



HURRICANE RESILIENT WOODEN HOUSES

safer building and retrofitting guidelines



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safer building and retrofitting guidelines

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Edition

The first edition of these guidelines were produced for the urban disaster risk reduction project BRACED (Building Resilience and Capacities for Emerging Disasters) implemented by HFHI in Portmore, Jamaica from 2014 to 2018. The guidelines have been updated during a post-disaster project (Shelter and Settlements response to Hurricane Maria in Dominica, 2018) implemented by Habitat for Humanity Trinidad and Tobago, funded by Lutheran World Relief.

2nd Edition. Roseau, Dominica, September 2018.

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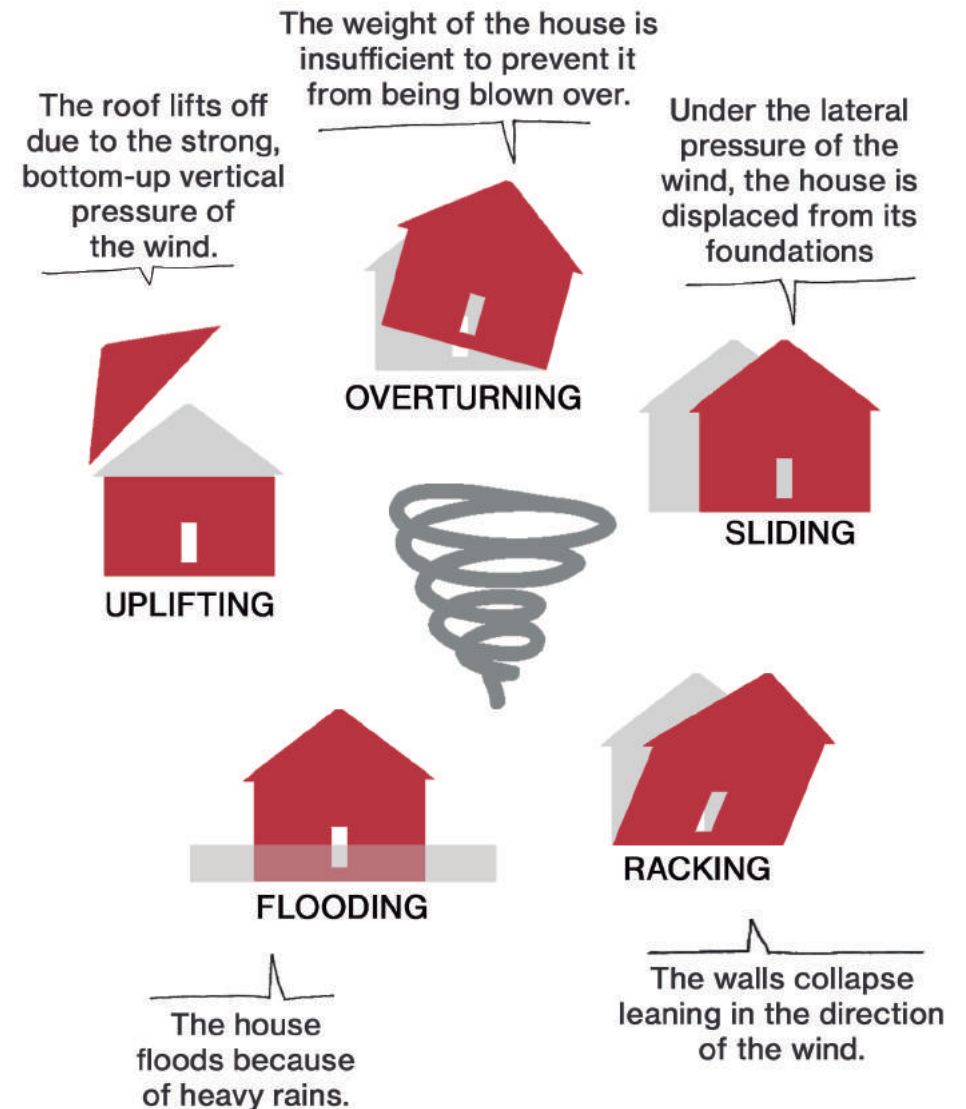
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INTRODUCTION

These guidelines aim to explain in a simple way **key solutions** to prevent wooden houses from being damaged in the event of a hurricane. The target audience is both building professionals and community members interested in safer building.

This publication explains through sketches the main vulnerabilities of light buildings facing strong winds and rains, and proposes some **low cost technical improvements** to make houses more resistant and safer. The recommendations given here are useful for both the construction of new housing and the retrofitting of existing ones.

The concept of **resilience** is about adaptation, and it goes beyond building resistant homes. Resilience is also about how to quickly recover from damage. The final pages of this manual propose some tips about what to do just before the storm, in case our house is still not safe enough.



SAFE LOCATION

in order
to avoid



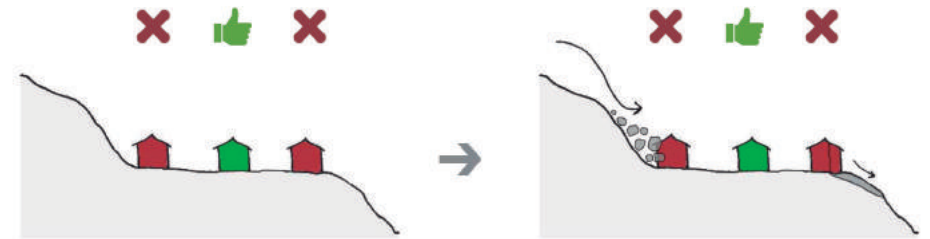
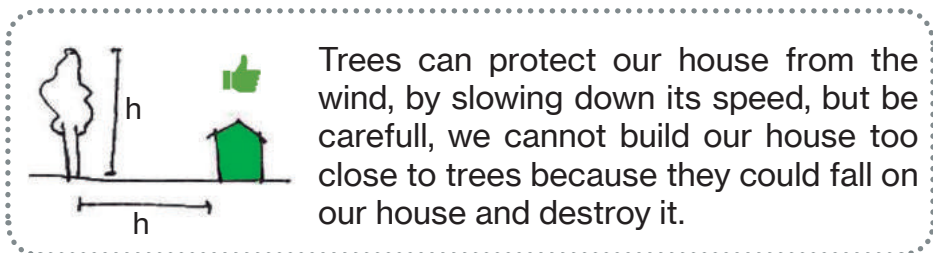
The first thing to take into account when we start building a new house, is **WHERE** to build it. It is very important to choose a safe location for our house. This decision will reduce our exposure to hazard.



We have to keep our house at a safe distance from the water bodies. If we build too close to rivers, heavy rains caused by tropical storms will cause floods that may affect our house.



If we build close to the sea, storm surges and heavy waves will destroy our house.



If we build our house on a slope, we have to be aware of landslide risk as our house can be pushed down the hill. Also, if we place our house too close to a hillside, a landslide can destroy and bury our house.



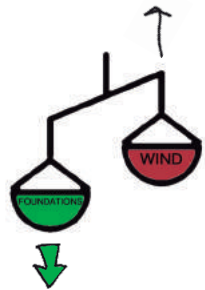
If the house is located at the top of the hill it is much more exposed to winds.



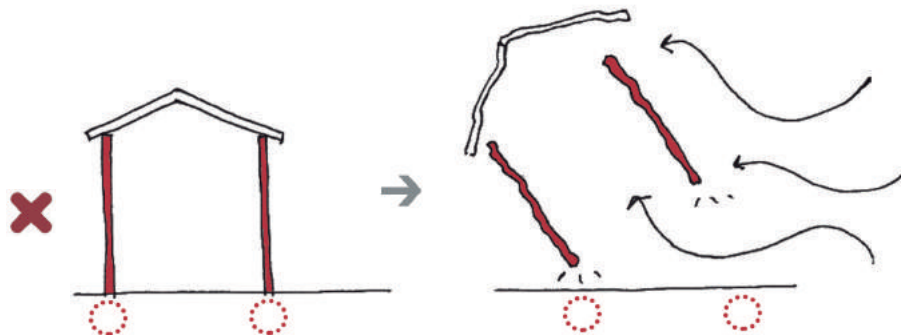
If the soil on our land is composed of filling material, we should avoid placing the foundation of the house on the filled area as this kind of soil is not yet compact enough to support the structure and it could slide down.

