

HURRICANE RESISTANT BUILDINGS

Building CAT-5 Resistant Timber Roofs An Illustrated Guide for Builders





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Introduction

The year 2020 set a record for the highest number of tropical/subtropical storms registered in a year. According to data from the National Oceanic and Atmospheric Administration (NOAA), the 2020 Atlantic Hurricane Season was the busiest year, with 29 events that caused economic losses estimated at US\$ 50 billion, according to data from AON (1). Climate change has also brought with it an increased risk of the impact of higher intensity storms (2). The rise in water temperature in the Atlantic is causing a greater chance for hurricanes to develop. These natural events are not only more frequent but, in some cases, more catastrophic as well.

One major impediment to resilience is the lack of suitably qualified or experienced professionals to design and build hurricane-resistant buildings in many countries that are typically the most affected. In most developing countries, current building codes do not encourage the construction of robust structures that will withstand major hurricanes nor are the building codes enforced. Additionally, reconstruction after the impact of such events is often rushed and poorly designed and executed.

The Pan American Health Organization (PAHO) aims to reduce the recurrent damage following the impact of major hurricanes, with this illustrated, easy-to-follow guide to build Category 5-resistant roofs and external walls.

Context: Who this guide is for and when to use it

These guidelines are to be used by local builders and laymen for the safe design and construction of roofs in hurricane-prone regions. True sustainability is achieved once people understand what they can do to help themselves and prevent future damage and losses. Therefore, we aim to provide graphic tools illustrating the safe and proper way to build and connect timber roofs to help minimize the loss of building infrastructure, impact on livelihoods and loss of lives.

Scope: What is contained in this Guide?

Gable or Hip Roofs: recommended sizing and spacing of the timber structure.

Many buildings, including essential facilities such as health centres and shelters, are often built without the input from qualified structural engineers, designers, and builders. This guide provides detailed illustrations and information on the sizing of typical components for timber roofs which are resilient to wind speeds equivalent to Category 5 Hurricanes¹.

Minimum typical detailing for external concrete block walls is also included as the support structure for the timber roof.

Building geometry constraints of this Guide

This guide can be used for buildings in general, as long they comply with the following dimensions:

- Maximum building width: 60 feet or 18.3 metres
- Maximum building length: 80 feet or 24.4 metres
- Maximum mean roof height: 33 feet or 10 metres. Buildings that are 1-storey to 3-storeys high
- Minimum roof pitch: 20 degrees

The information in this guide pertains to buildings that are either partially or fully enclosed in the event of a storm or hurricane. This means that the windows and doors should be fully closed to prevent wind or driving rain from causing damage to the interior furnishings and finishes of the building.

The guide is applicable to pitched roofs that are either hip or gable, as illustrated in the next page.

Key: How to use this Guide

This Guide is divided into 6 chapters. Chapters 1 and 2 provide an introduction on buildings, the performance of different buildings according to their geometry, and the components of roofs and walls for the reader's reference. Chapter 4

^{1.} Category 5 Hurricane, according to the Saffir-Simpson scale, has minimum 3-second gust wind speeds of 173 mph or 77m/s over land.



contains illustrations of typical timber connectors, which should be installed at every timber joint or intersection. Chapter 5 contains useful information on roof sheeting and roofing screws. Chapter 6 comprises a simple Checklist that should be followed for timber roofs.

Chapter 4 contains practical design information to determine the maximum spacing of different standard sizes of timber roof members. It includes the roof components sizing and configuration. To find out which configuration/sub chapter applies to you, follow these steps:

- 1. Determine which exposure category your building falls into:
 - a. Exposure B refers to an urban or suburban location or a downtown location.
 - b. Exposure C refers to open country or grasslands.
 - c. Exposure D refers to flat unobstructed site facing a large water body.
- 2. Determine what is your roof type. This guide contains two types: gable or hip.
- 3. Determine the maximum spacing of the timber rafters and purlins in imperial or metric units for three standard timber sizes. Each table represents a maximum building width and includes two types of timber: hardwood or softwood.

CHAPTER 1 Building Performance

Building geometry

The illustrations below highlight safe, robust building shapes that are resilient (\checkmark), that is, inherently able to withstand many of the forces that impact them, versus shapes that may be more susceptible to damage (\times) when impacted by events such as hurricanes and earthquakes (3).

Figure 1. Regular geometric shapes are recommended



Figure 2. Irregular plan geometries are more prone to damage





Figure 3. Irregular geometries in elevation are also more prone to damage

Figure 4. Breaking up of irregular geometry to make it regular



CHAPTER 2 Building Components

Roof components





For reference, Figure 5 illustrates the main roof components that will be mentioned in the following sections of this guideline.

In this document, a minimum roof pitch of 20° is considered for gable roofs and 22.6° for hip roofs. The main timber structural members are considered, that is, the rafters and purlins.

Walls (masonry walls)

This guideline considers 6" (150mm) wide block walls as the minimum external wall thickness. Walls need to be reinforced horizontally and vertically to increase the resistance to high winds and earthquakes. At a minimum, the horizontal reinforcement should be steel reinforcing bars inserted every third block course, and the vertical reinforcement is a steel bar inserted every second core (the hollow pockets of the concrete block) and filled with concrete or cement grout for keeping the steel bar in place, as shown in illustration (a). Illustration (b) shows the reinforced concrete (RC) beams over the gable end walls, also called the

capping beam. The ring beam is the horizontal beam that forms a ring around the building. The reinforced concrete columns frame the corners of the block walls, provide resistance and support for the walls and roof. The lintel beams provide support around door and window openings (4).



Figure 6. (a) typical minimum framing structural frame components of concrete block masonry walls and (b) typical reinforcement for portion of wall

It is recommended that a certified structural engineer advise on the correct reinforcement requirements for the structural walls, beams, columns, and foundation.

CHAPTER 3 Roofs to Resist Category 5 Hurricanes

This chapter presents the design of lightweight timber roofs to resist Category 5 Hurricanes. Follow the four steps listed below to design your roof.

Step 1 – Select the Exposure Category based on your building's location

Each table represents one of three different geographic locations [based on building codes (5)] referred to as 'Exposure Categories.' These three categories are as follows:



Step 2 – Select your roof type (shape)

Each table represents one of two different types of roof types/shapes:



Step 3 – Select the maximum width of your building

Two maximum widths are presented in each table: 15.3m or 50-feet, and 18.3m or 60-feet.

Step 4 – Select the type of lumber or wood material to be used

Two types of wood are presented. Each table represents either softwoods of pine or cedar, or hardwoods of oak and maple. Refer to Annex 2 for the specific list of types of woods.

Buildings in Exposure B – Gable roof



Maximum spacing for rafters based on different typical sizes are indicated in the tables below. Hardwoods and softwoods are shown in separate tables. Refer to Annex 2 for the list of suitable types of wood considered in this design.

The purlins, for the typical timber roof framing for a gable roof, are considered to have a standard size of $50 \text{ mm} \times 50 \text{ mm} (2' \times 2'')$ at a maximum spacing of 1000 mm (2'-0''). Each purlin connection to rafter carries an uplift force of 0.8 kN or 180 lbs.

Applicable for buildings with a maximum width of 15.3m. (Metric units)

Softwood: Pines and Cedars				
	Maximum allowable rafter spacing (mm) Uplift forces at connections (kN)			
Rafter sizes (mm)	Higher strength	Lower strength	Higher strength	Lower strength
150 x 50	450	360*	2.60	2.08
200 x 50	790	630	4.57	3.64
250 x 50	1230	980	7.11	5.66

Hardwood: Maples or Oak				
	Maximum allowable rafter spacing (mm) Uplift forces at connections (kN)			connections (kN)
Rafter sizes (mm)	Higher strength	Lower strength	Higher strength	Lower strength
150 x 50	600	490	3.47	2.83
200 x 50	1050	860	6.07	4.97
250 x 50	1630	1330	9.42	7.69

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Softwood: Pines and Cedars				
	Maximum allowable rafter spacing (in) Uplift forces at connections (lbs)			
Rafter sizes (in)	Higher strength	Lower strength	Higher strength	Lower strength
6 x 2	18	14*	584	468
8 x 2	31	25	1027	818
10 x 2	48	39	1598	1272

Applicable for buildings with a maximum width of 50'. (Imperial units)

Hardwood: Maples or Oak				
	Maximum allowabl	e rafter spacing (in)	Uplift forces at c	onnections (lbs)
Rafter sizes (in)	Higher strength	Lower strength	Higher strength	Lower strength
6 x 2	24	19	780	636
8 x 2	41	34	1365	1117
10 x 2	64	52	2118	1729

Applicable for buildings with a maximum width of 18.3m. (Metric units)

Softwood: Pines and Cedars				
	Maximum allowable rafter spacing (mm) Uplift forces at connections (kN)			connections (kN)
Rafter sizes (mm)	Higher strength	Lower strength	Higher strength	Lower strength
150 x 50	310	250*	2.14	1.73
200 x 50	550	440	3.8	3.04
250 x 50	860	680	5.94	4.70

Hardwood: Maples or Oak				
	Maximum allowable	rafter spacing (mm)	Uplift forces at o	connections (kN)
Rafter sizes (mm)	Higher strength	Lower strength	Higher strength	Lower strength
150 x 50	420	340*	2.9	2.35
200 x 50	730	600	5.05	4.15
250 x 50	1140	930	7.88	6.43

Softwood: Pines and Cedars				
	Maximum allowable rafter spacing (in) Uplift forces at connections (lbs)			
Rafter sizes (in)	Higher strength	Lower strength	Higher strength	Lower strength
6 x 2	12	10*	481	389
8 x 2	22	17	854	683
10 x 2	34	27	1335	1057

Applicable for buildings with a maximum width of 60'. (Imperial units)

Hardwood: Maples or Oak				
	Maximum allowable rafter spacing (in) Uplift forces at connections (lbs)			connections (lbs)
Rafter sizes (in)	Higher strength	Lower strength	Higher strength	Lower strength
6 x 2	17	13*	652	528
8 x 2	29	24	1135	933
10 x 2	45	37	1771	1445

* Spacing too close and inefficient use of material. Consider using larger size rafters or higher strength wood.

Buildings in Exposure B – Hip roof



Maximum spacing for rafters based on different typical sizes are indicated in the tables below. Hardwoods and Softwoods are shown in separate tables. Refer to Annex 2 for the list of suitable types of wood considered in this design.

The purlins, for the typical timber roof framing for a gable roof, are considered to have a standard size of $50 \text{mm x} 50 \text{mm} (2'' \times 2'')$ at a maximum spacing of 915mm (3'-0''). Each purlin connection to rafter carries an uplift force of 0.8kN or 180lbs.

Softwood: Pines and Cedars				
	Maximum allowable rafter spacing (mm) Uplift forces at connections (kN)			
Rafter sizes (mm)	Higher strength	Lower strength	Higher strength	Lower strength
150 x 50	540	430*	2.58	2.05
200 x 50	950	760	4.53	3.63
250 x 50	1460	1100	6.97	5.25

Applicable for buildings with a maximum width of 15.3m. (Metric units)

Hardwood: Maples or Oak				
	Maximum allowable	rafter spacing (mm)	Uplift forces at o	connections (kN)
Rafter sizes (mm)	Higher strength	Lower strength	Higher strength	Lower strength
150 x 50	710	580	3.39	2.77
200 x 50	1250	1000	5.96	4.77
250 x 50	1900	1580	9.07	7.54

Applicable for buildings with a maximum width of 50'. (Imperial units)

Softwood: Pines and Cedars				
	Maximum allowable rafter spacing (in) Uplift forces at connections (lbs)			
Rafter sizes (in)	Higher strength	Higher strength Lower strength		Lower strength
6 x 2	21	17*	580	461
8 x 2	37	30	1018	816
10 x 2	57	43	1567	1180

Hardwood: Maples or Oak				
	Maximum allowable rafter spacing (in) Uplift forces at connections (lbs)			
Rafter sizes (in)	Higher strength	Higher strength Lower strength		Lower strength
6 x 2	28	23	762	623
8 x 2	49	39	1340	1072
10 x 2	75	62	2039	1695

Softwood: Pines and Cedars					
	Maximum allowable rafter spacing (mm) Uplift forces at connections (kN)				
Rafter sizes (mm)	Higher strength	Lower strength	Higher strength	Lower strength	
150 x 50	370	300*	2.11	1.71	
200 x 50	660	530	3.77	3.02	
250 x 50	1000	820	5.71	4.68	

Applicable for buildings with a maximum width of 18.3m. (Metric units)

Hardwood: Maples or Oak				
	Maximum allowable	rafter spacing (mm)	Uplift forces at o	connections (kN)
Rafter sizes (mm)	Higher strength Lower strength		Higher strength	Lower strength
150 x 50	500	400*	2.85	2.28
200 x 50	880	710	5.02	4.05
250 x 50	1350	1100	7.70	6.28

Applicable for buildings with a maximum width of 60'. (Imperial units)

Softwood: Pines and Cedars				
	Maximum allowable rafter spacing (in) Uplift forces at connections (lbs)			
Rafter sizes (in)	Higher strength	Higher strength Lower strength		Lower strength
6 x 2	15	12*	474	384
8 x 2	26	21	847	679
10 x 2	39	32	1284	1052

Hardwood: Maples or Oak				
	Maximum allowable rafter spacing (in) Uplift forces at connections (lbs)			
Rafter sizes (in)	Higher strength	Higher strength Lower strength		Lower strength
6 x 2	20	16*	641	513
8 x 2	35	28	1128	910
10 x 2	53	43	1731	1412

* Spacing too close and inefficient use of material. Consider using larger size rafters or higher strength wood.

