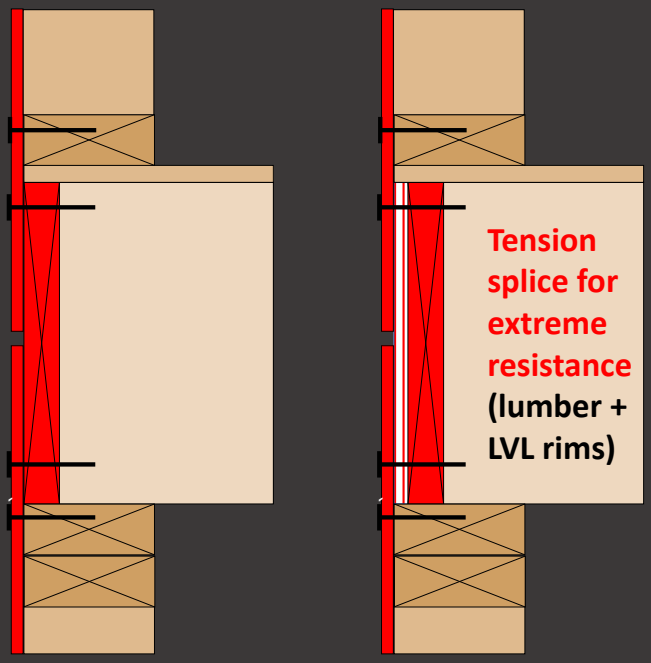
<u>Continuous</u> wood sheathing that crosses multiple assemblies provides excellent uplift load path



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Wall-to-base uplift resistance

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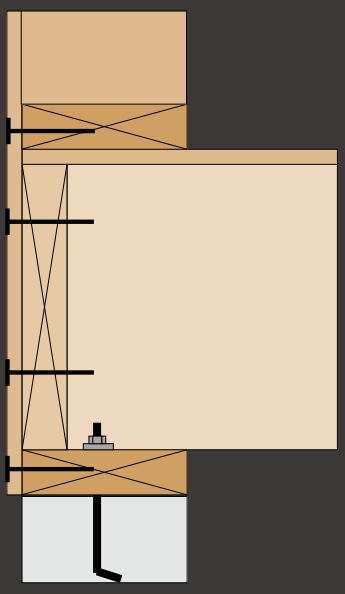
Overlap the sheathing across sill plate provides superior uplift



80

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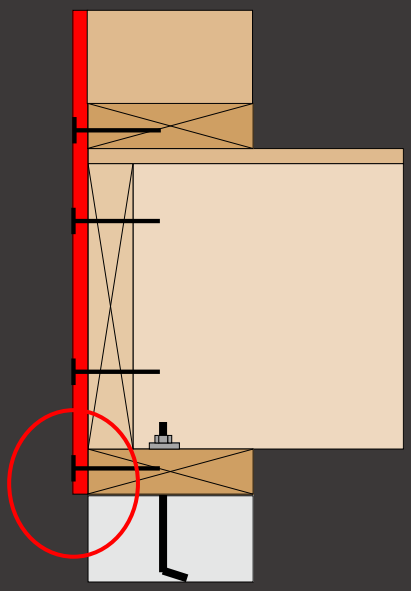
Overlap the sheathing across sill plate provides superior uplift



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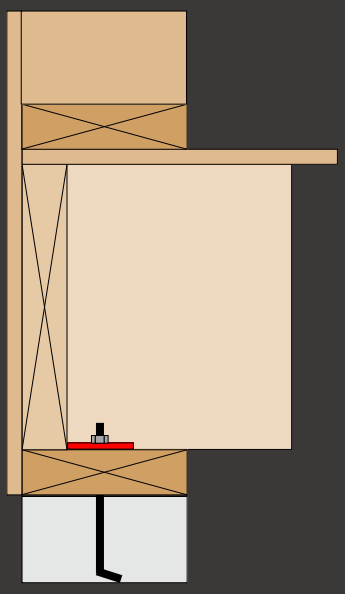
Increasing the size of anchor bolt washers will ensure sill plate does not lift off foundation.



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How to build wind-resilient buildings

8. Make sure the roof covering keeps the building dry

Use high wind –resistant shingles

Better underlayment on entire roof as insurance if shingles are ripped off

https://fortifiedhome.org/
(384) Wind Testing - YouTube

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How to build wind-resilient buildings

9. If available, use high strength garage doors to prevent a large opening when low-strength garage door blows in.

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Garage doors
The garage is gone. It is likely that the doors were open or blew in, and then the rest of the garage had little chance

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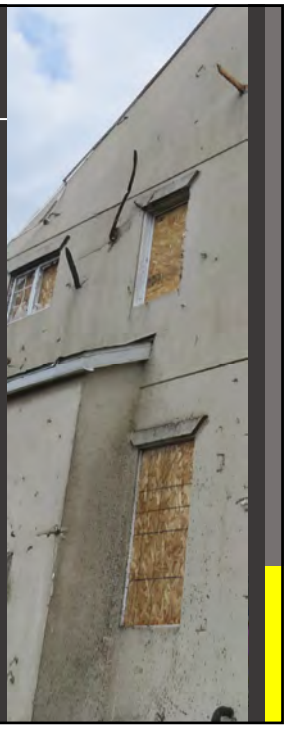
How to build wind-resilient buildings

10. If practical, use high wind-resistant windows

The larger the window opening, the more damage to the house if window shatters due to debris.