HEAVY FOUNDATIONS

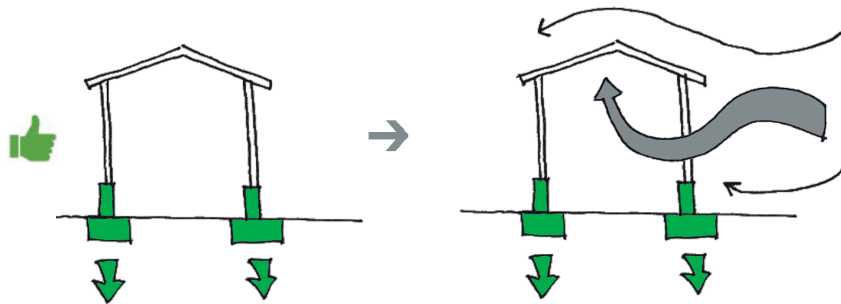
in order to avoid



We need to make sure that our house foundations are **STRONGER THAN THE WIND**. Our foundations must be very heavy so that the wind will not blow our house down.

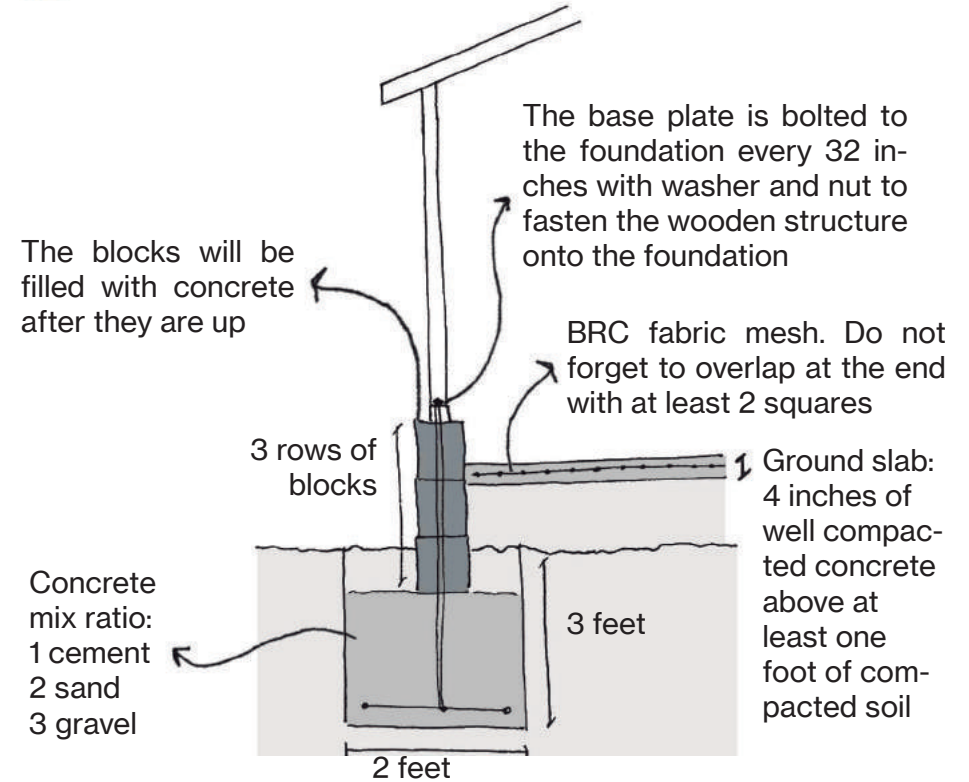


If we have no foundations, or they are weak, or they are not properly anchored to the walls, they will not prevent our house from being overturned or from sliding.

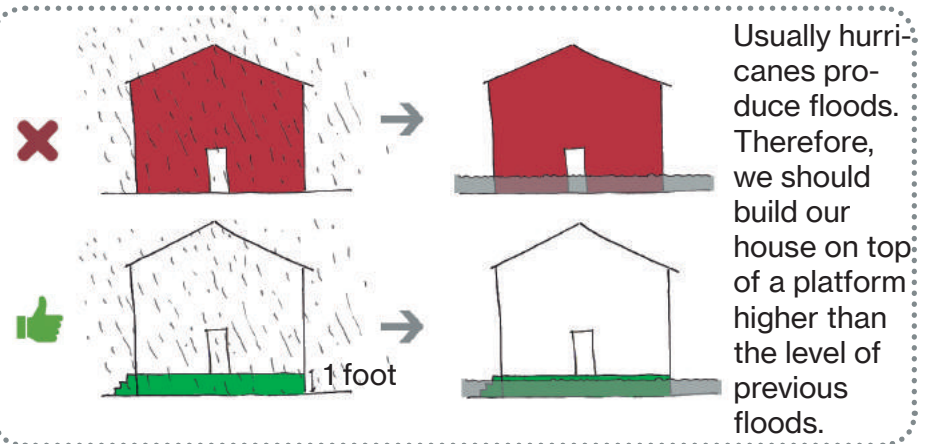


We should make sure our foundations are the right size to resist lift wind force. If our foundations are heavy and well connected to walls, even strong wind will not overturn our house.

How to build a strong foundation

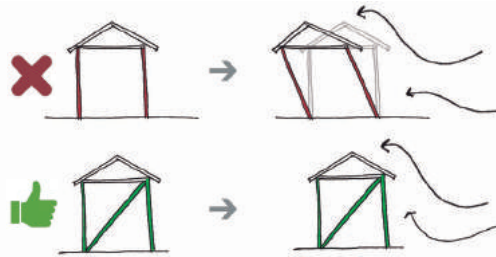


Be aware of floods!

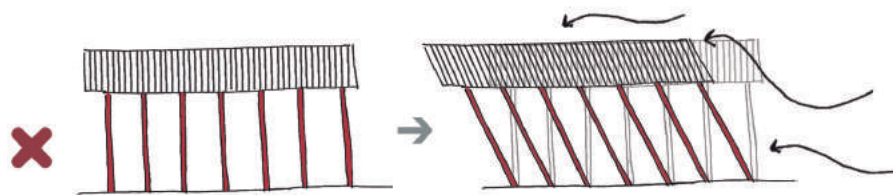


BRACED WALLS

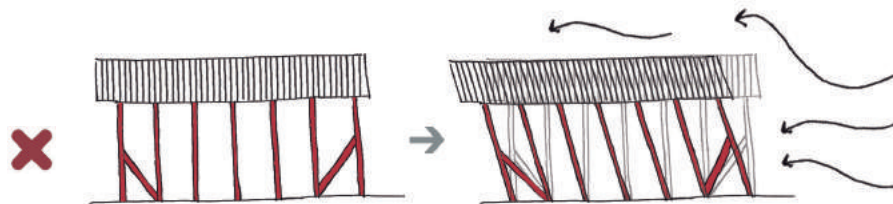
in order to avoid



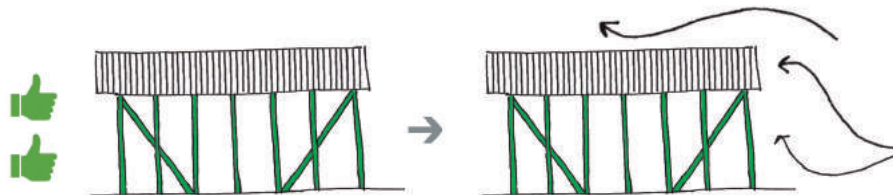
We need to ensure that our walls are **RIGID AND STRONG**. If our walls are made by light materials they must be braced in order to avoid racking.



Non rigid walls made of timber are not strong enough to resist the wind and will be pushed over.

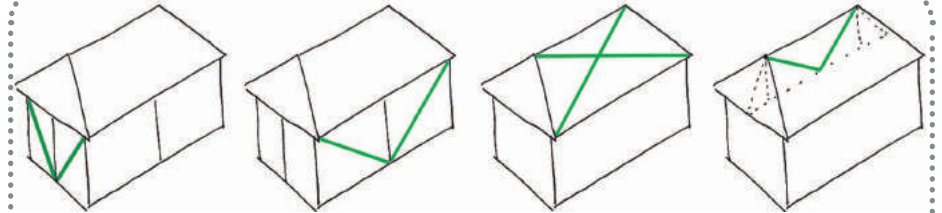


Walls can become rigid by adding braces. We need to ensure that diagonals are stronger than the wind to avoid collapsing.



Walls with strong braces that are properly anchored to foundations will make our house safer.

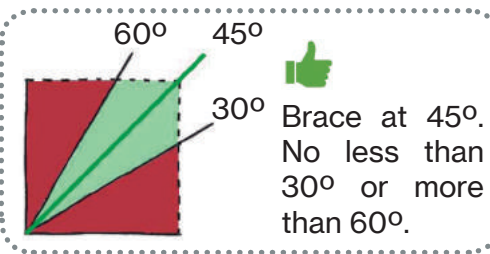
Brace it all!