Buildings in Exposure C – Gable roof



Maximum spacing for rafters based on different typical sizes are indicated in the tables below. Hardwoods and Softwoods are shown in separate tables. Refer to Annex 2 for the list of suitable types of wood considered in this design.

The purlins, for the typical timber roof framing for a gable roof, are considered to have a standard size of $50 \text{mm x} 50 \text{mm} (2'' \times 2'')$ at a maximum spacing of 915mm (3'-0''). Each purlin connection to rafter carries an uplift force of 0.8kN or 180lbs.

Softwood: Pines and Cedars					
	Maximum allowable rafter spacing (mm) Uplift forces at connections (kN)				
Rafter sizes (mm)	Higher strength	Higher strength Lower strength		Lower strength	
150 x 50	310	240*	2.62	2.03	
200 x 50	540	430*	4.57	3.64	
250 x 50	840	670	7.10	5.67	

Applicable for buildings with a maximum width of 15.3m. (Metric units)

Hardwood: Maples or Oak				
	Maximum allowable rafter spacing (mm) Uplift forces at connections (kN)			
Rafter sizes (mm)	Higher strength	Lower strength	Higher strength	Lower strength
150 x 50	410	330*	3.47	2.79
200 x 50	720	590	6.09	4.99
250 x 50	1110	910	9.39	7.7

Softwood: Pines and Cedars					
	Maximum allowable rafter spacing (in) Uplift forces at connections (lbs)				
Rafter sizes (in)	Higher strength	Lower strength	Higher strength	Lower strength	
6 x 2	12	9*	589	456	
8 x 2	21	17*	1027	818	
10 x 2	33	26	1596	1275	

Applicable for buildings with a maximum width of 50'. (Imperial units)

Hardwood: Maples or Oak				
	Maximum allowabl	e rafter spacing (in)	Uplift forces at c	onnections (lbs)
Rafter sizes (in)	Higher strength	Higher strength Lower strength		Lower strength
6 x 2	16	13*	780	627
8 x 2	28	23	1369	1122
10 x 2	44	36	2111	1731

Applicable for buildings with a maximum width of 18.3m. (Metric units)

Softwood: Pines and Cedars				
	Maximum allowable rafter spacing (mm) Uplift forces at connections (kN)			
Rafter sizes (mm)	Higher strength Lower strength		Higher strength	Lower strength
150 x 50	210	170*	2.12	1.72
200 x 50	380	300*	3.84	3.03
250 x 50	580	470	5.87	4.75

Hardwood: Maples or Oak				
	Maximum allowable	rafter spacing (mm)	Uplift forces at o	connections (kN)
Rafter sizes (mm)	Higher strength	Higher strength Lower strength		Lower strength
150 x 50	280	230*	2.83	2.33
200 x 50	500	410*	5.06	5.06
250 x 50	770	630	7.79	7.79

Softwood: Pines and Cedars				
	Maximum allowable rafter spacing (in) Uplift forces at connections (lbs)			
Rafter sizes (in)	Higher strength	Lower strength	Higher strength	Lower strength
6 x 2	8	7*	477	387
8 x 2	15	12*	863	681
10 x 2	23	19	1320	1068

Applicable for buildings with a maximum width of 60'. (Imperial units)

Hardwood: Maples or Oak				
	Maximum allowable rafter spacing (in) Uplift forces at connections (lbs)			
Rafter sizes (in)	Higher strength	Lower strength	Higher strength	Lower strength
6 x 2	11	9*	636	524
8 x 2	20	16*	1137	933
10 x 2	30	25	1751	1432

* Spacing too close and inefficient use of material. Consider using larger size rafters or higher strength wood.

Buildings in Exposure C – Hip roof



Maximum spacing for rafters based on different typical sizes are indicated in the tables below. Hardwoods and Softwoods are shown in separate tables. Refer to Annex 2 for the list of suitable types of wood considered in this design.

The purlins, for the typical timber hip roof framing, are considered to have a standard size of 50 mm x 50 mm (2'' x 2'') at a maximum spacing of 1200 mm (4'-0''). Each purlin connection to rafter carries an uplift force of 0.68 kN or 153 lbs.

The minimum pitch for this roof is 22.6° (5:12).

Softwood: Pines and Cedars				
	Maximum allowable rafter spacing (mm) Uplift forces at connections (kN)			
Rafter sizes (mm)	Higher strength	Higher strength Lower strength		Lower strength
150 x 50	350	280*	2.53	2.03
200 x 50	620	500	4.49	3.62
250 x 50	960	770	6.95	5.57

Applicable for buildings with a maximum width of 15.3m. (Metric units)

Hardwood: Maples or Oak				
	Maximum allowable	rafter spacing (mm)	Uplift forces at o	connections (kN)
Rafter sizes (mm)	Higher strength Lower strength		Higher strength	Lower strength
150 x 50	470	380*	3.4	2.75
200 x 50	830	670	6.01	4.85
250 x 50	1280	1040	9.26	7.53

Applicable for buildings with a maximum width of 50'. (Imperial units)

Softwood: Pines and Cedars				
	Maximum allowable rafter spacing (in) Uplift forces at connections (lbs)			
Rafter sizes (in)	Higher strength	Lower strength	Higher strength	Lower strength
6 x 2	14	11*	569	456
8 x 2	24	20	1009	814
10 x 2	38	30	1562	1252

Hardwood: Maples or Oak					
	Maximum allowable rafter spacing (in) Uplift forces at connections (lbs)				
Rafter sizes (in)	Higher strength	Higher strength Lower strength		Lower strength	
6 x 2	19	15*	764	618	
8 x 2	33	26	1351	1090	
10 x 2	50	41	2082	1693	

Softwood: Pines and Cedars				
	Maximum allowable rafter spacing (mm) Uplift forces at connections (kN)			
Rafter sizes (mm)	Higher strength	Higher strength Lower strength		Lower strength
150 x 50	240	190*	2.08	1.64
200 x 50	430	350*	3.72	3.03
250 x 50	670	540	5.80	4.67

Applicable for buildings with a maximum width of 18.3m. (Metric units)

Hardwood: Maples or Oak				
	Maximum allowable	rafter spacing (mm)	Uplift forces at o	connections (kN)
Rafter sizes (mm)	Higher strength Lower strength		Higher strength	Lower strength
150 x 50	330	260*	2.86	2.25
200 x 50	580	470	5.02	4.07
250 x 50	890	730	7.7	6.32

Applicable for buildings with a maximum width of 60'. (Imperial units)

Softwood: Pines and Cedars				
	Maximum allowable rafter spacing (in) Uplift forces at connections (lbs)			
Rafter sizes (in)	Higher strength	Lower strength	Higher strength	Lower strength
6 x 2	9	7*	468	369
8 x 2	17	14*	836	681
10 x 2	26	21	1304	1050

Hardwood: Maples or Oak				
	Maximum allowable rafter spacing (in) Uplift forces at connections (lbs)			
Rafter sizes (in)	Higher strength	Higher strength Lower strength		Lower strength
6 x 2	13	10*	643	506
8 x 2	23	19	1128	915
10 x 2	35	29	1731	1421

* Spacing too close and inefficient use of material. Consider using larger size rafters or higher strength wood.

Buildings in Exposure D – Gable roof



Maximum spacing for rafters based on different typical sizes are indicated in the tables below. Hardwoods and Softwoods are shown in separate tables. Refer to Annex 2 for the list of suitable types of wood considered in this design.

The purlins, for the typical timber gable roof framing, are considered to have a standard size of 50mm x 50mm (2'' x 2'') at a maximum spacing of 915mm (3'-0''). Each purlin connection to rafter carries an uplift force of 0.92kN or 207lbs.

Applicable for buildings with a maximum width of 15.3m. (Metric units)

Softwood: Pines and Cedars				
	Maximum allowable rafter spacing (mm) Uplift forces at connections (kN)			
Rafter sizes (mm)	Higher strength	Higher strength Lower strength		Lower strength
150 x 50	250	200*	2.6	2.01
200 x 50	440	350*	4.58	3.64
250 x 50	680	540	7.07	5.62

Hardwood: Maples or Oak				
	Maximum allowable rafter spacing (mm) Uplift forces at connections (kN)			connections (kN)
Rafter sizes (mm)	Higher strength	Lower strength	Higher strength	Lower strength
150 x 50	330	270*	3.43	2.81
200 x 50	580	480	6.03	4.99
250 x 50	900	630	9.36	7.7

Softwood: Pines and Cedars					
	Maximum allowable rafter spacing (in) Uplift forces at connections (lbs)				
Rafter sizes (in)	Higher strength	Lower strength	Higher strength	Lower strength	
6 x 2	10	8*	584	451	
8 x 2	17	14*	1030	818	
10 x 2	27	21	1539	1263	

Applicable for buildings with a maximum width of 50'. (Imperial units)

Hardwood: Maples or Oak				
	Maximum allowabl	e rafter spacing (in)	Uplift forces at c	connections (lbs)
Rafter sizes (in)	Higher strength Lower strength		Higher strength	Lower strength
6 x 2	13	11*	771	632
8 x 2	23	19	1356	1122
10 x 2	35	29	2104	1731

Applicable for buildings with a maximum width of 18.3m. (Metric units)

Softwood: Pines and Cedars				
	Maximum allowable rafter spacing (mm) Uplift forces at connections (kN)			connections (kN)
Rafter sizes (mm)	Higher strength Lower strength		Higher strength	Lower strength
150 x 50	170	140*	2.12	1.74
200 x 50	310	240*	3.86	2.99
250 x 50	470	380*	5.85	4.73

Hardwood: Maples or Oak				
	Maximum allowable rafter spacing (mm) Uplift forces at connections (kN)			
Rafter sizes (mm)	Higher strength Lower strength		Higher strength	Lower strength
150 x 50	230	190*	2.86	2.36
200 x 50	410	330*	5.1	4.11
250 x 50	630	510	7.84	6.35

Softwood: Pines and Cedars					
	Maximum allowable rafter spacing (in) Uplift forces at connections (lbs)				
Rafter sizes (in)	Higher strength	Higher strength Lower strength		Lower strength	
6 x 2	7	6*	477	391	
8 x 2	12	9*	868	672	
10 x 2	19	15*	1315	1063	

Applicable for buildings with a maximum width of 60'. (Imperial units)

Hardwood: Maples or Oak				
	Maximum allowable rafter spacing (in) Uplift forces at connections			
Rafter sizes (in)	Higher strength	Higher strength Lower strength		Lower strength
6 x 2	9	7*	643	531
8 x 2	16	13*	1146	924
10 x 2	25	20	1762	1427

* Spacing too close and inefficient use of material. Consider using larger size rafters or higher strength wood.

Buildings in Exposure D – Hip roof

Maximum spacing for rafters based on different typical sizes are indicated in the tables below. Hardwoods and Softwoods are shown in separate tables. Refer to Annex 2 for the list of suitable types of wood considered in this design.

The purlins, for the typical timber hip roof framing, are considered to have a standard size of 50mm x 50mm (2" x 2") at a maximum spacing of 915mm (3'-0"). Each purlin connection to rafter carries an uplift force of 0.95kN or 215lbs.

The minimum pitch for this roof is 22.6° (5:12).

Applicable for buildings with a maximum width of 15.3m. (Metric units)

Softwood: Pines and Cedars				
	Maximum allowable rafter spacing (mm) Uplift forces at connections (kN)			
Rafter sizes (mm)	Higher strength	Higher strength Lower strength		Lower strength
150 x 50	290	230*	2.55	2.02
200 x 50	510	410*	4.49	3.61
250 x 50	790	630	6.95	5.54

Hardwood: Maples or Oak					
	Maximum allowable rafter spacing (mm) Uplift forces at connections (kN)				
Rafter sizes (mm)	Higher strength	Lower strength	Higher strength	Lower strength	
150 x 50	380	310*	3.34	2.73	
200 x 50	680	550	5.98	4.84	
250 x 50	1050	860	9.24	7.56	

Applicable for buildings with a maximum width of 50'. (Imperial units)

Softwood: Pines and Cedars				
	Maximum allowable rafter spacing (in) Uplift forces at connections (lbs)			
Rafter sizes (in)	Higher strength	Lower strength	Higher strength	Lower strength
6 x 2	11	9*	573	454
8 x 2	20	16*	1009	812
10 x 2	31	25	1562	1245

Hardwood: Maples or Oak				
	Maximum allowable rafter spacing (in) Uplift forces at connections (lbs)			
Rafter sizes (in)	Higher strength	Lower strength	Higher strength	Lower strength
6 x 2	15	12*	751	614
8 x 2	27	22	1344	1088
10 x 2	41	34	2077	1699

Applicable for buildings with a maximum width of 18.3m. (Metric units)

Softwood: Pines and Cedars									
	Maximum allowable rafter spacing (mm) Uplift forces at connections (kN)								
Rafter sizes (mm)	Higher strength	Lower strength	Higher strength	Lower strength					
150 x 50	200	160*	2.1	1.68					
200 x 50	360	280*	3.79	2.95					
250 x 50	550	440	5.79	4.63					

Hardwood: Maples or Oak									
	Maximum allowable	rafter spacing (mm)	Uplift forces at connections (kN)						
Rafter sizes (mm)	Higher strength	Lower strength	Higher strength	Lower strength					
150 x 50	270	220*	2.84	2.31					
200 x 50	470	390*	4.94	4.1					
250 x 50	730	600	7.68	6.31					

Applicable for buildings with a maximum width of 60'. (Imperial units)

Softwood: Pines and Cedars									
	Maximum allowable rafter spacing (in) Uplift forces at connections (lbs)								
Rafter sizes (in)	Higher strength	Lower strength	Higher strength	Lower strength					
6 x 2	8	6*	472	378					
8 x 2	14	11*	852	663					
10 x 2	22	17	1302	1041					

Hardwood: Maples or Oak									
	Maximum allowable rafter spacing (in) Uplift forces at connections (lbs)								
Rafter sizes (in)	Higher strength	Lower strength	Higher strength	Lower strength					
6 x 2	11	9*	638	519					
8 x 2	19	15*	1111	922					
10 x 2	29	24	1726	1418					

* Spacing too close and inefficient use of material. Consider using larger size rafters or higher strength wood.

