

SUPPLEMENTAL MATERIALS

ASCE Natural Hazards Review

Capacity-Building to Support Safer Housing through Appropriate Hurricane Strap Use

Briar Goldwyn, Cole Velasquez, Abbie B. Liel,
Amy Javernick-Will, and Matthew Koschmann

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1 **S1. Lecture slides from capacity-building approach**

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University of Colorado Boulder

Increasing wood roof safety in future hurricanes

Briar Goldwyn and Cole Velasquez

Agenda:

A. Background on our project

B. Pre-presentation interviews

C. Presentation and discussion:

1. How wood roofs are damaged in a hurricane
2. Recommendations for avoiding catastrophic damage
3. The types of hurricane straps that should be used at different connections
4. Installing hurricane straps correctly
5. What to do if hurricane straps are not available

D. Post-presentation interviews

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We interviewed and surveyed over 400 builders, hardware store employees, residents, engineers, and architects across Puerto Rico to understand concerns with housing safety

60+ Interviews

~350 Surveys

Multi-hazard perceptions of housing safety within Puerto Rico's informal construction sector

Field observations

3

Based on builders' and residents' experiences, we analyzed the expected performance of wood and concrete housing in hurricanes and earthquakes

Field observations

Hardware store inventory

Engineering assessments & prioritized recommendations

Wind & seismic engineering performance assessments

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We compared these perceptions of housing safety and structural analysis to identify several areas for technical construction capacity development

Unsafe design and construction practices motivated by capacity limitations, according to builders and hardware store employees

Focus areas:
E.g., the use of hurricane straps to secure key roof connections

Common structural vulnerabilities in wood and concrete housing in hurricanes and earthquakes

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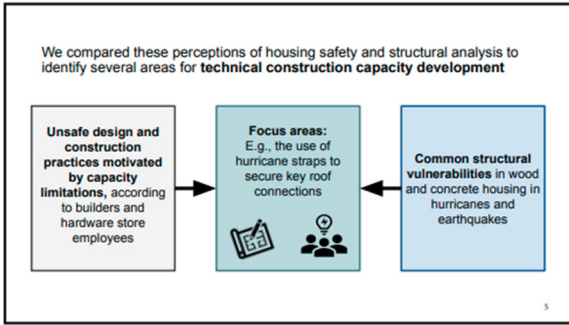
Now, we're working on a way to share our research findings as recommendations

We want to interview you before and after a short training module to understand:

- If you've learned anything
- If you think these recommendations are important to share
- Challenges associated with these recommendations
- Suggestions to improve it

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To explain the importance of hurricane straps at key roof connections, let's start by discussing **how to avoid catastrophic failure**

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Which connections tend to fail first in a hurricane?

(A) Conexión de la viga/armadura a la placa superior
 (B) Conexión de la correa a la viga/armadura
 (C) Conexión de la viga central a la viga/armadura
 (D) Conexión del panel a la correa

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Which connections lead to the most catastrophic failure?

(A) Conexión de la viga/armadura a la placa superior
 (B) Conexión de la correa a la viga/armadura
 (C) Conexión de la viga central a la viga/armadura
 (D) Conexión del panel a la correa

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In a wood roof structure, the **panels tend to be the weak link** and are torn off first **because nails secure the panels**

Source: FEMA (2018)

15

Next, other more catastrophic failures can occur like the **purlin-to-truss/rafter connections**

Source: ABC News

This can look like the panels were ripped off, but involves more structural damage to the roof

16

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Damage to this **truss/rafter-to-top plate connection** is the most catastrophic roof failure because it leads to damage of the whole roof to wall connection

Labels: Purlin to Truss Connection, Truss, Truss to Wall Connection, Purlin, Roof Panel, Wind uplift force

Grid labels: ROOF REINFORCEMENT, NO ROOF REINFORCEMENT

Source: Simpson Strong Tie

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You can **avoid costly and dangerous roof damage** but making sure that everything is anchored to the foundation with the correct fasteners

Grid labels: ROOF REINFORCEMENT, NO ROOF REINFORCEMENT

Source: FLADH

Source: Simpson Strong Tie

19

You can **avoid costly and dangerous roof damage** but making sure that everything is anchored to the foundation with the correct fasteners

Which locations should fasteners be prioritized?
Which types of fasteners should be used where?

Grid labels: ROOF REINFORCEMENT, NO ROOF REINFORCEMENT

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Truss/rafter-to-top plate connection should be strengthened with **H1 straps** or **H2.5A straps**. H1 straps are not as strong as **H2.5A straps**

H1 straps:

Wind uplift force

Max uplift capacity: 480 lbs

H2.5A straps:

Wind uplift force

Max uplift Capacity: 615 lbs

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Truss/rafter-to-wall (top plate) connection are commonly strengthened with the H1, H2.5A, and H10A

1 H1 Installation (H1.81Z similar)

4 H2.5A Installation (nails into both top plates)

15 H10A Installation

Source: Simpson Strong Tie

24

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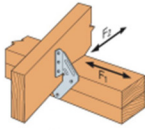
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15 H10A Installation