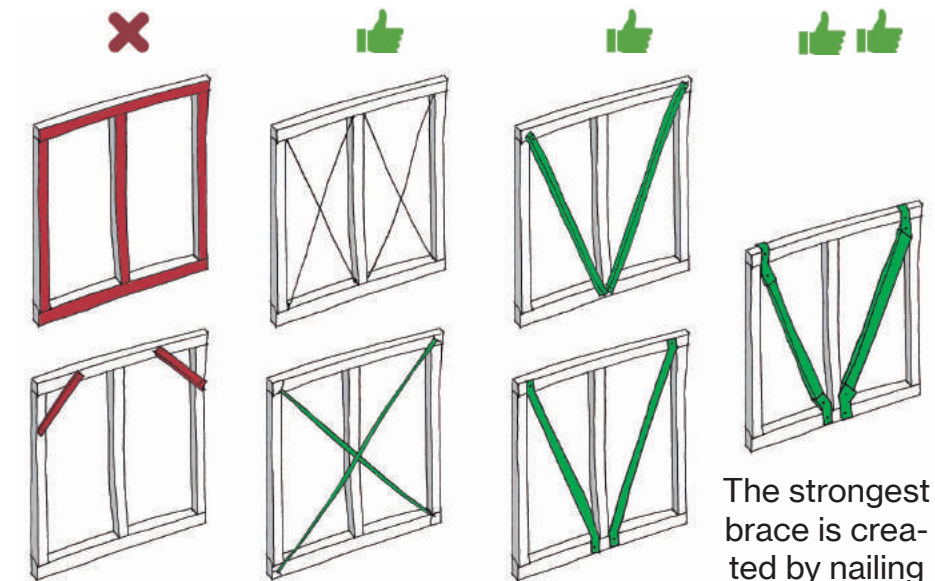
Brace every wall.

Brace below the roof.

Brace between roof trusses.



Brace at 45°. No less than 30° or more than 60°.



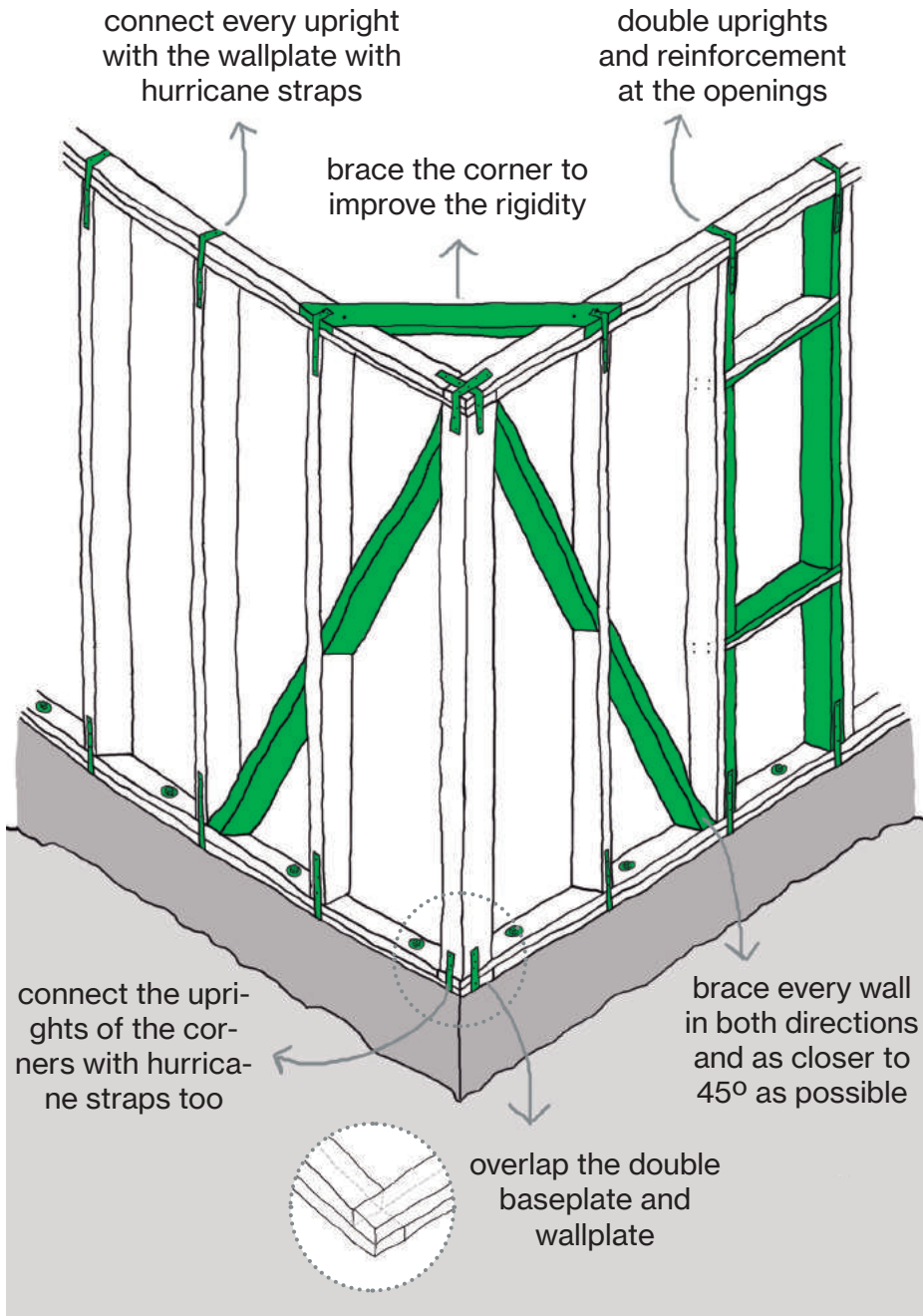
No brace or a small brace is weak.

Tie thick galvanized steel wire or use rebars.

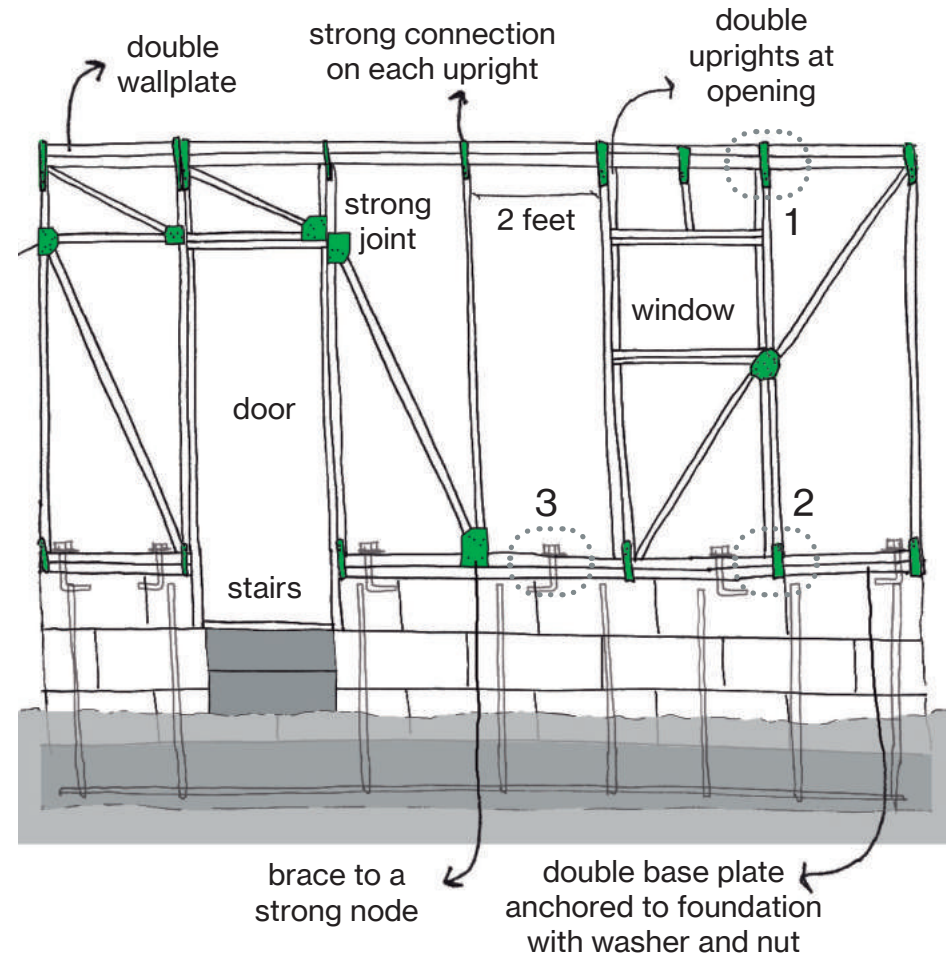
Nail timber or galvanized steel straps.