CHAPTER 4 Timber Roof Connectors

This section illustrates the typical connectors for timber roof members to resist high winds. The specific type and size of connector depends on the uplift forces that need to be resisted at each connection. It also depends on the proprietary strength of the brand of the hurricane connector available in your specific country.

Note that the uplift forces for the rafters and purlins are included in the design tables in Chapter 4'Roofs to Resist Category 5 Hurricanes' of this guide. The connector(s) used should have a minimum strength to resist the uplift forces stated in the table.



Examples of types of connectors

Prescriptive connectors

PAHO does not advocate for specific suppliers or manufacturers.

In an attempt the make this guide more prescriptive and definitive in the building information provided, the following information has been taken from the Simpson StrongTie® High Wind Guide (available from: https://embed.widencdn. net/pdf/plus/ssttoolbox/gdm2sgxtml/F-C-HWG20.pdf?u=cjmyin) (6). This is proprietary information on hurricane straps (connectors) manufactured by Simpson StrongTie®. These connectors are readily available throughout the Americas.

The load tables give the uplift load resistance of each model of connector and the illustrations highlight possible uses for these straps/ connectors.



Icon Legend

Extra Corrosion Protection

The teal arrow icon identifies products that are available with additional corrosion protection (ZMAX®, hot-dip galvanized or double-barrier coating). The SS teal arrow icon identifies products also available in stainless steel. Other products may also be available with additional protection; contact Simpson Strong-Tie for options, The end of the product name will indicate what type of extra corrosion protection is provided (Z = ZMAX, HDG = hot-dip galvanized or SS = stainless steel). Stainless products may need to be manufactured upon ordering. See pp. 8-10 for information on corrosion, and visit our website strongtie.com/info for more technical information on this topic. See p. 52 for more information in stainless steel nail requirements.



SS

SD Strong-Drive® SD Connector Screw Compatible This icon identifies products approved for installation with Simpson Strong-Tie® Strong-Drive® SD Connector screw. See strongtie.com/sd for more information.

Rafter Connectors

			Fastener	rs (Total)	DF/S	P Allowable	Loads	SPF	Allowable L	.oads	
	Model	Qty.	To	To	Uplift	Parallel to	Perp. to	Uplift	Parallel to	Perp. to	
	110.	med.	Truss/Rafter	Plates	(160)	(160)	(160)	(160)	(160)	(160)	
	H2.5T	1	(5) 0.131" x 1 ½"	(5) 0.131" x 1 1/2"	420	135	145	420	135	145	
SS	H2.5ASS ¹¹	1	(5) 0.131° x 21/2°	(5) 0.131" x 21/2"	440	75	70	380	75	70	
	H1	1	(6) 0.131" x 1 ½"	(4) 0.131" x 21/2"	480	510	190	425	440	165	
	H2.5T	1	(5) 0.131" x 21/2"	(5) 0.131" x 21/2"	590	135	145	565	135	145	
	H2.5A	1	(5) 0.131" x 1 1/2"	(5) 0.131" x 1 ½"	6352	110	110	540	110	110	
	HGA10KT	1	(4) 1/4" x 1 1/2" SDS	(4) 1/4" x 3" SDS	650	1,165	940	500	840	675	
	LTS12 ¹³	1	(6) 0.148° x 1 1/2°	(6) 0.148" x 11/2"	660 ²	755	1255		755	1255	
	H2.5A	1	(5) 0.131" x 21/2"	(5) 0.131" x 21/2"	730*	110	110	615	110	110	
	TSP ⁹	1	(9) 0.148" x 1 1/2"	(6) 0.148" x 11/2"	755	310	190	650	265	160	
SS	H8	1	(5) 0.148" x 1 1/2"	(5) 0.148° x 1 1/2°	780	95	90		95	90	
	H11Z	1	(6) 0.162" x 2 1/2"	(6) 0.162" x 21/2"	830	525	760	715	450	655	TARGE AND AND
	H10A Sloped	1	(9) 0.148" x 1 1/2"	(9) 0.148" x 11/2"	855	590	285	760	505	285	
	H1	2	(12) 0.131" x 1 1/2"	(8) 0.131" x 21/2"	960		380	850	880	330	PIZIA HZ MA TEP
	H10ASS ¹¹	1	(9) 0.148" x 1 1/2"	(9) 0.148" x 11/2"	970	565	170	835	485	170	similar) MIS12
SS	MTS1213	1	(7) 0.148" x 1 1/2"	(7) 0.148" x 11/2"	990	755	1255	850	755	1255	(LIS. FIS similar) (H1, H14
	H2.5T	2	(10) 0.131" x 21/2"	(10) 0.131" x 21/2"	990	270	290	990	270	290	siniar)
	TSP ⁹	1	(9) 0.148" x 1 1/2"	(6) 0.148" x 3"	1,015	310	190	875	265	160	
	H10AR	1	(9) 0.148" x 1 1/2"	(9) 0.148" x 1 1/2"	1,050	490	285	905	420	285	
	H10A-2	1	(9) 0.148" x 1 1/2"	(9) 0.148" x 1 1/2"	1,080	680	260	930	585	225	
	H10A	1	(9) 0.148" x 1 1/2"	(9) 0.148" x 1 1/2"	1,1052	565	285	1,015	485	285	
	H2.5T	2	(10) 0.131" x 2 1/2"	(10) 0.131" x 21/2"	1,180	270	290	1,130	270	290	
	H2.5A	2	(10) 0.131" x 1 1/2"	(10) 0.131" x 1 1/2"	1,2702	220	220	1,080	220	220	
	H14	1	(12) 0.131" x 1 1/2"	(13) 0.131" x 21/2"	1,275	725	285	1,050	480	245	
	HTS16 th	1	(12) 0.148" x 1 1/2"	(12) 0.148" x 1 1/2"	1,310	756	1255		755	1255	
SS	LTS1213	2	(12) 0.148" x 1 1/2"	(12) 0.148" x 1 1/2"	1,3202	1505	250 ^s	1,110	1505	250 ^s	
	H16	1	(2) 0.148" x 1 1/2"	(10) 0.148" x 1 1/2"	1,370			1,180			
	H2.5A	2	(10) 0.131" x 2 1/2"	(10) 0.131" x 21/2"	1,460?	220	220	1,230	220	220	
SS	MTS12 ^{rs}	2	(14) 0.148" x 1 1/2"	(14) 0.148" x 1 1/2"	1,980	1505	250 ^s	1,700	150 ⁵	250 ^s	

Truss/Rafter to Masonry/Concrete

	One-Ply SP Rafter/Truss					Two- or Th	ree-Ply SP	Rafter/Tr	188	Blocking sor shown for clevity installed shape'r or wraitedu shape'r or wraitedu shape'r or		
	Model No.	Qty. Req.	Application	Fasteners to Rafter/Truss (Total) ⁴	Uplift (160)	F ₁ (160)	F ₂ (160)	Fasteners to Rafter/Truss (Total) ⁴	Uplift (160)	F ₁ (160)	F2 (160)	NLTED NLTED
	HETAL12	1	Block/Concrete	(10) 0.148" x 1 1/2"	1,040	390'	1,040	(10) 0.162" x 3½"	1,235	390'	1,040	
	META12	1	Block/Concrete	(7) 0.148° x 132°	1,420	340	770	(6) 0.162* x 3½*	1,450	340	770	
E 5422 0441	META16, META18, META20, META24, META40	i.	Block/Concrete	(8) 0.148° x 1½°	1,450	340	770	(6) 0.162° x 3½°	1,450	340	770	
	HETA12	1	Block/Concrete	(7) 0.148* x 11/2*	1,455	340	770	(7) 0.162* x 3½*	1,730	340	770	Two MFTA
SS	HETA16, HETA20, HETA24, HETA40	1	Block/Concrete	(9) 0.148° x 1½°	1,810	340	770	(8) 0.162° x 3½°	1,810	340	770	Ancharge
LAL 20	HETAL16 HETAL20	1	Block/Concrete	(14) 0.148° x 1½°	1,810	390'	1,040	(13) 0.162" x 31½"	1,810	3907	1,040	
	META12, META16, META18, META20	210	Block	(10) 0 148° x 1 W ¹⁰	1.875	680	770	(14) 0 162" x 314"	1,795	1.285	1.080	
1420	META24, META40	TA24, META40	Concrete	(10) 0.140 x 172		000	110	(14) 0.102 2.072	2,435	1,200	1,203	+5 rebar
ss	HETA12, HETA16,		Block						2,365			Adjustave before not phown for clusty
11A20 3941	HETA20, HETA24, HETA40	A20, HETA24, 2**	0 Concrete (10) 0.148" x 1 1/2"0 1,920 680 770 (12) 0.16	2,560	2,560	2,560 1,350 1,43		2,560	2,560	1,350 1,430	DETAL28	
	HHETA16 HHETA20		Block						2,365			
	HHETA24, HHETA40	20	Concrete	(10) 0.148" x 152"	1,920	680	770	(12) U.162" x 31/2"	3,180	1,350	1,430	
	HHETA16, HHETA20, HHETA24, HHETA40	1	Block/Concrete	(10) 0.148° x 1½°	2,120	340ª	770	(9) 0.162° x 3½°	2,120	340*	770	
	DETAL20	1	Block/Concrete	(18) 0.148" x 11/2"10	2,480	2,000	1,370	-		-	-	(min.) to achieve littled looph

Hip Rafter to Wall Connector

			Fat	teners	DF/SP Allow	vable Loads	SPF Allowa	able Loads	
	Model Member No. Size		То	To To Well		(160)		(160)	
			Truss/Rafter	10 Wall	Uplift	F1	Uplift	F1	
	TJC37 (1-85°)	2x4 min.	(6) 0.131" x 112"	(6) 0.131° x 11/2°	3757	_	3257		
	TJC57 (1-85°)	2x6 min.	(12) 0.131" x 1 1/2"	(12) 0.131" x 1 1/2"	750'	-	6457	-	
SS	HCP21	2x	(6) 0.148° x 11/2°	(6) 0.148" x 11/2"	590	255	510	220	
SS	HCP1.811	1%	(6) 0.148" x 11/2"	(6) 0.148" x 11/2"	590		510	220	
	MTSM16	2x	(7) 0.148" x 11/2"	(4) 1/4" x 21/4" Titten Turbo""3	830	-	715	-	

Rafter Connectors

			Fastener	rs (Total)	DF/S	P Allowable	Loads	SPF	Allowable L	oads	
	Model No.	Qty. Req. ¹⁰	To Truss/Rafter	To Plates	Uplift (160)	Parallel to Plate (F ₁) (160)	Perp. to Plate (F ₂) (160)	Uplift (160)	Parallel to Plate (F ₁) (160)	Perp. to Plate (F ₂) (160)	
	H2.5T	1	(5) 0.131" x 1 1/2"	(5) 0.131" x 1 ½"	420	135	145	420	135	145	
SS	H2.5ASS11	1	(5) 0.131" x 21/2"	(5) 0.131" x 232"	440	75	70	380	75	70	
	H1	1	(6) 0.131" x 1 1/2"	(4) 0.131" x 21/2"	480	510	190	425	440	165	
	H2.5T	1	(5) 0.131" x 2 1/2"	(5) 0.131" x 2 1/2"	590	135	145	565	135	145	
	H2.5A	1	(5) 0.131" x 1 1/2"	(5) 0.131" x 1 1/2"	635 ²	110	110	540	110	110	
	HGA10KT	1	(4) 1/4" x 1 1/2" SDS	(4) 1/4" x 3" SDS	650	1,165	940	500	840	675	
	LTS1213	1	(6) 0.148" x 1 1/2"	(6) 0.148" x 1 1/2"	660 ²	755	1255	555	755	1255	
	H2.5A	1	(5) 0.131" x 2 1/2"	(5) 0.131" x 2 1/2"	730 ²	110	110	615	110	110	
	TSP ⁹	1	(9) 0.148" x 1 1/2"	(6) 0.148" x 1 1/2"	755	310	190	650	265	160	
SS)	H8	1	(5) 0.148" x 11/2"	(5) 0.148" x 1 1/2"	780	95	90	710	95	90	
	SDWC1560012	1	-	-	8052	380 ²	225	505	265	190	100000
	H11Z	1	(6) 0.162" x 21/2"	(6) 0.162" x 21/2"	830	525	760	715	450	655	A CARDON ON
	H10A Sloped	1	(9) 0.148" x 1 1/2"	(9) 0.148" x 11/2"	855	590	285	760	505	285	
	H1	2	(12) 0.131" x 1 1/2"	(8) 0.131" x 21/2"	960		380	850	880	330	11254. Tep
	H10ASS ¹¹	1	(9) 0.148" x 1 1/2"	(9) 0.148" x 1 1/2"	970	565	170	835	485	170	uinita) MTEL2 (US.HTS MTEL2
SS)	MTS1213	1	(7) 0.148" x 1 1/2"	(7) 0.148" x 11/2"	990	755	1255	850	755	1255	Senior) (et. etc. senior) senior)
	H2.5T	2	(10) 0.131" x 2 1/2"	(10) 0.131" x 21/2"	990	270	290	990	270	290	convector not shows for clarity
	TSP [®]	1	(9) 0.148" x 1 1/2"	(6) 0.148" x 3"	1,015	310	190	875	265	160	
	H10AR	1	(9) 0.148" x 1 1/2"	(9) 0.148" x 1 1/2"	1,050	490	285	905	420	285	
	H10A-2	1	(9) 0.148" x 1 1/2"	(9) 0.148" x 1 1/2"	1,080	680	260	930	585	225	
	H10A	1	(9) 0.148" x 1 1/2"	(9) 0.148" x 1 1/2"	1,1052	565	285	1,015	485	285	
_	H2.5T	2	(10) 0.131" x 232"	(10) 0.131" x 21/2"	1,180	270	290	1,130	270	290	
	SDWC1560012	2	-	-	1,200	685	995	1,045	495	670	
	H2.5A	2	(10) 0.131" x 1 1/2"	(10) 0.131" x 1 1/2"	1,270 ²	220	220	1,080	220	220	
	H14	1	(12) 0.131" x 1 1/2"	(13) 0.131" x 2 1/2"	1,275	725	285	1,050	480	245	
	HTS16 ¹³	1	(12) 0.148" x 1 1/2"	(12) 0.148" x 1 1/2"		755	1255	1,125	755	1255	
SS)	LTS1213	2	(12) 0.148" x 1 1/2"	(12) 0.148" x 1 1/2"	1,320 ²	1505	250 ⁵	1,110	150 ⁵	250 ⁵	
	H16	1	(2) 0.148" x 1 1/2"	(10) 0.148" x 1 1/2"			_	1,180		_	
	H2.5A	2	(10) 0.131" x 2 1/2"	(10) 0.131" x 21/2"	1,4602	220	220	1,230	220	220	
SS	MTS1213	2	(14) 0.148" x 1 1/2"	(14) 0.148" x 1 1/2"		150 ⁵	250 ⁵		1505	250 ⁵	

CHAPTER 5 Roof Sheeting

Typically, corrugated galvanised metal roof sheets are used as the lightweight, affordable, and easy-to-install metal roof sheeting over most buildings. Galvanised metal sheets are generally defined by the gauge: 22ga., 24ga. The higher the gauge number, the thinner the sheet thickness. Galvanised metal consists of a thin layer of zinc anticorrosive coating to protect the inner mild steel metal sheet.