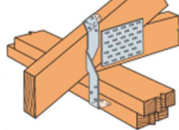
Source: Simpson Strong Tie

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At the **truss/rafter-to-top plate connection**: Do not bend the H1 strap. That strap is designed to not be bent and to include a nail at the bottom. You **CAN** bend the MTS12 strap to fit your needs as shown:



H1 strap, Source: Simpson Strong Tie

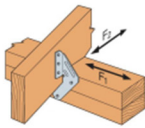


MTS12 strap, Source: Simpson Strong Tie

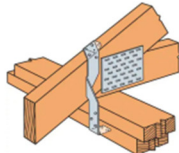
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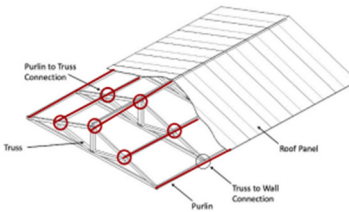


MTS12 strap, Source: Simpson Strong Tie

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Then, we recommend strengthening the **purlin-to-truss/rafter connections** with: **Purlin Screws or H3 Hurricane Straps**



SOWS Timber Screw (3" or 4")

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How to read the information on hurricane straps:

Model No.	Ga.	Fasteners (in.)			DF/SP Allowable Loads			SPF/HF Allowable Loads			Code Ref.		
		To Rafter/Truss	To Plates	To Studs	Uplift (160)	Lateral (160)	Uplift with 0.131" x 1 1/2" Nails (160)	Uplift (160)	Lateral (160)	Uplift with 0.131" x 1 1/2" Nails (160)			
H1	18	(2) 0.131 x 1 1/4	(4) 0.131 x 2 1/8	---	480	570	170	455	425	440	165	370	BC, FL, LA
H1-RZ	18	(2) 0.131 x 1 1/4	(4) 0.131 x 2 1/8	---	540	440	170	480	465	380	130	385	---
H2A	18	(2) 0.131 x 1 1/4	(2) 0.131 x 1 1/4	(2) 0.131 x 1 1/4	525	130	55	---	495	130	55	---	BC, FL, LA
H2ASS	18	(2) 0.131 x 1 1/4	(2) 0.131 x 1 1/4	(2) 0.131 x 1 1/4	400	130	55	400	345	130	55	345	---
H2-SA	18	(2) 0.131 x 2 1/8	(2) 0.131 x 2 1/8	---	700	110	110	625	615	110	110	540	BC, FL, LA
H2-SASS	18	(2) 0.131 x 2 1/8	(2) 0.131 x 2 1/8	---	440	75	70	365	380	75	70	370	---
H2-ST	18	(2) 0.131 x 2 1/8	(2) 0.131 x 2 1/8	---	590	135	145	480	565	135	145	475	---
H3	18	(4) 0.131 x 2 1/8	(4) 0.131 x 2 1/8	---	400	210	170	400	365	180	145	290	BC, FL, LA

The H1 strap should be installed with 6 x 1 1/2 fasteners and 4 x 2 1/2 fasteners:

Common nails or specified SD Screws

Types of wood:

DF/SP Allowable loads: Douglas Fir & Southern Pine

SPF/HF Allowable loads: Spruce, pine, fir, or hemlock (Soft woods)

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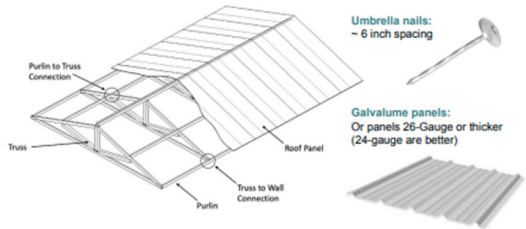
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Finally, the panels can be secured on the roof structure with more nails, nails with a wider head diameter (umbrella nails), thicker gauge roof panels, or galvalume panels

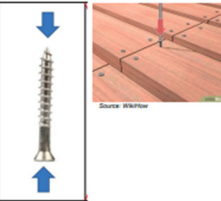


Umbrella nails:
- 6 inch spacing

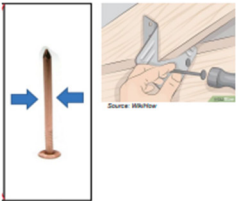
Galvalume panels:
Or panels 26-Gauge or thicker
(24-gauge are better)

Generally: Screws are designed for grip strength and nails are designed for shear loads (but it isn't always that simple, specific screws are designed with tension & shear in mind)

Screws have grip strength, withstanding down/upward pressures



Nails have shear strength, withstanding shearing forces



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Nails (or *specified screws designed for shear strength*) should be used in hurricane straps

Screws will be sheared off when used in a hurricane strap

Hurricane straps are designed for nails because nails' shear strength

Source: Albany County Firemen's Association

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A toe-nailed connection (without hurricane straps) relies on the **nails' pullout capacity**

Toe-nailed connection:

Hurricane straps are designed to have common nails or **specified SD screws** in **each opening**:

Recommended

All nails used: Hurricane strap will fail at/after it reaches its full potential

Not Recommended

Insufficient nails: Hurricane strap will fail before it reaches its full potential

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You can only bend **specified** hurricane straps. You can only bend those specific hurricane straps **once**

MTS12

MTS12 strap before and after **ONLY** bending. Source: Simpson Strong Tie