The strongest brace is created by nailing timber and galvanized steel straps.

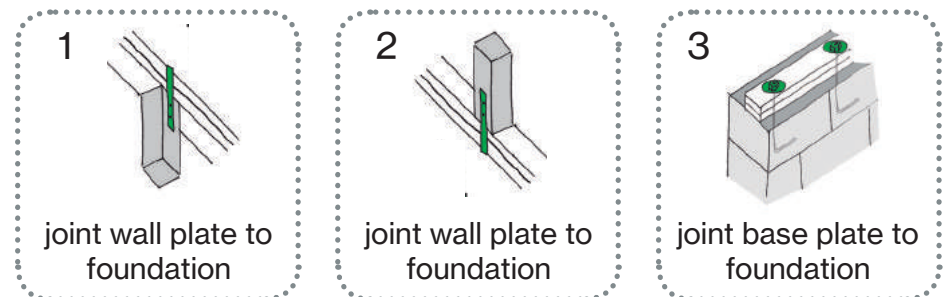
👍 How to brace the corners



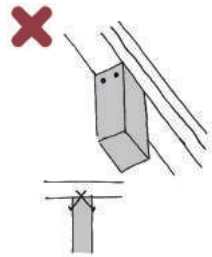
👍 How to brace walls with openings



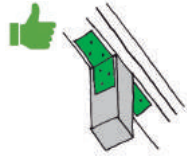
👍 Important connections (see next page)



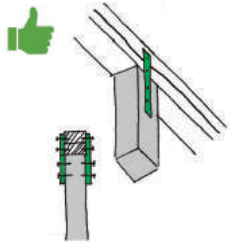
1 - Connections studs with wallplate



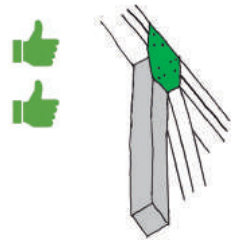
Toenail connections are not strong enough for this type of joint. Reinforce them.



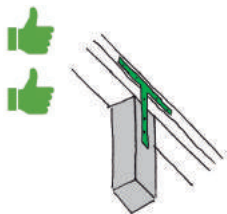
Metal brackets or straps are reinforcing the unions against the wind.



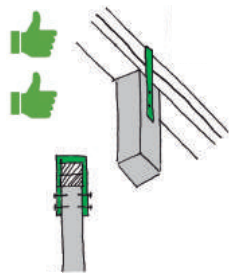
Hurricane straps can also be used to reinforce the connections.



Gusset plates can also be used, especially for diagonal connections in trusses or bracings.

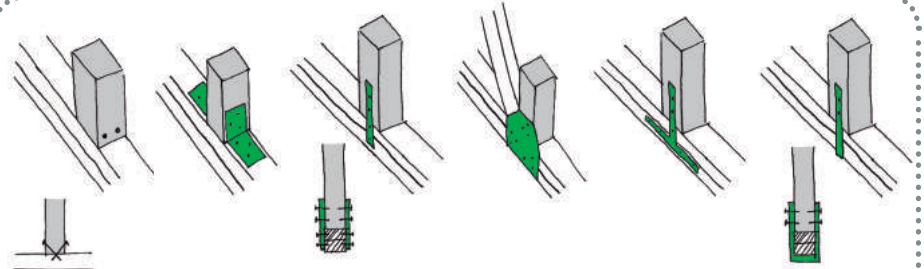


T-shape hurricane straps are strong because they have more nails.



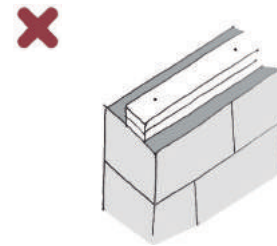
Hurricane straps that go under the base plate are the strongest.

2 - Connections studs with baseplate

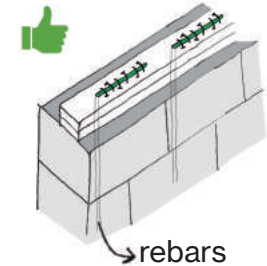


We use the same connections used for the wall plate to the studs, we use for the base plate to the stud.

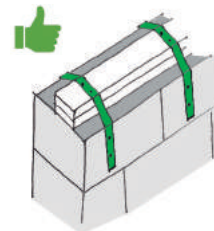
3 - Connections base plate with foundation



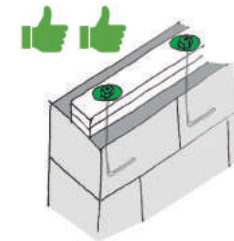
Just nailing the baseplate to the concrete is not strong enough for the winds.



If the rebar is there, the best solution is to bend them and to reinforce the joint with some nails in both directions.



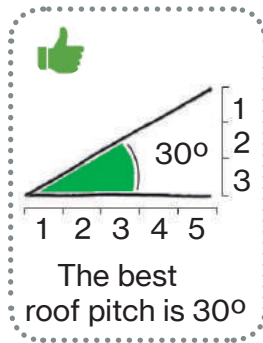
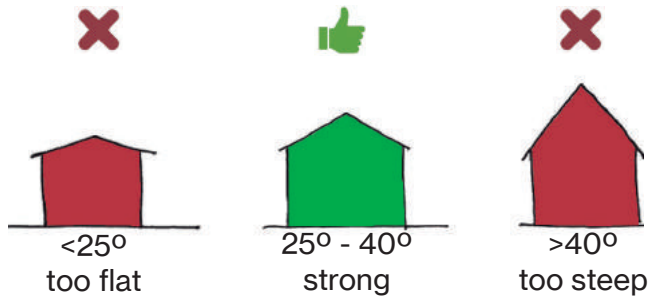
If there are no rebar to connect the baseplate to the foundation, we can use hurricane straps.



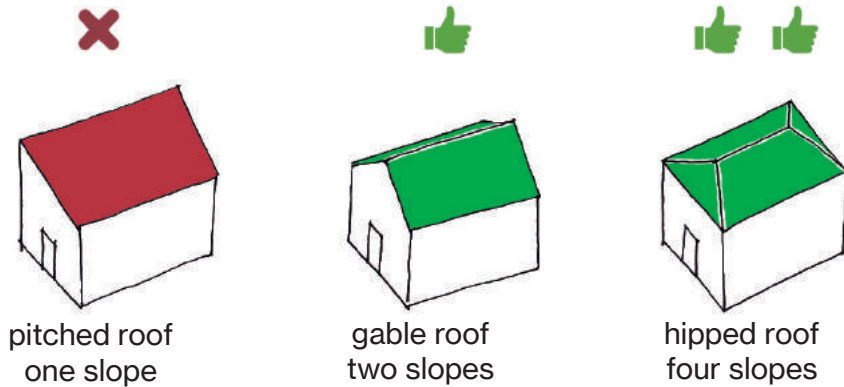
If it is us doing the wall, we will use J bolt with washer and nut to tie baseplate to the foundation every 32 inches.



The shape of our roof is critical for its resistance because of **AERODYNAMICS**.



Flat or steep roofs are more likely to be blown off by the wind.



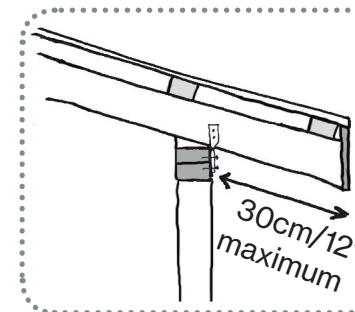
The pitched roof is the weakest shape and therefore is not recommended. The gable roof is a little better but the strongest one is the hipped roof because it is the most aerodynamic.



If the eave is too long it is easier for the wind to lift the roof of our house.



If the eave is short it will be more difficult for the wind to lift our roof.