There are other types of durable anticorrosive metal sheets, such as Galvalume. This is where the base metal is protected with a layer of Aluminium (AI), Zinc (Zn) and Silicon (Si). It is similar in appearance to galvanized sheets and has similar durability benefits; however, Galvalume may be more durable in coastal environments.



Figure 7. (a) Typical Galvalume layers, (b) Typical Galvanised layers

Roof sheets

Metal roof sheets come in many different proprietary profile shapes, such as those illustrated in the next page:



Different manufacturers use different layer composition, thicknesses, and profiles to achieve the strength and durability of the metal sheeting. There is no standard industry thickness related to gauge, that is, 24-gauge may refer to 0.45mm thick from one manufacturer and 0.5mm thick from a different manufacturer.

It is important to check that the metal sheeting used on the building is suitable for the environment in which the building is located. Marine and coastal environments may require thicker anti-corrosive protection than buildings located in inland urban or country areas.

Roofing screws

There are specific sections of gable or hip roofs that attract higher wind pressures (refer to light orange perimeter strips around each face of the roof in image 9 below). The roof sheets should be connected using galvanised or stainless-steel metal screws at appropriate maximum spacings to ensure that the roof sheet does not tear or rip off in high winds. The high wind pressure zones may require that roof screws in these areas are spaced more closely together. Usually, the roof sheet manufacturer specifies the maximum allowable spacing of the screws to ensure the design resistance is achieved (7).



Figure 9. (a) High pressure zones in gable roofs, (b) High pressure zones in hip roofs

Leak prevention between the roofing screw and roof sheet connection can be achieved by the following:

1. Using roofing screws that have a compressible rubber gasket under the washer to prevent water ingress under the washer, installing the screws properly.

Figure 10. Roofing screw positioning



2. Connect the screws through the crest of the corrugated roof sheets. This location will ensure the screw penetration is exposed to less water than the valley of the roof sheet and that the screw head has enough space for the connection. Manufacturers of different roof sheet profiles would specify the correct location and spacing of the roof screws to satisfy wind pressures. Also ensure that roof sheets have adequate lap between sheets, as per the manufacturer's specifications.

Figure 11. Screw connection on roof sheet



Use cyclone washers (8). An example is shown in the figure below.

Figure 12. Example of cyclone washers





CHAPTER 6 Quality Control Checklist



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Wood as an engineering material [Internet]. Madison, WI: USDA Forest Service, Forest Products Laboratory; 1999. General technical report FPL ; GTR-113: p. 4.1–4.45 Available from: <u>https://www.fs.usda.gov/treesearch/ pubs/7149</u>.

Annex 1 – Wind Speeds

Relationship between Wind Speeds in Design Codes and Saffir—Simpson Scale Hurricane Wind Scale

The hurricane reports from the National Hurricane Center include the Saffir-Simpson Hurricane Categories 1 to 5. This scale is relied on by local emergency management agencies in order to warn the populations of the need to prepare for upcoming severe weather systems. The Saffir-Simpson Hurricane Scale has wide acceptance and popularity. Its five Categories are based on wind speed intensity and barometric pressure at the centre of the storm. The quoted wind speeds determining the various Categories are sustained wind speeds with a 1-minute averaging time at 33 ft over open water. It is understood that the wind speeds categorising the hurricanes are the most intense in the system—typically in the north-east eye wall. Those speeds are not necessarily the ones impacting on any particular island or part of an island.

It is important to note that the wind speeds reported by the National Hurricane Centre are not the same as those determined by researchers specifically for use in the design of structures.

The American Society of Civil Engineers ASCE 7 standard commonly used by engineers for wind-resistant design purposes in the USA and the Caribbean uses a 3-second gust speed at 33 ft above ground in open terrain with scattered obstructions having heights generally less than 30 feet – commonly associated with flat open country and grasslands. This is known as Exposure C. The wind speed thus defined is the Basic Wind Speed for use in structural design.

This section lists basic wind speeds for different return periods across several countries in the Americas. The basic wind speed is used to develop the design wind speeds for building design in the respective countries. The Saffir-Simpson Hurricane Scale wind speeds are also included as a comparison between the basic wind speeds versus Category 5 Hurricane wind speeds.

Hurricane Category	Sustained Win Wa	nd Speed over iter	Gust Wind Spe	eed over Water	Gust Wind Speed over Land		
	mph	m/s	mph	m/s	mph	m/s	
1	74-95	33-42	90-116	40-51	81-105	36-47	
2	96-110	43-49	117-134	52-59	106-121	48-54	
3	111-129	50-57	135-157	60-70	122-142	55-63	
4	130-156	58-69	158-190	71-84	143-172	64-76	
5	>157	>70	>191	>85	>173	>77	

Table 1.1 Approximate Relationship between Wind Speeds in ASCE 7 and Saffir–Simpson scale Hurricane Wind Scale

Note: Country wind speeds in red text exceed the minimum wind speed for Category 5 Hurricanes.

Table 1.2 Wind speeds - The Caribbean

Note: 2019 PAHO wind hazard maps publication (10), same as the OECS Building Code wind speeds (updated in September 2016). When using ASCE 7–10 the following values shall be adopted for the Basic Wind Speed V for Category II Buildings.

Location	700-year [mph]	1700-year [mph]	
Trinidad (S)	87	110	
Trinidad (N)	128	147	
Isla Margarita	133	152	
Grenada	154	168	
Bonaire	149	156	
Curacao	149	165	
Aruba	146	162	
Barbados	152	169	
Saint Vincent	155	171	
Saint Lucia	155	172	
Martinique	159	171	
Dominica	159	172	
Guadeloupe	157	168	
Montserrat	161	172	

Location	700-year [mph]	1700-year [mph]	
St. Kitts and Nevis	163	170	
Antigua and Barbuda	160	168	
Saint Martin/Sint Maarten	167	175	
Anguilla	165	176	
US Virgin Islands	167	176	
British Virgin Islands	169	180	
Grand Cayman	187	198	
Little Cayman/Cayman Brac	178	197	
Hispaniola	110-160	120-170	
Jamaica	140-160	150-170	

Note: The above values are 700-year return period for Category II Buildings and 1700-year return period for Category III and IV Buildings. These are "failure" wind speeds therefore a Load Factor of 1.0 does not need to be applied.

Table 1.3 Wind speeds - Latin America

Location	50-year [mph]	200-year [mph]	700-year [mph]	1700-year [mph]
Cuba			120-170	140- 190
Dominic Republic			120- 175	125- 185
Puerto Rico			150-170	160- <mark>180</mark>
Mexico	56-144	62- 177		
Guatemala	68.4		70-140	
Honduras			70-170	
El Salvador ^s				
Nicaragua	67-125	81-157	70-170	
Costa Rica	62-87			
Panama	72-87			
Brazil	67-112			
Colombia			70-120	

Location	50-year [mph]	200-year [mph]	700-year [mph]	1700-year [mph]
Colombia Archipelago: Providencia and Santa Catalina San Andrés			140 125	155 145
Venezuela (excluding Margarita)			70-130	

⁶ El Salvador building code states a basic wind pressure of 30 kgf/m2 or 0.3kPa. This is derived from a wind speed of 15.4 m/s or 34.6 mph, however neither the averaging period nor the return period are identified.

Annex 2 – List of Hardwoods and Softwoods

Types of Softwoods and Hardwoods that are suitable for use in the designs illustrated in this guide are listed here. (11)

Softwood							
Material	Higher strength	Lower strength					
Cedar	Eastern red cedar	Atlantic white					
	Incense	Northern white					
	Port-Orford	Western redcedar					
	Yellow						
Pine	Jack	Eastern white					
	Loblolly	Lodgepole					
	Longleaf	Ponderosa					
	Pitch	Red					
	Pond	Spruce					
	Sand	Sugar					
	Shortleaf	Western white					
	Slash						
	Virginia						

Notes:

Design stresses considered for the higher strength softwood are:

- Bending stress parallel to grain, Sp = 21.2 N/mm²
- Shear stress parallel to grain, $Sv = 5.9 \text{ N/mm}^2$

Design stresses considered for the lower strength softwood are:

- Bending stress parallel to grain, Sp = 16.5 N/mm²
- Shear stress parallel to grain, $Sv = 4.8 \text{ N/mm}^2$

Hardwood							
Material	Higher strength	Lower strength					
Cherry	Black						
Maple	Sugar	Bigleaf					
		Black					
		Red					
		Silver					
0ak, red	Black	Laurel					
	Cherrybark	Northern red					
	Pin	Southern red					
	Scarlet	Willow					
	Water						
0ak, white	Chestnut	Bur					
	Live	Overcup					
	Post						
	Swamp chestnut						
	Swamp white						
	White						
Walnut	Black						

Notes:

Design stresses considered for the higher strength hardwood are:

- Bending stress parallel to grain, Sp = 27.3 N/mm²
- Shear stress parallel to grain, Sv = 9.3 N/mm²

Design stresses considered for the lower strength hardwood are:

- Bending stress parallel to grain, $Sp = 22.3 \text{ N/mm}^2$
- Shear stress parallel to grain, Sv = 8.1 N/mm²

Annex 3 – Sample Calculation

The sample calculations in this annex are for reference by civil/structural engineers who may be using this guide.

Project: Hurricane Resist	ant Buildi	ngs			Date: 12-Jul-21			
Engineer: Shalini Jagnarine-Azan Page: 1 of 5								
Description: Gable Roof_180mph_Exposure B								
Design reference code: ASCE	7-16							
Input all items in red.								
Wind Loads based on Catego	ry 5 Hurric	anes: 3-se	c gust wind	speeds	over land: >173mph (77m/s)			
Item description:	Value	Unit	Reference	Unit	Notes			
Basic wind speed, V	80.5	m/s =	180	mph	BASIC WIND SPEED, V. Three-second gust speed at 33 ft (10 m) above the ground in Exposure C (see Section 26.7.3) as determined in accordance with Section 26.5.1.			
Building description:								
Enclosed			26.2		BULDING, ENCLOSED A building that has the total area of openings in each wall, that neceves poolwe extempl pressure, less than or equil to 4 st (10.37 m) or 1% of the area of that wall, which were its smaller. This condition is expressed for each wall by the following equation: $Ao = 0.01$ kg, opening the state of the state state of the state br>external pressure, in the (model) and Ag = the goes are of that wall in which Ao is identified, in fiz (m2).			
Low-rise			26.2		BUILDING, LCW-RISE: Enclosed or partially enclosed building that complex with the following conditions: 1. Mean roof height h less than or equal to 60 ft (18 m). 2. Mean roof height h does not exceed least horizontal dimension.			
Building category	ш				Table 1.5-1, ASCE 7-16 in hurricane prone region			
Importance factor	1.00		Table 6.1		Buildings and other structures, the failure of which could pose a substantial risk to human life			
Site Location:								
Surface roughness	в		26.7.2		Surface Roughness B. Urban and suburban areas, wooded areas, or other terrain with numerous, closely spaced obstructions that have the size of single-family dwellings or larger			
Exposure	в		26.7.3		Exposure B: For buildings or other structures with a mean roof height less than or equal to 30 ft (9.1 m), Exposure B shall apply where the ground surface roughness, as defined by Surface Roughness B			
Wind Directionality factor, Kc	0.85		Table 26.6-1		main wind force-resisting system			
Topographic Effects:					To calculate different Kzt for different topographic locations			
Topographical factor, Kzt	1		26.8		Kzt = (1+K1K2K3)2 Taken for ease of calculation in this template			
Gust factor, G	0.85		26.11.1		Gust-Effect Factor. The gust-effect factor for a rigid building or other structure is permitted to be taken as 0.85.			
Velocity pressure								
exposure coefficients, Kz	0.72	1	able 26.10-1	1	For exposure B and height of 33ft.			
Ground elevation factor, Ke	1.00		Tbl. 26.9-1		Take Ke = 1.0 for all cases as worse case			

Project: Hurricane Resis	tant Buildi	ngs		Date: 12-Jul-21				
Engineer: Shalini Jagna	Engineer: Shalini Jagnarine-Azan Page: 2 of 5							
Description: Gable Roof_180mph_Exposure B								
1000	17	9		1				
Building Geometry:	Value	Unit	Reference	Unit	Notes			
Structure height, h	10	m =	33	ft	Assume max. 3-storeys			
Roof angle	20	degrees			Use this as the minimum recommended pitch for all roofs, 4' 3/8". 1' (4.38:12)			
Building length, L	24.5	m =	80.4	ft	Use maximum building width & length as 80ft, 24.5m			
b/l =	0.41							

Wind Velocity pressure, qz = 0.613 Kz. Kzt. Kd. Ke. V2 (N/m2) hence, qz = qh = 2.43 kN/m2

Important Note:

26.12.3 Protection of Glazed Openings. Glazed openings in Risk Category II, III, or IV buildings located in hurricane-prone regions shall be protected as specified in this section.