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Debris breaks windows, increases wind interior pressures

94


Wood frame houses have built-in redundancy

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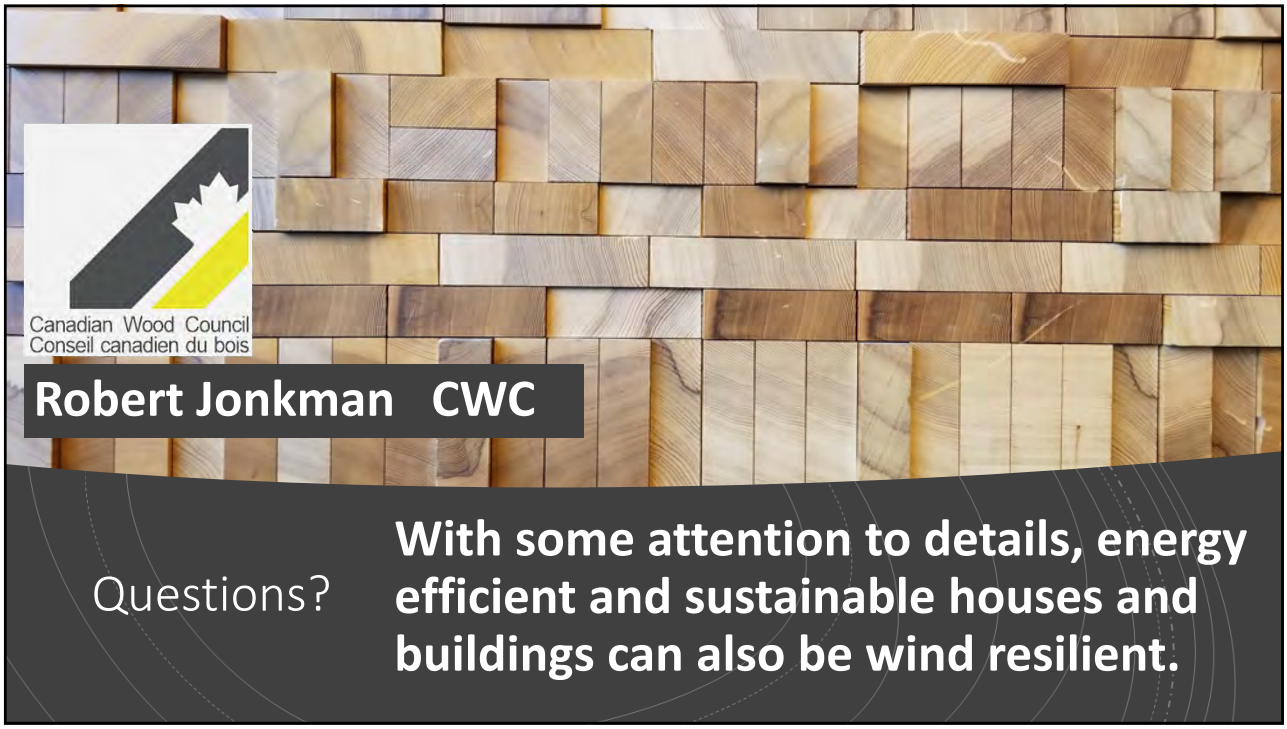
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Robert Jonkman CWC
Questions?
With some attention to details, energy efficient and sustainable houses and buildings can also be wind resilient.

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How to build wind-resilient buildings
1. Highest priority – keep the roof sheathing on
How to build wind-resilient buildings
2. Beef up the gable ends
How to build wind-resilient buildings
3. Connect upper roof framing and components to lower roof framing robustly
Piggy-backed trusses
Lumber over-framing
Dormers to roof
Chimneys
How to build wind-resilient buildings
4. Ensure wall sheathing is adequately attached to resist suction
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5. Ensure enough wall sheathing is adequately attached to resist lateral movement (NBC Part 9)
How to build wind-resilient buildings
6. Use wall sheathing or other methods to bridge assemblies to resist uplift
How to build wind-resilient buildings
7. Check the entire uplift load path:
Roof-to-wall
Wall-to-floor floor to wall
Wall-to-sill Sill-to-foundation
How to build wind-resilient buildings
8. Make sure the roof covering keeps the building dry
Use high wind –resistant shingles
Better underlayment on entire roof as insurance if shingles are ripped off
How to build wind-resilient buildings
9. If available, use high strength garage doors to prevent a large opening when low-strength garage door blows in.
How to build wind-resilient buildings
10. If practical, use high wind-resistant windows
The larger the window opening, the more damage to the house if window shatters due to debris.

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