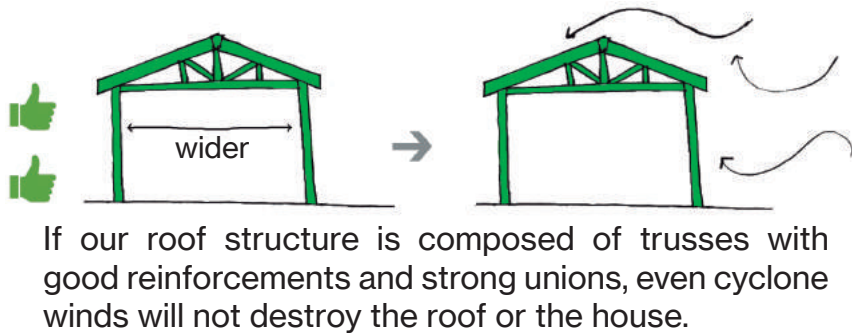
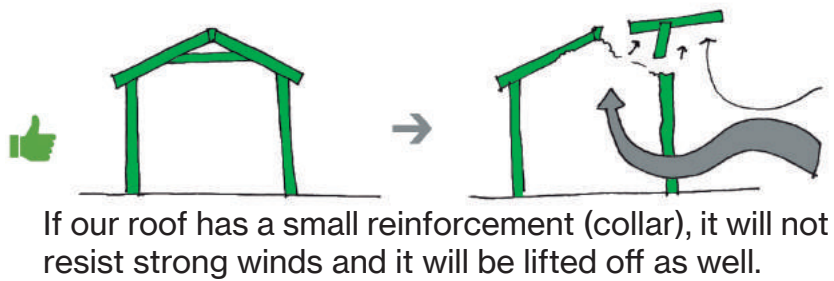
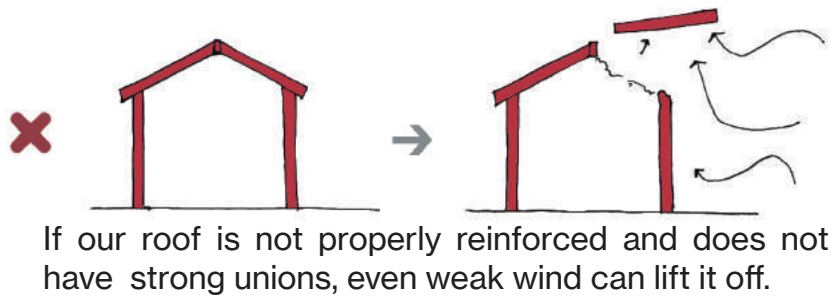
Keep eaves short to prevent the roof from being blown off and long enough to protect the walls from rain.



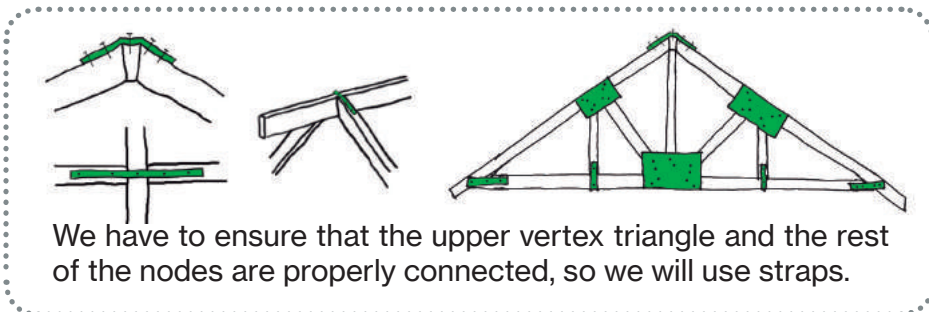
We should not extend the main roof of our house to cover a veranda or car port, because if wind blows this roof off it will also blow the main roof off.



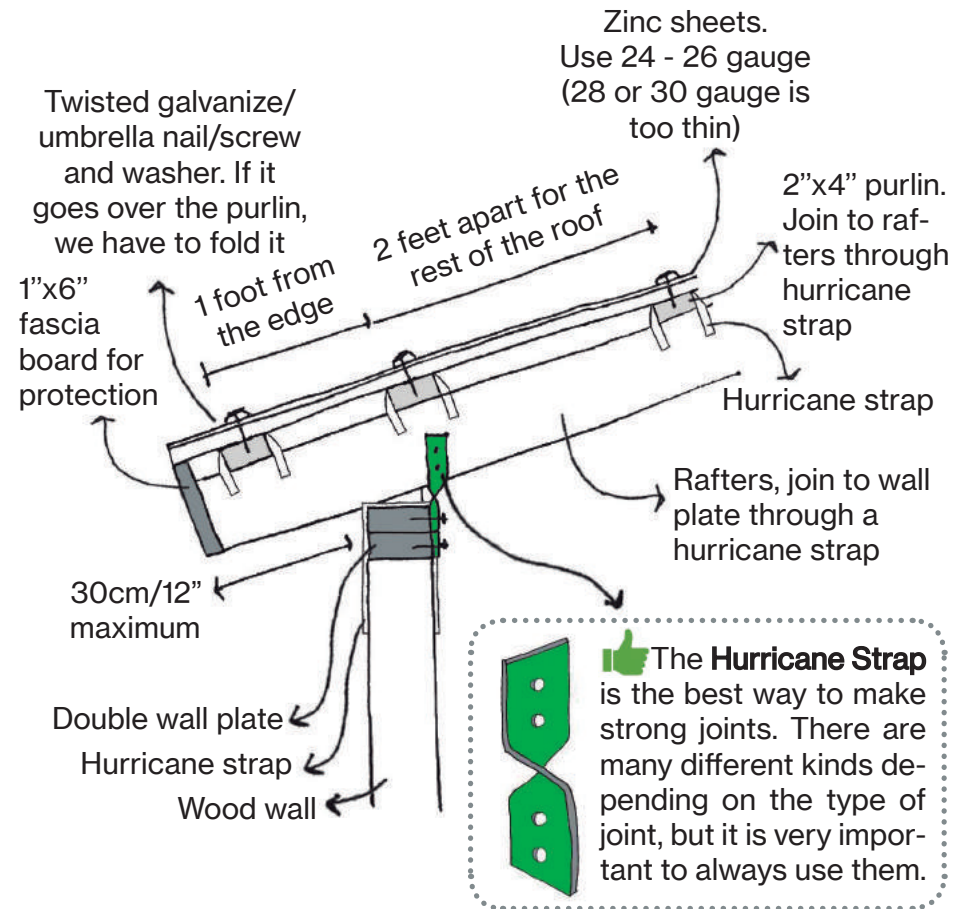
Verandas and car ports should have a separate roof so the wind will lift this roof only, and our main roof will not be affected.