26.12.3.1 Wind-Bome Debris Regions. Glazed openings shall be protected in the following:

1. Within 1 mi (1.6 km) of the coastal mean high water line where the basic wind speed is equal to or greater than 130 mi/h (58 m/s), or

2. In areas where the basic wind speed is equal to or greater than 140 mi/h (63 m/s).

Internal pressure Coefficient		Table 26.13-1	for enclosed building
	0.18		
coefficient, GCpi	-0.18		

WIND LOADS ON BUILDINGS: MAIN WIND FORCE RESISTING SYSTEM (ENVELOPE PROCEDURE)

rence
-1
3

Building Geometry Assumptions:

Length, L =	24.5	m =	80.4	ft		
Width, w =	9.8	m =	32.2	ft	Assume width	is half length
Width of edge zones E, a = 0.4h	4	m or a =	10% (w) =	0.98 m		
But a cannot be less than, 4% of	0.392	m or a =		0.98 m		
=> width of edge pressure zon	0.98	m				

Width of edge higher wind pressure zones, for closer spacing roof sheet connectors, a:

Building width (m)	a (m)
24.5	2.45
19.6	1.96
18.4	1.84
12.25	1.23
9.8m or less	0.98

Project. Hurricane Resistant Buildings						Date:	Date: 12-Jul-21		
Engineer: Shalini Jagna	neer. Shalini Jagnarine-Azan						3 of 5		
Description: Gable Roof_	180mph_Exp	oosure B							
					28				
External pressure	Roo	fzones, f	or 20deg ang	le]				
coefficients	2	2E	3	3E					
coefficient, GCpf	-0.69	-1.07	-0.48	-0.69	Load Ca	se A - wind	d direction	predominantly on long side of building	
coefficient, GCpf	-0.69	-1.07	-0.37	-0.53	Load Ca	se B - wind	d direction	predominantly on short side of building	
an and a second and a second and a second a se	-0.87	-1.25	0.66	-0.87	Ca beal				
GCpf - GCpi	-0.07	1.25	-0.00	0.07	Load Ca	D D			
	-0.07	-1.25	-0.00	-0.71	Jeoad Ca	50 0			
	-2.11	-3.04	-1.60	-2.11	Load Ca	se A			
wind pressure, p (KN/m2)	-2.11	-3.04	-1.34	-1.72	Load Ca	se B			
	111								
Use maximum pressure in	main roof a	area, zon	es 2 and 3, p	=	-2.11	kN/m2 =	-44.1	psf	
Use maximum pressure in	edge roof a	area, zon	es 2E and 3E	, pe =	-3.04	kN/m2 =	-63.4	psf	
. Alexandress									
Loading:									
Dead load for timber roof, D	C								
Light frame wood root with b	board ceiling,	waterpro	ofing and	14	psf =	0.67	kPa		
insulation (3pst) & metal sh	eeting =		1000						
Roof live load, Lr =	14/	20	pst =	0.96	kPa	Ref. IBC	2018 16	1607.1	
Force due to wind pressure	W:	10 . A A				0.04			
Consider high-pressure edg	e areas as ci	ntical desi	gn load, W =	-63.4	pst =	-3.04	kPa		
Rasic Load Combinations		nef	Pa (kN/m2)						
Load case 1	D+Lr	34.0	1.63						
Load case 2:	D + 0.6W	-24.0	-1.15						
	D + 0.75Lr								
Load case 3:	+ 0.45W	0.5	0.02						
Load case 4:	0.6D + 0.6W	-29.6	-1.42						
Most onerous load case for	design check	of timbe	r members, F	-29.6	psf =	-1.42	kPa		
Timber rafter check:									
Material:									
Caribbean pitch pine = GS	C18 strength	class or S	SS C27						
Material properties:									
Bending parallel to grain, Sp	=	27.3	N/mm2						
Shear parallel to grain, Sv =		9.25	N/mm2						
Gable Roof Geometric prop	erties based	on max	nof dimension	ns and m	in nitch				
Recall max building length	(I) and width	(W) =	24 5	m =	80.4	Ĥ			
Let building width =	(a) and main	()	18.3	m =	60.0	ft			
A share a shar			20	degrees	00.0				
Refer least between energy and well state 1 and		20	achices						
Rafter length between anex	and wall plat	te I raf =	9 74	m =	31 9				
Rafter length between apex	and wall plat	te, Lraf =	9.74	m =	31.9	ft.			
Rafter length between apex Let max. spacing of rafter, S	and wall plat Graf =	te, Lraf =	9.74	m = m = m2 =	31.9 1.38	ft ft			