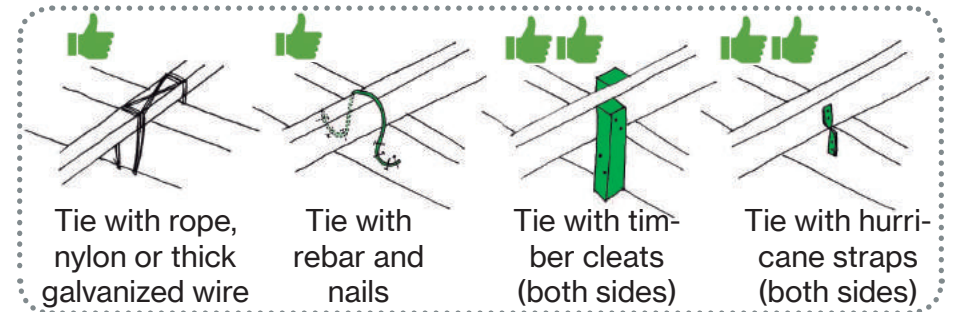
👍 Reinforcing the wooden roof structure



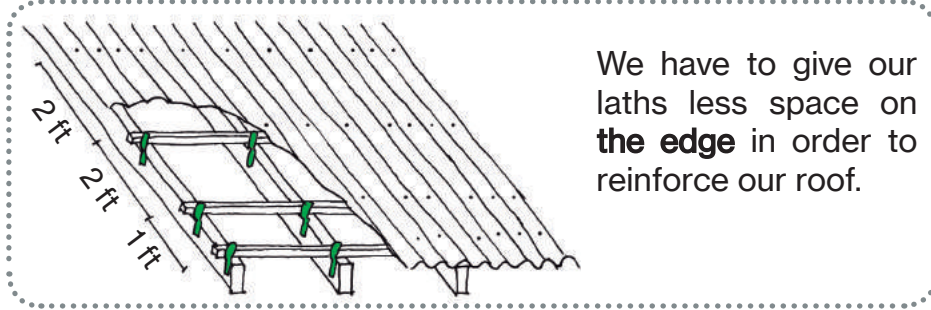
👍 How to build a strong roof



👍 We can make our purlin-rafter joints stronger

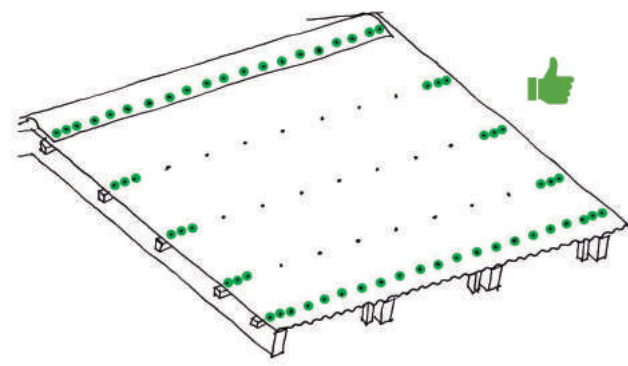


👍 Control the **spacing** of our laths

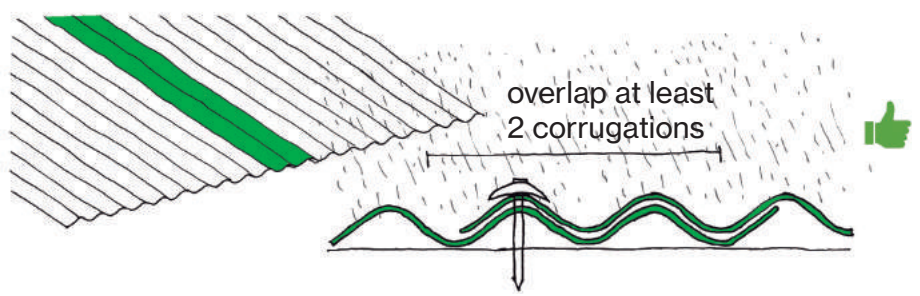


We have to give our laths less space on **the edge** in order to reinforce our roof.

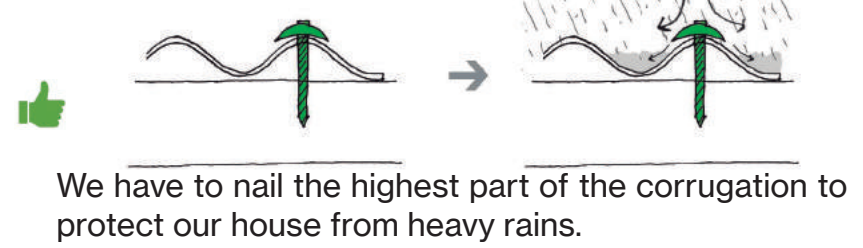
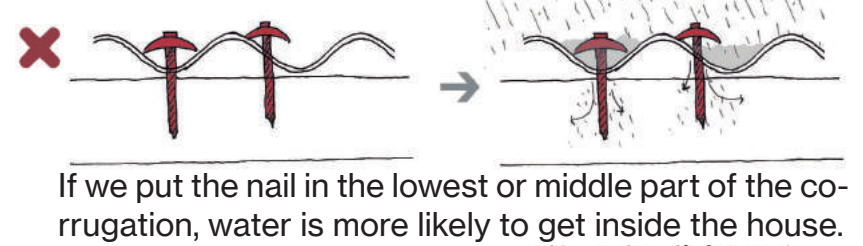
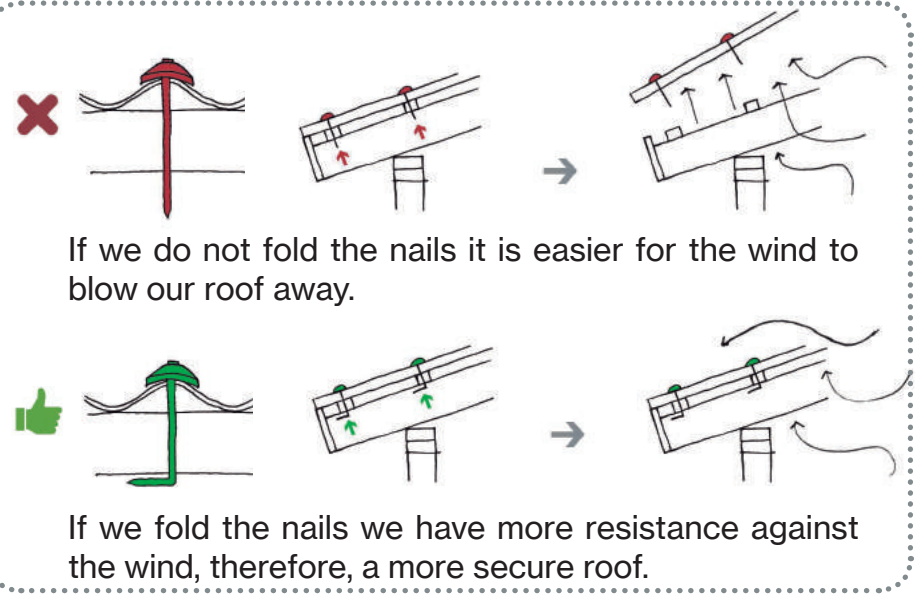
Reinforcing **the edges** of our roof with more nails will make it more difficult for the wind to lift.



Be aware of the rain and **overlap** your sheets.



👍 Fold your nails

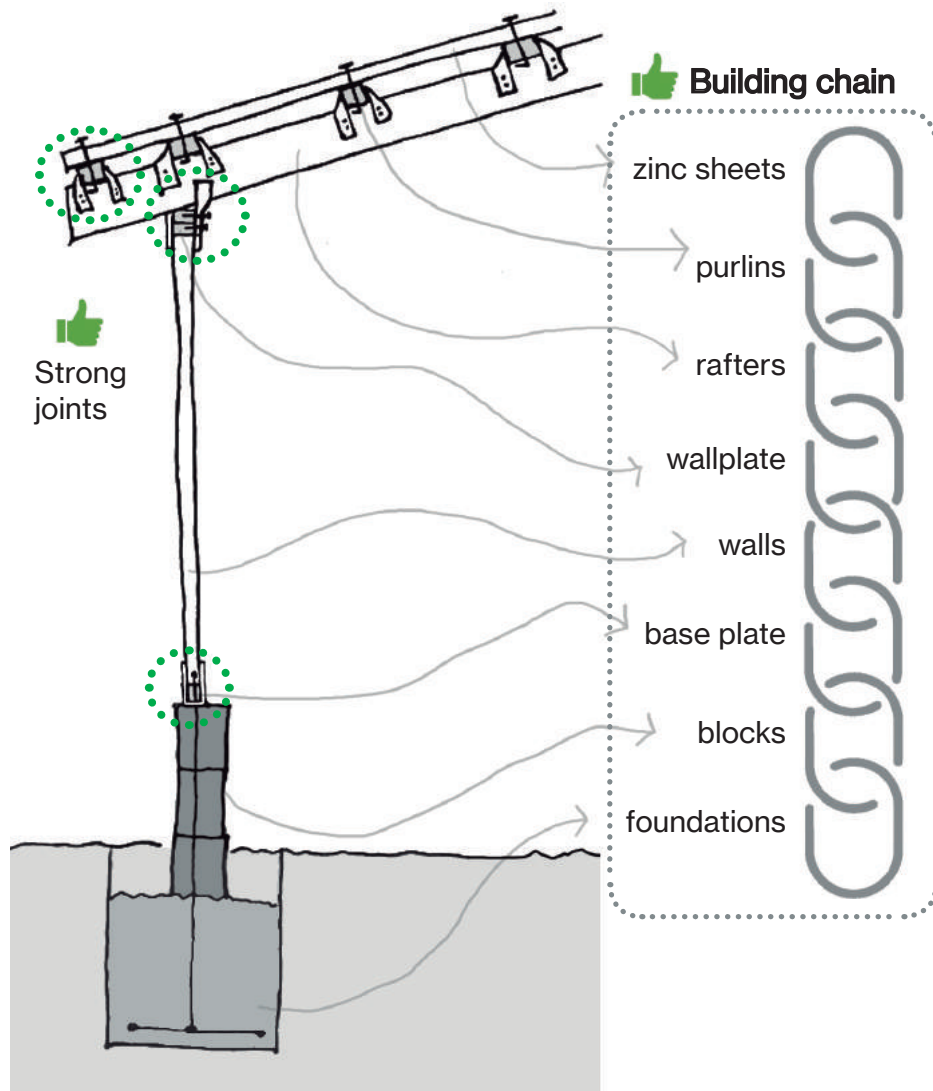


TIE BOTTOM-UP

in order
to avoid

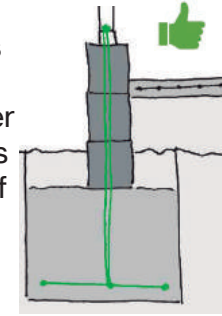


Every element of our house must be linked to the others as a **CHAIN**, so if the wind comes, all the pieces of the house will resist together.



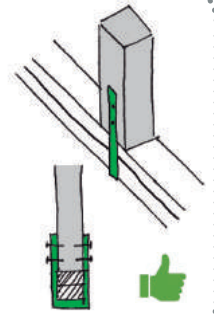
foundations blocks base plate

This connection has to be tied with washer and nut. It is made out of steel rebar. *Page 11*



base plate walls

This connection is made out of a hurricane strap and bolts. We have to put a double base plate. *Page 15*



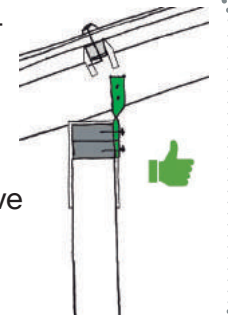
walls wallplate

This connection is also made of a hurricane strap and bolts. We have to put a double wallplate. *Page 15*



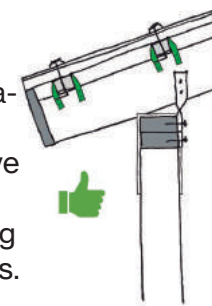
wallplate rafters

This connection is made of a twisted hurricane strap and bolts. We have to connect every rafter. *Page 15*



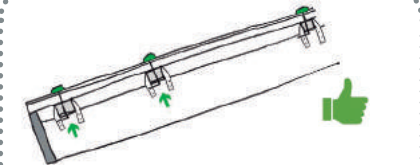
rafters purlins

This connection is made with a hurricane strap and bolts. We have to be aware of the spacing between laths. *Page 21*



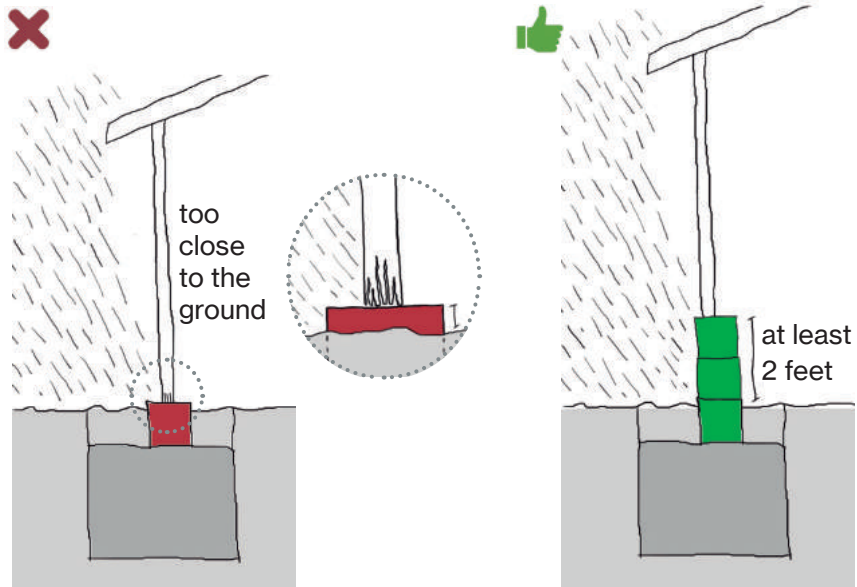
purlins zinc sheets

This connection is made of a twisted umbrella head nail and washer. We have to fold the nail. *Page 23*



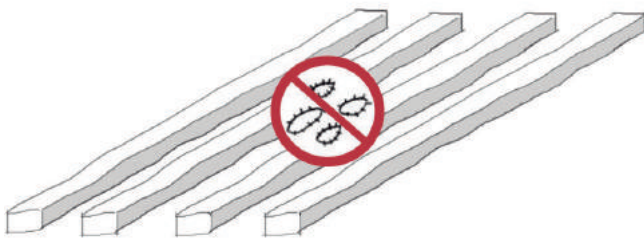
PROTECT YOUR TIMBER

👍 From the water



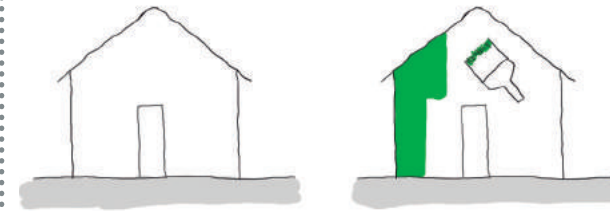
If the timber is in contact with the ground or very close to it, the timber will get **wet constantly** and will become rotten. At least 3 rows of blocks will protect your wood from rain and soil moisture.

👍 From the insects



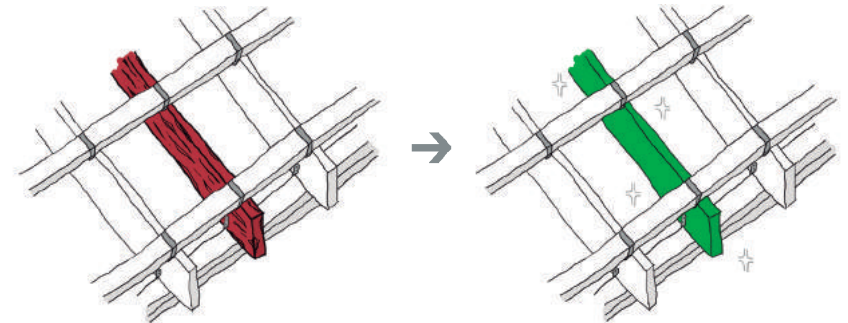
To avoid the termites or other insects to destroy your timber, make sure you only buy **treated timber**. If not available, periodically use an external treatment against insects

👍 From the sun

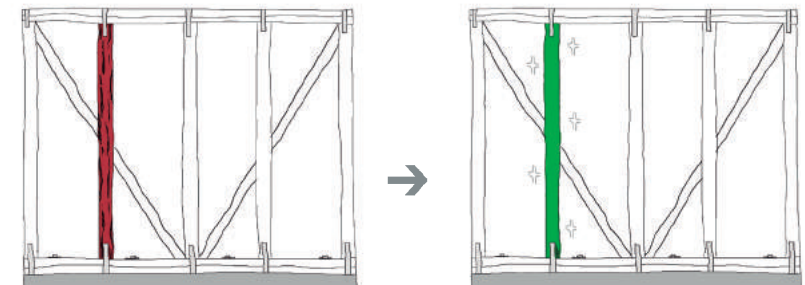


To protect your plywood and timber from the sun, paint it or varnish it. It will last longer and in better conditions.

👍 Replace the rotten timber



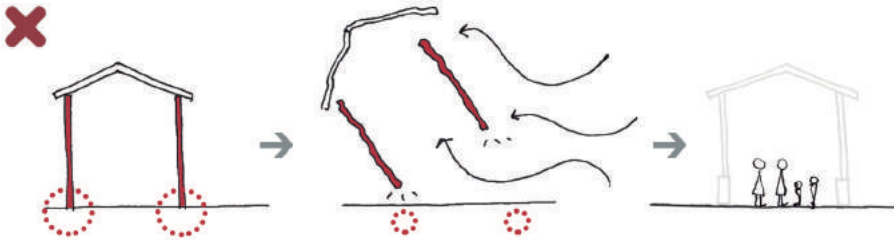
If you find a rotten timber in your house, you should replace it as soon as possible with a new treated one. Remind to properly tie it down with hurricane straps and brackets.



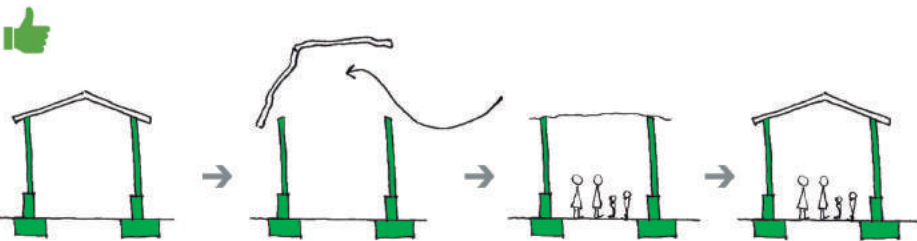
INVESTMENT PRIORITIES



When our house needs repairs, it is important to go little by little, and **REPAIR THE MOST IMPORTANT PARTS FIRST**. If not, we may invest in repairs that do not help us in the event of a disaster.



If we start investing by improving **only the roof**, but our house does not have good foundations or they are not well connected to the walls, even if the roof is good, if a hurricane strikes, the entire house will be lifted and after the hurricane we will have **nowhere to live**. We will have to rebuild our entire house.