EngineerShalini Jagnarine-AzanPage: 4 of 5Description:Gable Roof 180m (B Exposure 8)Check Imber rafer size: rafer deph, H =150 mm x width, B =50 mmDessed Imber section, h =144 mm x width, b =44 mmMaterial properties of Imber: Bending parallel to grain, S =27.3 N/mm2Shear parallel to grain, S =9.3 N/mm2Wet exposure coefficient, k2 =0.9duration load factor, k3 =1.75 for D + L + W in 3-sec gustsdepth modification factor, k7 =1.08 k7 + (300h)*O.11 for beam depths <300mmSection modulus based on dressed Imber size, S v152084 mm3UDL design load on rafter. w = P x Sraf =0.60 k/m =Alowabb bending stress, sp = Sp xk2 xk3 xk7 =46.61 N/mm2Alowabb bending stress, sp = Sp xk2 xk3 xk7 =46.61 N/mm2Alowabb bending stress, hy = p x Sx =7.1 kk/m use zone 2, as rafter length criticalActual bending (M = wL_x/6 =7.1 kk/m use zone 2, as rafter length criticalActual bending stress, hy = Sy xk3 =1.61 N/mm2Shear capacity, Sv = sy x (23, bd) =66.38 kN(Note: vmax = 3/2, v/bd]Actual bear arters, sv = Sv xk3 =1.61 N/mm2Shear capacity, Sv = sv x(23, bd) =66.28 bisActual bear arter, v = wL_y =2.00 N =Gas a kM[Note: vmax = 3/2, v/bd]Actual shear a rafter, v = WL_y =2.00 N =Effective wind area =0.42 m2 =Let spacing of purities, Spure =1.4 ftLet spacing of purities, Spure =1.7 fs for D + L + W in 3-sec gustsupr	Project: Hurricane Resistant Buildings	Date: 12-Jul-21					
Description: Gable Roof 180mph Exposure B Check timber rates rate: rather depth, H = 150 mm x width, b = 44 mm Material properties of timber: Bending parallel to grain, Sp = 27.3 N/mm2 Shear parallel to grain, Sp = 9,3 N/mm2 wet exposure coefficient, K2 = 0,9 duration load factor, K3 = 1.75 for D + L + W in 3-sec gusts depth modification factor, K3 = 1.75 for D + L + W in 3-sec gusts depth modification factor, K3 = 1.75 for D + L + W in 3-sec gusts depth modification factor, K3 = 1.75 for D + L + W in 3-sec gusts depth modification factor, K3 = 1.75 for D + L + W in 3-sec gusts depth modification factor, K3 = 1.08 K7 = (300 kH/m = 40.8 Lb/ft Allowabb bending stress, sp = 50 kX xX sX xK = 46.61 N/mm2 Allowabb bending stress, sp = 50 kX xX sX xK = 7.1 kHm (dressed size) Actual bending stress, sp = 50 kX xX sX = 7.1 kHm (dressed size) Actual bending stress, sp = 50 kX xX sX = 7.1 kHm (dressed size) Actual bending stress, sp = 50 kX xX sX = 7.1 kHm (dressed size) Actual bending stress, sp = 50 kX s= 16.19 N/mm2 Actual bending stress, sp = 50 kX s= 16.19 N/mm2 Actual bending callowabbe bending strength, member size OK Timber purins check: Material to be same as rafler. Length of purin, Log = rafler spacing = 0.42 m = 1.4 ft Let spacing of purins, Spor= 1 m = 3.3 ft Let spacing of purins, Spor= 27.3 N/mm2 Shear panallel, Log = rafler spacing = 0.42 m = 1.4 ft Decision data a = 0.42 m = 4.52 sq. ft Check timber purins check: Material to be same as rafler. Length of purin, Spor= 27.3 N/mm2 Shear panallel to grain, Sp = 9.3 X/mm2 Shear panallel to grain, Sp = 27.3 N/mm2 Shear panallel to grain, Sp = 27.3 N/mm2 Shea	Engineer. Shalini Jagnarine-Azan	Page: 4 of 5					
Check imber rater size: Take depth, H = 150 mm x width, B = 50 mm Dressed imber section, h = 144 mm x width, b = 44 mm Material properties of timber: Bending parallel to grain, S = 27.3 N/mm2 Shear parallel to grain, S = 47.3 N/mm2 Shear parallel to grain, S = 47.3 N/mm2 Material properties of timber: Bending parallel to grain, S = 47.3 N/mm2 Material properties of timber: Bending parallel to grain, S = 47.3 N/mm2 Material properties of timber: Bending parallel to grain, S = 47.3 N/mm2 Material properties of timber: Bending parallel to grain, S = 47.3 N/mm2 Material properties of timber: Bending parallel to grain, S = 47.3 N/mm2 Material properties of timber: Bending stress, sv = S x x 37 = 46.61 N/mm2 Abovable bending stress, sv = S x x 37 = 7.1 k/m (dressed size) Actual bending stress, sv = S x x x 3 = 16.19 N/mm2 Shear capacity, S = x x x (23, bd) = 66.38 k/M [Note: vmax = 32, v/bd] Actual bending Stress, sv = S x x x 3 = 16.19 N/mm2 Shear capacity, S = x x x (23, bd) = 66.38 k/M [Note: vmax = 32, v/bd] Actual bending Stress, sv = S x x x 3 = 16.19 N/mm2 Shear capacity, S = x x x (23, bd) = 66.38 k/M [Note: vmax = 32, v/bd] Actual shear stress, sv = S x x x 3 = 16.19 N/mm2 Shear capacity, S = x x x (23, bd) = 66.38 k/M [Note: vmax = 32, v/bd] Actual shear stress, sv = S x x x 3 = 10.19 N/mm2 Shear capacity, S = x x x (23, bd) = 66.38 k/M [Note: vmax = 32, v/bd] Actual shear stress, sv = S x x x 3 = 10.42 m = 1.4 ft Lesspain of purins, Spur = 1 m = 3.3 ft Effective wind area = 0.42 m = 1.4 ft Lesspain of purins, Spur = 1 m = 3.3 ft Effective wind area = 0.42 m = 27.3 N/mm2 Material to Spain, Spu = 27.3 N/mm2 Shear parallel to grain, Sp = 27.3	Description: Gable Roof_180mph_Exposure B						
rafter dept. H = 150 mm x width, B = 50 mm Material properties of timber Bending parallel to grain, Sp = 27.3 N/mm2 Shear parallel to grain, Sp = 27.3 N/mm2 Shear parallel to grain, Sp = 7.7 in N/mm2 Shear parallel to grain, Sp = 7.7 in N/mm2 Sectom modilus, Z = (16) x BHY 2 = 108 k7 = (300 h/b): 11 for beam depths =300 mm Sectom modilus, Z = (16) x BHY 2 = 10.8 k7 = (300 h/b): 11 for beam depths =300 mm Sectom modilus, Stress, sp = 50 kX kX skX f = 0.60 kN/m = 40.8 Lb/ft Allowabb bending stress, sp = 50 kX kX skX f = 0.60 kN/m = 40.8 Lb/ft Allowabb bending stress, sp = 50 kX kX skX f = 0.60 kN/m = 40.8 Lb/ft Allowabb bending stress, sp = 50 kX kX skX f = 0.60 kN/m = 40.8 Lb/ft Allowabb bending stress, sp = 50 kX kX skX f = 7.1 kN/m (dressed size) Actual bending stress, sp = 50 kX = 7.1 kN/m (dressed size) Actual bending stress, sp = 50 kX = 7.1 kN/m (dressed size) Actual bending stress, sp = 50 kX = 63.8 kN Blowabb bending stress, sp = 50 kX = 63.8 kN Actual bending a lowabb bending trength, member size OK Allowabb bending stress, sp = 50 kX = 63.8 kN Actual bending a lowabb bending trength, member size OK Timber purins check: Material to be same as rafler. Length of purin, Log r = nafler spacing = 0.42 m = 1.4 ft Let spacing of purins, Spor = 1 m = 3.3 ft Elet spacing of purins, Spor = 0.42 m = 1.4 ft Dressed timber section, h = 44 mm x width, B = 50 mm Dressed timber section, h = 50 mm x width, B = 50 mm Dressed timber section, h = 50 mm x width, B = 50 mm Dressed timber section, h = 44 mm x width, B = 50 mm Dressed timber section, h = 44 mm x width, B = 50 mm Dressed timber section, h = 44 kK m x width, B = 50 mm Dressed timber section, h = 44 kK m x width, B = 50 mm Dressed timber section, h = 44 kK m x width, B = 50 mm Dressed timber section, k2 = 0.93 M/m2 section modulus, Z = (16) kB/H ² = 20833 mm3 Section modulus based on dressed timber size, S5 h 11497.3 mm3 UDL design load on rafter, w = PX Spor = 1.42 kN/m = 97.3 Lb/ft	Check timber rafter size:						
Dressed imber section, h =144mm xwidth, b =44mmMaterial properties of timber: Bending parallel to grain, SP =7.3N/mm2Shear parallel to grain, SP =9.3N/mm2wet exposure coefficient, k2 =0.9duration load factor, k3 =1.75for D + L + W in 3-sec gustsdepth modification factor, k3 =1.76for D + L + W in 3-sec gustsdepth modification factor, k3 =1.76for D + L + W in 3-sec gustsSection modulus 2 = (16) x EH/2 =187500mm3Section modulus stased on dressed timber size, SN152064mm3Alowabe bending stress, sp = Sp xk2 xk3 xk7 =0.60 k/m =40.8 LbftAlowabe bending stress, sp = Sp xk2 xk3 xk7 =1.61 Nmm2Actual bending (M = wt_w/6 =Actual bending (M = wt_w/6 =7.1 k/muse zone 2, as rafter length enticalActual bending Stress, sy = Sy xk3 =1.61 Nmm2Actual bending Stress, sy = Sy xk3 =Actual bending Stress, sy = Sy xk3 =1.61 Nmm2Actual bending Stress, sy = Sy xk3 =Actual bending C = allowable bender stress, sy = Sy xk3 =1.61 Nmm2Actual bending Stress, sy = Sy xk3 =1.61 Nmm2Actual bending Stress, sy = Sy xk3 =1.61 Nmm2Shear parallel to grain, Sper1.7 k/mShear parallel to grain, Sper2.7 N/mm2Shear parallel to grain, Sper2.7 N/mm2UBertis Albertin size:0.9 MmPuritine Albertin Stressed Stresses9.7 N/mm2Shear parallel to grain, Sper2.7 N/mm2Bend parallel to grain, Sper <td>rafter depth, H = 150 mm x width, B = 50 mm</td> <td></td>	rafter depth, H = 150 mm x width, B = 50 mm						
Material properties of timber: Bending parallel to grain, Sy = 27.3 N/mm2 Shear parallel to grain, Sy = 9.3 N/mm2 wet exposure coefficient, K2 = 0.9 duration load factor, K3 = 1.08 k7 = (300 h/p.0.11 for beam depths =300mm Section modulus based on dressed timber size, Sx 152064 mm3 UDL design load on raffer, w = P x Sraf = 0.60 kN/m = 40.8 Lb/ft Allowabb bending stress, sy = Sx k2 xK3 xK = 7.1 kN/m (dressed size) Actual bending, stress, sy = Sx k2 xK3 xK = 7.1 kN/m (dressed size) Actual bending, w = P x Sraf = 0.60 kN/m = 40.8 Lb/ft Allowabb bending stress, sy = Sx k2 xK3 xK = 7.1 kN/m (dressed size) Actual bending, V = Y x (27.4 k2 k3 xK) = 65.2 k1 k3 k3 k1 Actual bending stress, sy = Sx xK3 = 16.19 N/mm2 Allowabb bending strength, member size OK Allowabb bending strength, MP = sp x Sx = 7.1 kN/m (dressed size) Actual bending x = Sy xK3 = 16.19 N/mm2 Actual bending x = Sy xK3 = 2.90 kN = 652.6 lbs Actual shear on rafter, V = Ww_m/2 = 2.90 kN = 652.6 lbs Actual shear on rafter, V = Ww_m/2 = 2.90 kN = 452.8 g, ft Check timber purins check: Material to be same as rafter. Length of purin, Loper = rafter spacing = 0.42 m = 1.4 ft Let spacing of purins, Spur= 1 m = 3.3 ft Eventy wind mea = 0.42 m2 = 4.52 sq. ft Check timber purin size: Dressed timber section, h = 50 mmx width, B = 50 mm Dressed timber section, h = 50 mmx width, B = 50 mm Dressed timber section, h = 44 mmx width, b = 44 mm Material porperings of timber: Bending parallel to grain, Sp = 27.3 N/mm2 Section modulus, Z = (16) X BH/2 = 2083.3 mm3 Section modulus, Z = (16) X BH/2 = 2083.3 mm3 Section modulus, Z = (16) X BH/2 = 2083.3 mm3 UDL design load on rafter, w = P X Spur = 1.42 kN/m = 97.3 Lb/ft	Dressed timber section, h = 144 mm x width, b = 44 mm						
Material properties of timber: Bending parallel to grain, SP = 9.3 N/mm2 Wet exposure coefficient, k2 = 0.9 duration load factor, k3 = 1.75 for D + L + W in 3-sec gusts depth modification factor, k1 = 1.08 k/r = 100 k/m = 40.8 Lbft Allowable bending stress, sp = Sp xk2 xk3 xk7 = 46.61 N/mm2 Allowable bending stress, sp = Sp xk2 xk3 xk7 = 46.61 N/mm2 Allowable bending stress, sp = Sp xk2 xk3 xk7 = 46.61 N/mm2 Allowable bending stress, sp = Sp xk2 xk3 xk7 = 46.61 N/mm2 Allowable bending stress, sp = Sp xk2 xk3 xk7 = 46.61 N/mm2 Allowable bending stress, sp = Sp xk2 xk3 xk7 = 46.61 N/mm2 Allowable bending stress, sp = Sp xk2 xk3 xk7 = 46.61 N/mm2 Allowable bending stress, sp = Sp xk2 xk3 xk7 = 46.61 N/mm2 Allowable bending stress, sp = Sp xk2 xk3 xk7 = 46.61 N/mm2 Allowable bending stress, sp = Sp xk2 xk3 xk7 = 46.61 N/mm2 Allowable bending stress, sp = Sp xk3 xk3 = 16.19 N/mm2 Shear capacity, Sv = sy x(23, bd) = 66.38 k/M [Note: vmax = 3.2, v/bd] Actual bending (x = allowable bending strength, member size OK Actual shear stress, sv = Sv xk3 = 10.19 N/mm2 Shear capacity, Sv = sy x(23, bd) = 66.38 k/M [Note: vmax = 3.2, v/bd] Actual shear strength, OK Timber puritins check: Length of purini, Lpur = rafter spacing = 0.42 m = 1.4 ft Let spacing of purinis, Spur = 1 m = 3.3 ft Effective wind area = 0.42 m2 = 4.52 sq, ft Check timber purities of timber: Bending parallel to grain, Sp = 27.3 N/mm2 Shear parallel to grain, Sp = 27.3 N/mm2 Shear parallel to grain, Sp = 27.3 N/mm2 Shear parallel to grain, Sp = 27.3 N/mm2 Section modulus, Z = (16) x BH/2 = 208.33 mm3 Section modulus abaed on draster, k2 = 0.9 duration load factor, k3 = 1.75 for D + L + W in 3-sec gusts depth modification factor, k7 = 1.24 k/7 = 208.33 mm3 UDL design load on rafter, w = P x Spur = 1.42 k/7 m = 97.3 Lb/ft							
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Shear parallel to grain, $S_{P} = 0.3$ N/mm2 wet exposure coefficient, $k_{2} = 1.75$ for $D + L + W$ in 3-sec gusts duration load factor, $k_{3} = 1.75$ for $D + L + W$ in 3-sec gusts depth modification factor, $k_{3} = 1.75$ for $D + L + W$ in 3-sec gusts depth modification factor, $k_{3} = 1.75$ for $D + L + W$ in 3-sec gusts depth modification factor, $k_{3} = 1.75$ for $D + L + W$ in 3-sec gusts depth modification factor, $k_{3} = 1.75$ for $D + L + W$ in 3-sec gusts depth modification factor, $k_{3} = 1.618$ k/mm2 Allowable bending stress, $s_{9} = 5p_{x}k_{2} + k_{3} + k_{3} = 0.60$ k/m = 40.8 Lb/ft Allowable bending stress, $s_{9} = 5p_{x}k_{2} + k_{3} + k_{4} = 0.80$ k/m = 40.8 Lb/ft Allowable bending stress, $s_{9} = 5p_{x}k_{2} + k_{3} + k_{4} = 7.1$ k/m (dressed size) Actual bending is stress, $s_{9} = 5p_{x}k_{2} + k_{3} + k_{4} = 7.1$ k/m (dressed size) Actual bending stress, $s_{9} = 5p_{x}k_{2} + k_{3} + 16.19$ N/mm2 Shear capacity, $b_{7} = s_{x} + (23, bd) = 66.38$ k/m (Note: vmax = 3/2, V/bd) Actual shear artners, $v = (23, bd) = 66.38$ k/m (Note: vmax = 3/2, V/bd) Actual shear artner, $V = w_{-1} = 20$ k/m = 1.4 ft Lesphein of purins, Spure = 1 m = 3.3 ft Effective wind area = 0.42 m = 1.4 ft Lesphein of purins, Spure = 1 m = 3.3 ft Effective wind area = 0.42 m = 4.52 sq. ft Check timber purities of timber Bending parallel to grain, $S_{9} = 27.3$ N/mm2 Shear parallel to grain, $S_{9} = 27.3$ N/mm2 She	Bending parallel to grain, Sp = 27.3 N/mm2						
wet exposure coefficient, $k^2 = 0.9$ depth modification k3 = 1.75 for D + L + W in 3-sec gusts depth modification factor, $k^2 = 1.08$ k7 = (300 h/p.0.11 for beam depths =300 mm Section modulus based on dressed timber size, Sx Section modulus based on dressed timber size, Sx Section modulus based on dressed timber size, Sx Allowabb bending stress, sp = 50 k2 k3 k3 k7 Allowabb bending stress, sp = 50 k2 k3 k3 k7 Allowabb bending stress, sp = 50 k2 k3 k3 k7 Allowabb bending stress, sp = 50 k2 k3 k3 k7 Allowabb bending stress, sp = 50 k2 k3 k3 k7 Allowabb bending stress, sp = 50 k3 s Barc rapacity, Sv = s x (2.3 k3 s Barc rapacity, Sv = s x (2.3 k3 s Barc rapacity, Sv = s x (2.3 k3 s Actual beard in w4m ² /s = 7.1 kNm (dressed size) Actual beard in w4m ² /s = 7.1 kNm (dressed size) Actual beard in w4m ² /s = 7.1 kNm (dressed size) Actual beard in w4m ² /s = 7.1 kNm (dressed size) Actual beard in w4m ² /s = 7.1 kNm (dressed size) Actual beard in w4m ² /s = 7.1 kNm (dressed size) Actual beard in w4m ² /s = 7.1 kNm (dressed size) Actual beard in w4m ² /s = 7.1 kNm (dressed size) Actual beard in w4m ² /s = 7.1 kNm (dressed size) Actual beard in w4m ² /s = 7.1 kNm (dressed size) Actual beard in portion k5, s = 0.42 m = 1.4 ft Let spacing of purines, Spur = 0.42 m = 1.4 ft Let spacing of purines, Spur = 0.42 m = 4.52 s q. ft Check timber purine size: Dressed timber section, h = 44 mm x width, b = 44 mm Material portion sign, S = 7.7 3 N/mm2 wet exposure coefficient, k2 = 0.9 depth modification factor, k7 = 1.24 k7 = (2003) *0.11 for beam depths =300 mm Section modulus, Z = (16) k3 HH ² = 20833 mm3 Section modulus, Z = (16) k3 HH ² = 1.42 kN/m = 97.3 Lb/ft	Shear parallel to grain, Sv = 9.3 N/mm2						
duration load factor, k3 = 1.75 for D + L + W in 3-sec gusts depth modification factor, k7 = 1.08 k7 = 100 k7 + 10 for beam depths -300mm Sector modulus 2 = (16) x EH/2 = 187500 mm3 Sector modulus based on dressed timber size, S5 152084 mm3 UDL design load on rafter, w = P x Sraf = 0.60 kHm = 40.8 Lbft Allowable bending strengs, hy = sp xSx = 7.1 kHm use zone 2, as rafter length entical Actual bending A = M_{w}/R^3 = 7.1 kHm use zone 2, as rafter length entical Actual bending A = M_{w}/R^3 = 7.1 kHm use zone 2, as rafter length entical Actual bending Strengs, hy = sp xKx = 16.19 Nmm2 Shear capacity, S7 = sp x (23, bd) = 66.38 kH [Note: vmax = 3/2, vbd] Actual bending A = M_{w}/R^2 = 2.00 kN = 652.6 lbs Actual shear of rafter, V = M_{w}/R^2 = 2.00 kN = 652.6 lbs Actual shear of rafter, V = M_{w}/R^2 = 0.42 m = 1.4 ft Let spacing of purins, Spur = 1 mm 3.3 ft Effective wind area = 0.42 m = 1.4 ft Let spacing of purins, Spur = 1 mm 3.3 ft Effective wind area = 0.42 m = 4.52 sq, ft Check limber purities Strength = 27.3 Nimm2 Material to be same as rafter; Purind epth, H = 50 mm x width, B = 50 mm Dressed Simber section, h = 44 mm x width, b = 44 mm Material pose conting is $Se = 27.3 Nimm2$ Shear parallel to grain, Sp = 27.3 Nimm2 Sector modulus tased on dressed simber size, Spi 1.12 kK7 = (200h) ¹⁰ .11 for beam depths <300mm Sector modulus tased on dressed simber sec, Spi 1.42 kN/m = 97.3 Lb/ft	wet exposure coefficient, k2 = 0.9						
depth modification factor, $k^2 = 1.08$ k/ $k^2 = (300h)^{10.11}$ for beam depths -300 mm Section modulus based on dressed timber size, Sx 152064 mm3 UDL design load on rafter, $w = Px$ Sraf = 0.60 kH/m = 40.8 Lb/ft Allowabb bending stress, $gx = Px$ K2 kX sk x^2 + 46.61 N/mm2 Allowabb bending stress, $gx = Px$ K2 kX sk x^2 + 46.61 N/mm2 Allowabb bending stress, $gx = Px$ K2 kX sk x^2 + 7.1 kH/m (dressed size) Actual bending $w = Vu_{xy}/2$ = 7.1 kH/m (dressed size) Actual beards $w = Vu_{xy}/2$ = 7.1 kH/m (dressed size) Actual beards $w = Vu_{xy}/2$ = 63.8 kV (Note: vmax = 3/2. v/bd) Actual shear or nafter, $V = Wu_{xy}/2$ = 2.90 kN = 652.6 lbs Actual shear or nafter, $V = Wu_{xy}/2$ = 0.42 m = 1.4 ft Let spacing of purins, Spur = 0.42 m = 1.4 ft Let spacing of purins, Spur = 0.42 m = 1.4 ft Let spacing of purins, Spur = 0.42 m = 4.52 sq. ft Check timber purins scheck: Material to be same as rafter. Length of purin, Spur = 4.50 mmx width, B = 50 mm Dressed timber section, h = 44 mmx width, b = 44 mm Material poperties of timber Bending parallel to grain, Sp = 7.7 3 N/mm2 Section modulus, Z = (16) x BH/2 = 2083 xm Section modulus, Z = (16) x BH/2 = 20833 xm Section modulus, Z = (16) x BH/2 = 20833 xm Section modulus, Z = (16) x BH/2 = 20833 xm Section modulus, Z = (16) x BH/2 = 20833 xm Section modulus, Z = (16) x BH/2 = 20833 xm Section modulus, Z = (16) x BH/2 = 20833 xm Section modulus, Z = (16) x BH/2 = 20833 xm Section modulus, Z = (16) x BH/2 = 20833 xm Section modulus, Z = (16) x BH/2 = 20833 xm Section modulus, Z = (16) x BH/2 = 20833 xm Section modulus, Z = (16) x BH/2 = 20833 xm Section modulus, Z = (16) x BH/2 = 20833 xm Section modulus, Z = (16) x BH/2 = 20833 xm Section modulus aded on rafter, $w = Px$ Spur = 1.42 kN/m = 97.3 Lb/ft	duration load factor, k3 = 1.75 for D + L + W in 3-sec gusts						
Sector modulus Z = (18) EH*2 = 187500 mm3 Sector modulus based on dressed timber size, Sr. 152084 mm3 Sector modulus based on orater, w = P. Sraf = 0.60 k/m = 40.8 Lbft Allowable bending strengs, Ng = p. St × 46.81 N/mm2 Allowable bending strengs, Ng = p. St × 7.1 k/m use zone 2, as rafter length critical Actual bending (M = M_{w}/R^{3} = 7.1 k/m use zone 2, as rafter length critical Actual bending V = Vk_37 = 16.19 N/mm2 Shear capacity, Sr = sr V(3) beil = 66.38 k/m (Note: vmax = 3/2, Vbd] Actual shear strengs, sr = Sr vk 3 = 16.19 N/mm2 Shear capacity, Sr = sr V(3) beil = 66.38 k/m (Note: vmax = 3/2, Vbd] Actual shear arters, sr = 200 k/m = 652.6 k/m Actual shear arters, sr = 0.42 m = 1.4 ft Let spacing of purins, Spar = 0.42 m = 1.4 ft Let spacing of purins, Spar = 0.42 m = 4.52 sq. ft Check timber purins for timber Bending parallel to grain, Sp = 27.3 N/mm2 Shear gaallel to grain, Sp = 27.3 N/mm2 Shear	depth modification factor, k7 = 1.08 k7 = (300/h)^0.11 for beam dep	pths <300mm					
Sector modulus based on dressed timber size, Sx 152084 mm3 UDL design load on rafter, w = P x Sraf = 0.60 kV/m = 40.8 Lb/ft Allowabb bending strength Mp = sp x Sx = 7.1 kV/m (dressed size) Allowabb bending strength Mp = sp x Sx = 7.1 kV/m (dressed size) Actual bending w = Vu_m/a = 7.1 kV/m (dressed size) Actual bending w = Sx = Sx x 3 = 16.19 N/mn2 Baser capacity, Sx = x (2.3 kN = 0.62 kV/m =	Section modulus 7 = (1/6) x RH*2 = 187500 mm3						
Volt design load on rafter, w = P x Sraf = 0.60 k/m = 40.8 Lb/ft Allowable bending strengs, Mp = sp xSx = 7.1 k/m (dressed size) Actual bending strengs, Mp = sp xSx = 7.1 k/m use zone 2, as rafter length critical Actual bending x = x, x = 0.60 k/m = 40.8 Lb/ft Actual bending x = x, x = 0.60 k/m = 7.1 k/m use zone 2, as rafter length critical Actual bending x = x, x = 0.60 k/m = 7.1 k/m use zone 2, as rafter length critical Actual bending x = x, x = 0.60 k/m = 7.1 k/m use zone 2, as rafter length critical Actual bending x = x, x = 0.60 k/m = 7.1 k/m use zone 2, as rafter length critical Actual bending x = x, y = 2.00 k/m = 652.6 k/m = 652.6 k/m = 652.6 k/m = 652.6 k/m = 7.1 k/m is zone 2.00 k/m = 652.6 k/m = 7.1 k/m is zone 2.00 k/m = 652.6 k/m = 7.1 k/m is zone 2.00 k/m = 652.6 k/m = 7.1 k/m is zone 2.00 k/m = 652.6 k/m = 7.00 k/m = 7.00 k/m = 7.3 k/m = 7	Section modulus based on dressed timber size Sv 152064 mm3						
UDL design load on rafter, w = P x Sraf = 0.60 kV/m = 40.8 Lbft Alowable bending stress, sp = Sxi X kV xX xX 46.81 N/mm2 Alowable bending stress, sp = Sxi X kV xX xX 46.81 N/mm2 Actual bending alowable bending stress, sp = Sxi X kV xX xX 7.1 kV/m use zone 2, as rafter length critical Actual bending alowable shearing alowable shearing alowable shearing alowable shearing Alowable shear stress, sv = Sv xX 3 16.19 N/mm2 68.38 kN [Note: vmax = 3/2, v/bd] Actual shear on after, V w w_uz (23. bd) = 68.38 kN [Note: vmax = 3/2, v/bd] Actual shear on after, V w w_uz (23. bd) = 68.38 kN [Note: vmax = 3/2, v/bd] Actual shear on after, V w w_uz (23. bd) = 68.38 kN [Note: vmax = 3/2, v/bd] Actual shear on after, V w w_uz (23. bd) = (A2 m = 1.4 ft Effective wind area = 0.42 m2 = 4.25 square for mm Material properties of timber: Bending parallel to grain, Sp = 27.3 N/mm2 Shear parallel to grain, Sp = 27.4 K/7 (300h)*0.11 for beam depths <300mm Section modulus, Z = (16) x BH/2 = 2083 mm3 Secti	decider modulus subset on dicessed amber size, or inized a mino						
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Actual bending, M = wL_v/8 = 7.1 kVm use zone 2, as rafter length critical Actual bending < allowable bending strength, member size OK	Allowable bending strength Mp = sp x Sx = 7.1 kNm (dressed	size)					
Actual serving a material properties of timber: Bener apparallel to grain, Sp = 27.3 N/mm2 Bener apparallel to grain, Sp = 20.833.3 mm3 Better modification factor, k ² = 20.833.3 mm3	Actual bending M = wi 3/8 = 7.1 kNm use zone	2 as rafter length critical					
Actual shear or nafter; V = wL _m /2 = 220 kN = 6528 kN [Note: vmax = 322 . Vbd] Actual shear or nafter; V = wL _m /2 = 220 kN = 6528 kN Actual shear or nafter; V = wL _m /2 = 220 kN = 652.6 libs Actual shear or nafter; V = wL _m /2 = 220 kN = 652.6 libs Actual shear or nafter; V = wL _m /2 = 140 ft Let spacing of puttins, Spur = 1.4 ft Let spacing of puttins, Spur = 0.42 m = 1.4 ft Let spacing of puttins, Spur = 0.42 m = 1.4 ft Let spacing of puttins, Spur = 0.42 m = 4.52 sq. ft Check limber puttins setting = 0.42 m = 4.4 mm Dressed simber section, h = 44 mm x width, B = 50 mm Dressed simber section, h = 44 mm x width, b = 44 mm Material properties of timber: Bending parallel to grain, Sp = 27.3 N/mm2 Shear parallel to grain, Sp = 2.73 N/mm2 Shear parallel to grain, Sp = 1.42 k/ T = 20833 3 mm3 WDL design load on rafter, w = P x Spur = 1.42 kN/m = 97.3 Lb/ft	Actual banding < allowable banding strength member size OK	2, as faiter length endear					
Allowable shara stress, sy = Sy xk3 = 16,19 N/mm2 Shear capacity, Sv = sy x (23, bd) = 68,38 kN [Note: vmax = 3/2, v/bd] Actual shear on rafter, V = wL _{m1} /2 = 2,90 kN = 652.6 lbs Actual shear on rafter, V = wL _{m1} /2 = 0,42 m = 1.4 ft Les spain of putinis, Spur = 1 m = 3.3 ft Effective wind area = 0,42 m 2 = 4.52 sq. ft Check timber putinis size: putini depth, H = 50 mm x width, B = 50 mm Material properties of timber: Bending parallel to grain, Sp = 27.3 N/mm2 Shear parallel to grain, Sp = 9.3 N/mm2 wet exposure coefficient, k2 = 0.9 duration load factor, k3 = 1.75 for D + L + W in 3-sec gusts depth modification factor, k7 = 1.24 k7 = (2003h)*0.11 for beam depths =300mm Section modulus, Z = (16) x BH/2 = 20833.3 mm3 UDL design load on rafter, w = P x Spur = 1.42 kN/m = 97.3 Lb/ft	Actual bending < allowable bending strength, member size OK						
Sever apacity, $5^{\nu} = s^{\nu} x (23, bd) = 63.38 \text{ M}$ [Note: wmax = 3/2, v/bd] Actual shear or nafter, $V = wL_{w1}/2 = 2.90 \text{ kN} = 652.6 \text{ ibs}$ Actual shear of allowable shear strength, OK Timber purlins check: Length of purlin, Lpur = rafter spacing = 0.42 m = 1.4 ft Let spacing of purlins, Spur = 0.42 m = 4.52 sq. ft Check limber purlins section, h = 0.42 m = 4.52 sq. ft Check limber purlins section, h = 44 mm x width, B = 50 mm Dressed simber section, h = 44 mm x width, b = 44 mm Material properties of timber: Bending parallel to grain, Sp = 27.3 N/mm2 Shear parallel to grain, Sp = 9.3 N/m2 wet exposure coefficient, k2 = 0.9 duration load factor, k3 = 1.75 for D + L + W in 3-sec gusts depth modification factor, k3 = 1.24 k7 = (300h)*0.11 for beam depths =300mm Section modulus, Z = (16) x BH ² Z = 20833 mm3 Section modulus, Z = (16) x BH ² Z = 20833 mm3 UDL design load on rafter, w = P x Spur = 1.42 kN/m = 97.3 Lb/ft	Allowable chear strace ev - Sv vk3 - 16 10 N/mm2						
Since capacity, or after, $Y = w_{m,1}^{(2)} = 2.90 \text{ km} = 652.6 \text{ kbs}$ Actual shear on after, $Y = w_{m,1}^{(2)} = 2.90 \text{ km} = 652.6 \text{ kbs}$ Actual shear on after, $Y = w_{m,1}^{(2)} = 2.90 \text{ km} = 652.6 \text{ kbs}$ Actual shear on after, $Y = w_{m,1}^{(2)} = 2.90 \text{ km} = 652.6 \text{ kbs}$ Timber purifins check: Material to be same as rafter. Length of purifin, Spor = 1 m = 3.3 ft Effective wind area = 0.42 m2 = 4.52 sq.ft Check timber purifin size: purifin depth, H = 50 mm x width, B = 50 mm Material properties of timber: Bending parallel to grain, Sy = 27.3 N/mm2 Shear parallel to grain, Sy = 9.3 N/mm2 wet exposure coefficient, k2 = 0.9 duration load factor, k3 = 1.75 for D + L + W in 3-sec gusts depth modification factor, k3 = 1.24 k7 = (2008)/h0.11 for beam depths <300mm Section modulus, Z = (16) x BH/2 = 2083.3 mm3 UDL design load on rafter, w = P x Spur = 1.42 kN/m = 97.3 Lb/ft	Chear capacity Sy = cy x /3/2 bd) = 68 28 kM [Note: ymax = 3/2	u(bd)					
Actual shear 4 and allowable shear strength. OK Timber purlins check: Length of purlin, Low r enther specing = 0.42 m = 1.4 ft Let spacing of purlins, Sour = 0.42 m = 3.3 ft Effective wind area = 0.42 m = 4.52 sq. ft Check limber purlins (size: mm x width, B = 50 mm Dressed simber section, h = 44 mm x width, B = 44 mm Material properties of limber: Bending parallel to grain, Sp = 2.7.3 N/mm2 Shear parallel to grain, Sp = 9.3 N/mm2 wet exposure coefficient, K2 = 0.9 duration load factor, K3 = 1.75 for D + L + W in 3-sec gusts depth modification factor, K3 = 1.24 k/7 = 20833 3 mm3 Section modulus, Z = (16) x BH/2 = 20833 3 mm3 Section modulus, Z = (16) x BH/2 = 1.42 kN/m = 97.3 Lb/ft	Actual shear on rafter $V = wl / 2 = 200 kM = 652.6 lbc$, vibul					
Actual sheaf < allowable shear strength, OK Timber purlins check: Matrial to be same as rafter: Length of purlin, Lpar = rafter spacing = 0.42 m = 1.4 ft Let spacing of purlins, Spur = 1 m = 3.3 ft Effective wind area = 0.42 m2 = 4.52 sq. ft Check timber purlin size: purlin depth. H = 50 mm x width, b = 50 mm Dessed timber section, h = 44 mm x width, b = 44 mm Material properties of timber: Bending parallel to grain, Sp = 27.3 N/mm2 Shear parallel to grain, Sp = 9.3 N/mm2 wet exposure coefficient, k2 = 0.9 duration load factor, k3 = 1.75 for D + L + W in 3-sec gusts depth modification factor, k7 = 1.24 k7 = (2083.3 mm3 Section modulus, Z = (16) x BH/2 = 2083.3 mm3 UDL design load on rafter, w = P x Spur = 1.42 kN/m = 97.3 Lb/ft							
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Timber putfins check: Length of putfin, Lpar = rafler spacing = 0.42 m = 1.4 ft Length of putfin, Lpar = rafler spacing = 1 m = 3.3 ft Effective wind area = 0.42 m = 4.52 sq.ft Check timber putfin size: 0.42 m m width, b = 50 mm Dessed timber section, h = 50 mm x width, b = 44 mm Material properties of timber: 27.3 N/mm2 Shear parallel to grain, Sp = 9.3 N/mm2 Shear parallel to grain, S = 9.3 N/mm2 Shear parallel tor, k3 = 1.75 for D + L + W in 3-sec gusts depth modification factor, k7 = 1.24 k7 = (300/h)·0.11 for beam depths <300mm	Timber and in charles						
Image the of set in, Lear = methylic, Le	Material to be came as rafter						
Length optimit, point relates backing = 0.42 m = 1.4 ft Effective wind area = 0.42 m = 3.2 ft Effective wind area = 0.42 m = 4.52 sq. ft Check timber pumitin size: 0.4 mmx width, b = 50 mm Deside timber section, h = 44 mmx width, b = 44 mm Material properties of timber: 27.3 N/mm2 Shear parallel to grain, Sy = 9.3 N/mm2 Shear parallel to grain, S = 1.75 for D + L + W in 3-sec gusts 44 49.1 44 duration load factor, k3 = 1.75 for D + L + W in 3-sec gusts 300mm 56.0 500mm Section modulus, Z = (16) x BH/2 = 2083.3 mm3 56.0 500mm 500mm UDL design load on rafter, w = P x Spur = 1.42 kN/m = 9.7.3 Lb/ft 1.42 kN/m 9.7.3 Lb/ft	Length of pudie Lours rafter opering = 0.42 m = 1.4 ft						
Extension of Damis, goot - 0.4 m2 = 4.52 sq. ft Deck key data size: 0.4 m2 = 4.52 sq. ft purint depth, H = 50 mm mm width, B = 50 Matrial properties of Imber section, h = 44 mm width, b = 44 mm Matrial properties of Imber Bending parallel to grain, Sy = 2.7.3 N/mm2 Shear parallel to grain, Sy = 9.3 N/m Shear parallel to grain, Sy = 9.3 N/m2 Shear parallel to grain, Sy = 9.3 N/m2 Shear parallel to torain, Sy = 9.3 N/m2 Shear parallel to train, Sy = 9.3 N/m2 Shear parallel to train, Sy = 1.75 for D + L + W in 3-sec gusts depth modification factor, k1 = 1.24 k7 = (300h)*0.11 for beam depths <300mm	Let engline of putting Spure 1 m 2 2 ft						
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Unlex Kinder Joinn Size: 50 mm x width, B = 50 mm Dressed timber section, h = 44 mm x width, B = 50 mm Material properties of Imber 44 mm x width, B = 44 mm Bending parallel to grain, Sp = 27.3 N/mm2 Shear parallel to grain, Sp = 9.3 Shear parallel to grain, Sp = 9.3 N/mm2 Shear parallel to train, Sp = 9.3 Wartafon load factor, k2 = 0.9 duration load factor, k2 = 0.9 duration load factor, k3 = 1.75 Section modulus, Z = (16) x BH*2 = 20833.3 mm3 s300mm s200mm s200mm Section modulus L = 46 (imber size, S) 1.14 k7 = (2003)*0.11 for beam depths <300mm	Check timber pudie circl						
Jonan Boyen, It = Do Mini X, Wadi, D = 44 mm Material properties of timber: 24 mm Bending parallel to grain, Sy = 27.3 Wmm2 Shear parallel to grain, Sy = 9.3 Wmm2 wet exposure coefficient, K2 = 0.9 duration load factor, K3 = 1.75 for D + L + W in 3-sec gusts depti modification factor, K3 = 1.24 K7 (3000/h):0.11 for beam depths <300mm	check umber punin size.						
Unessed united secular, in	Densed techor be 44 mm v width be 44 mm						
Material properties of limber: 27.3 N/mm2 Bending parallel to grain, Sy = 9.3 N/mm2 Shear parallel to grain, Sy = 9.3 N/mm2 wet exposure coefficient, K2 = 0.9 duration load factor, K3 = 1.75 for D + L + W in 3-sec gusts depti modification factor, K3 = 1.24 K7 (500h/h0.11 for beam depths <300mm	Dressed umber section, n = 44 mm x widin, b = 44 mm						
Bending parallel to grain, Sy = 27.3 N/mm2 Shear parallel to grain, Sy = 9.3 N/mm2 Shear parallel to grain, Sy = 9.3 N/mm2 wet exposure coefficient, K2 = 0.9 depth modification factor, K7 = 1.75 for D + L + W in 3-sec gusts depth modification factor, K7 = 1.24 k7 = (300h)*0.11 for beam depths <300mm	Material properties of timber						
Schemp paralle to grain, Sy = 1.3 Mmm2 Shear paralle to grain, Sy = 9.3 Mmm2 wet exposure coefficient, K2 = 0.9 dotation load factor, K3 = 1.75 for D + L + W in 3-sec gusts depti modification factor, K7 = 1.24 k7 = (300 h)*0.11 for beam depths <300mm	Banding parallal to grain So = 27.3 N/mm2						
Section modulus, Z = (16) x, BH*2 = 20833.3 mm3 Section modulus, Z = (176) x, BH*2 = 20833.3 mm3 Section modulus based on dressed timber size, Sx 14197.3 mm3 UDL design load on rafter, w = P x Spur = 1.42 kN/m = 97.3 Lb/ft	Shear parallel to grain, Sp = 0.3 N/mm2						
were opposite openuent, V2 = 000 000 deptit modification factor, K2 = 1.75 for D + L + W in 3-sec gusts deptit modification factor, K2 = 1.24 k7 = (300 h/p 0.11 for beam depths <300 mm	sitear paraller to grain, 5v = 5.5 km/m2						
Joint J	duration load factor k2 = 0.5						
Section modulus, Z = (16) x BH/2 = 20833.3 mm3 Section modulus, Z = (16) x BH/2 = 20833.3 mm3 Section modulus stated on dressed timber size, Sx 14197.3 mm3 UDL design load on rafter, w = P x Spur = 1.42 kN/m = 97.3 Lb/ft	denth modification factor $k7 = 1.75$ for $b + c + W = 356c$ guids denth modification factor $k7 = 1.24$ $k7 = (300 h) \times 0.11$ for heam day	othe <300mm					
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Section modulus based on dressed timber size, Sx 14197.3 mm3 UDL design load on rafter, w = P x Spur = 1.42 kN/m = 97.3 Lb/ft	Section modulus 7 = (1/6) x BH ⁴ 2 = 20833.3 mm3						
UDL design load on rafter, w = P x Spur = 1.42 kN/m = 97.3 Lb/ft	Section modulus based on dressed timber size St 14197.3 mm3						
UDL design load on rafter, w = P x Spur = 1.42 kN/m = 97.3 Lb/ft	devide moving pased on dessed minute size, ov 14191/3 minu						
e a congritor of failer, if - i is each - i the minin - of o both							
Allowable bending stress sp = Sp xk2 xk3 xk7 = 53 11 N/mm2	IIDI design load on rafter w = P x Sour = 1.42 kN/m = 97.3	316/#					
Allowable bending strength Mo s ny Sy = 0.8 kNm (dressed size)	UDL design load on rafter, w = P x Spur = 1.42 kN/m = 97.3 Allowable bending stress sp = Sp xk2 xk3 xk7 = 53 11 N/mm2	3 Lb/ft					
Anomalice bending strength mp = ap x ox = 0.0 kmm (dressed size)	UDL design load on rafter, w = P x Spur = 1.42 kN/m = 97.3 Allowable bending stress, sp = Sp xk2 xk3 xk7 = 53.11 N/mm2 Allowable bending streading	size)					
Actual pending M = W 1/8 = 0.03 kNm use zone 2 as ratter length critical	UDL design load on rafter, w = P x Spur = 1.42 kN/m = 97.3 Allowable bending stress, sp = Sp xk2 xk3 xk7 = 53.11 N/mm2 53.11 N/mm2 Allowable bending strength Mp = sp x Sx = 0.8 kNm (dressed actual bending the sp x Sx = 0.8 kNm	size) -2 as rafter length critical					
Actual bending, M = wt _{pu} //8 = 0.03 kNm use zone 2, as ratter length critical	$ \begin{array}{llllllllllllllllllllllllllllllllllll$	size) size) 2, as rafter length critical					
A ADIAL DADAUDA IN FULL TAX -	UDL design load on rafter, w = P x Spur = 1.42 kN/m = 97.3 Allowable bending stress, sp = Sp xk2 xk3 xk7 = 53.11 N/mm2 Allowable bending strength Mp = sp x Sx = 0.8 kNm (dressed	size)					
Actual bending, M = WLpu ⁻⁷ 6 = 0.03 kNm use zone 2, as rafter length critical	UDL design load on rafter, w = P x Spur = 1.42 kN/m = 97.3 Allowable bending stress, sp = 5p xk2 xk3 xk7 = 53.11 Nmm2 Allowable bending strength Mp = sp x Sx = 0.8 kN/m (dressed Actual bending m = 4 Mm/r/8 = 0.03 kN/m use zone Actual bending a request Mp = 50 kN/m (second actual bending a request Mp = 50 kN/m (second actual bending a request Mp = 50 kN/m (second actual bending a request Mp = 50 kN/m (second actual bending a request Mp = 50 kN/m (second actual bending a request Mp = 50 kN/m (second actual bending stress Mp = 50 kN/m (second actual bending a request Mp = 50 kN/m (second actual bending a request Mp = 50 kN/m (second actual bending stress Mp = 50 k	size) 2, as rafter length critical					