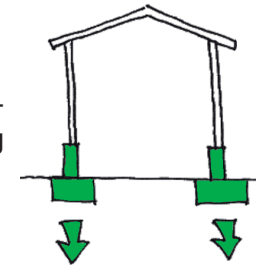


In this case we have decided to invest first in **retrofitting walls** and connecting them to our **strong foundations**. Our roof is not good enough to resist the the wind during the hurricane so it blows away. After the emergency we can buy a tarpaulin which is cheap and good enough to cover ourselves for a while. Later on, we will have resources to rebuild a new permanent and resilient roof.

Order of priorities when investing

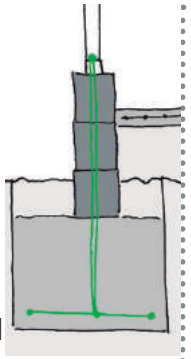
1. Foundations

The first thing to invest in are strong and heavy foundations that will keep our house in place during a hurricane. We can put more weight on the foundations to make it stronger.



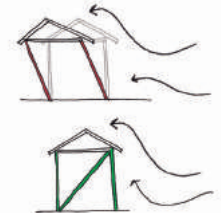
2. Tie your walls

Once we have strong foundations, we have to make sure your walls are strong and tied down.



3. Brace your walls

It is important to build strong walls or reinforce them in order to have a more stable house. Without bracing, our walls are too weak to withstand a hurricane, we have to make sure we brace them.



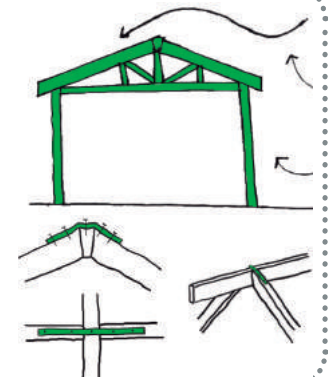
4. Tie your roof

Remember we have to tie our roof down to our strong walls with hurricane straps, to keep it safe during the hurricane.



5. Safer roof

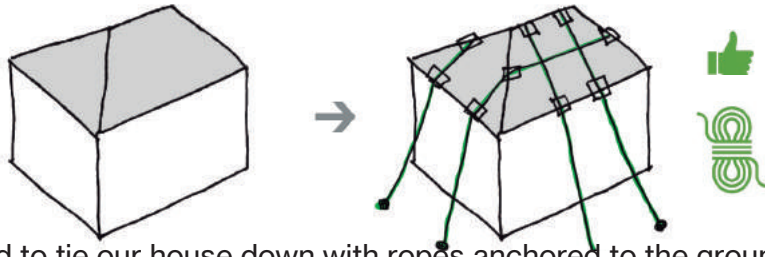
It is important to reinforce our roof with strong connections, to make it strong and heavy to resist the wind force.



WHAT TO DO JUST BEFORE THE STORM

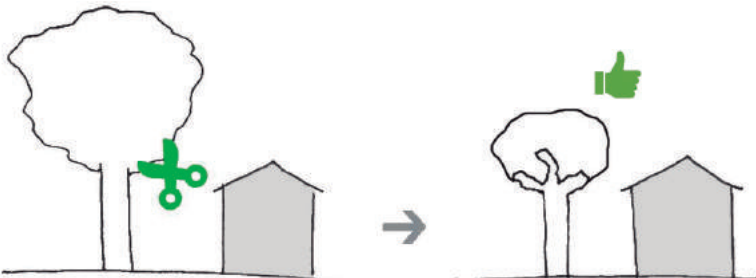
Once we are informed that a hurricane is coming, and especially if we think our house is not resistant enough, we can follow some tips that will **PROTECT OUR HOUSE** and **OURSELVES** in a short amount of time.

1. Tie your house down



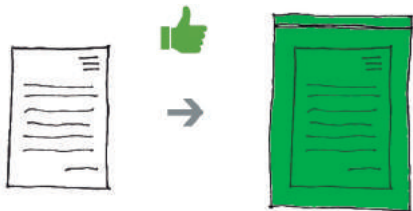
We need to tie our house down with ropes anchored to the ground.

2. Cut big branches



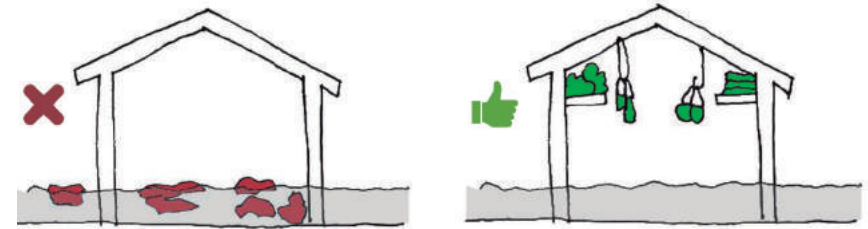
If there is any tree close to our house that could damage it, we will cut the branches in order to prevent the tree from being pulled down onto the house by the wind.

3. Save important documents



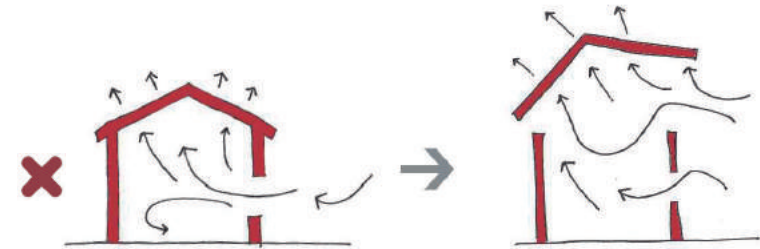
If we have any important things e.g. documents, it is better to put them in a plastic bag to protect them from floods.

4. Put important things high above ground

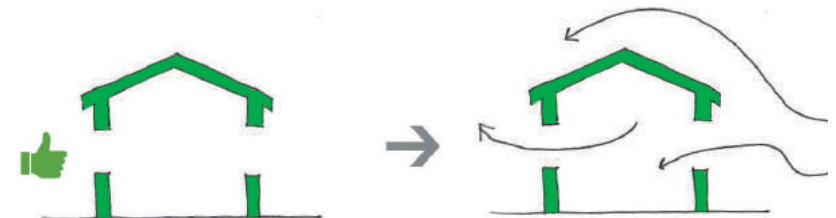


Before the emergency we must put our important things in a safe place. High above the ground is usually safer from floods.

5. Open doors and windows



When wind enters our house through an opening, and cannot find a way out, it increases pressure on the roof.



During the storm, we should open windows and doors to allow the wind to pass through and reduce pressure inside our house.

6. Evacuate



If we feel our house is not safe enough, we should evacuate with our emergency kit to a safer location.

MANUALS

Shelter safety handbook. Some important information on how to build safer. International Federation of Red Cross and Red Crescent Societies (IFRC). Switzerland, 2011.
<http://www.ifrc.org/PageFiles/95526/publications/305400-Shelter%20safety%20handbook-EN-LR.pdf>

Building with winds. Construction guide for Cyclone and windstorm prone areas. UN-Habitat. Mozambique, 2008
<https://www.sheltercluster.org/sites/default/files/docs/Building%20with%20Winds.pdf>

8 build back safer key messages. Shelter Cluster Philippines. Philippines, 2014
https://www.sheltercluster.org/sites/default/files/docs/8_key_messages_posters_final_v1.1_light.pdf

Shelter and Component Testing. OFDA transitional shelters: materials, techniques and structures. International Hurricane Research Center. U.S, 2012
https://www.usaid.gov/sites/default/files/documents/1866/WOW12-2012-02%20%28USAID-OFDA%29_FINAL%20REPORT.pdf

The safe roof retrofit .Construction Resource & Development Centre, Construction Industry Council. Jamaica, 2008.
https://huairou.org/wp-content/uploads/2016/06/BookletSafeRoofRetrofit_JamaicaCRDC.pdf

IFRC Shelter Kit Training package. International Federation of Red Cross and Red Crescent Societies (IFRC), 2011.

Guide to Dominica's Housing Standards. Dominica Physical Planning Division, UNDP, EWB. Dominica, 2018
http://physicalplanning.gov.dm/images/guide_to_dominica_houses_standard_may_2018.pdf

VIDEOS

Hurricanes: How to build a safer wooden house. Jamaican Red Cross and French Red Cross. Jamaica, 2008
<https://www.youtube.com/watch?v=vp7FxW0Ze6Y>

Making Your Roof Hurricane Proof. Office of Disaster Preparedness and Emergency Management (ODPEM), Jamaica, 2009
<https://www.youtube.com/playlist?list=PL3358CD53663EFB17>



we build strength, stability and
self-reliance through shelter