Project:	Hurricane Resistant Buildings	Date: 12-Jul-21
Engineer.	Shalini Jagnarine-Azan	Page: 5 of 5
Description	: Gable Roof 180mph Exposure B	

[Note: vmax = 3/2. v/bd] 67.0 lbs

Actual shear < allowable shear strength, OK

Instructions: How to use	e the spreads	sheet					
Step 1: Please change	roof width	and	timber stresses		in the calculation passes i.e. "Member size OK"		
Step 2: Adjust the	rafter depth	in the calculation until bending		bending			
Step 3: Copy the	rafter spacing	and	uplift	result in	the calculation into the correct table below		
Summary Results							

Gable Roof	width =	15.3m (5	Oft)			
Min. pitch = 50x50 purlins Material:	20degs Exposure: Max. Spacing (mm) 1000 Hardwood (higher strength)			B Uplift = 0.8kN (180lbs) Sp: 27.3MPa, Sv: 9.25MPa		
Rafter size depth x width	Spacing (mm)	Spacing (in)	Uplift Force (kN)	Uplift Force (lbs)		
150 x 50	600	24	3.47	780	1	
200 x50	1050	41	6.07	1365	1	
250 x 50	1630	64	9.42	2118	1	
Material:	Hardwood (higher strength)		Sp: 22.3	Mpa, Sv: 8.06 Mpa		
Rafter size depth x width	Spacing (mm)	Spacing (in)	Uplift Force (kN)	Uplift Force (lbs)		
150 x 50	490	19	2.83	636	1	
200 x50	860	34	4.97	1117]	
250 x 50	1330	52	7,69	1729	1	

Exposure Category 50x50 purlins Material:	B Max. Spac Hardwood	Width 1000 (higher st	18.3m (60ft Uplift = rength)) 0.8kN (180lbs) Sp: 27.3MPa, Sv: 9.25MPa		
Rafter size depth x width	Spacing (mm)	Spacing (in)	Uplift Force (kN)	Uplift Force (lbs)		
150 x 50	420	17	2.9	652	1	
200 x50	730	29	5.05	1135	1	
250 x 50	1140	45	7.88	1771	1	
Material:	Hardwood	(higher strength)		Sp: 22.3	Mpa, Sv: 8.06 Mpa	
Rafter size depth x width	Spacing (mm)	Spacing (in)	Uplift Force (kN)	Uplift Force (lbs)		
150 x 50	340	13	2.35	528	1	
200 x50	600	24	4.15	933	1	
250 x 50	930	37	6.43	1445]	



