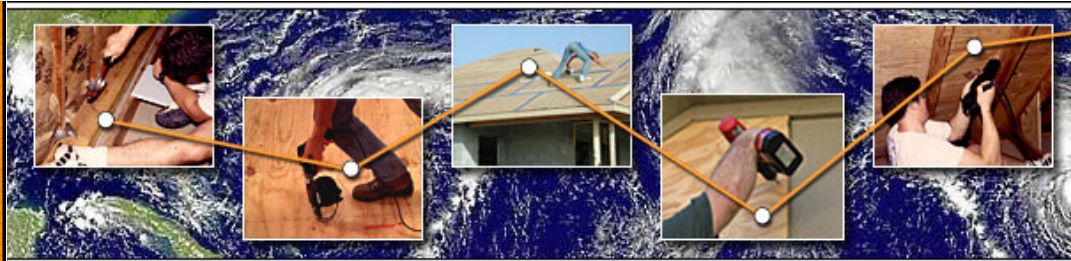


Hurricane Retrofit Guide



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Structural Connections

Loads and Load Paths:

Wind resistant homes are not only built to hold up their roofs but to also hold the roofs down. The weight of the roof is typically about 7 to 10 pounds per square foot (psf); but, the uplift pressures averaged over the roof in a strong hurricane can be four to five times that amount. On some areas, the uplift loads can be 10 to 15 times higher than the weight (70 to 130 psf). The uplift at the wall connections are magnified by the size of the roof because the pressures act on every square foot of the roof. For example, if the average uplift pressure on the roof is 50 psf, the weight of the roof is 10 psf and the roof is 30 feet wide, the uplift at the wall would be 600 pounds per foot of roof length [(50 psf - 10 psf) times one foot wide, times 15 feet (half the roof width)]. If the trusses or rafters are spaced every two feet, each connection of the rafter or truss to the wall would have to be able to hold down with a force of 1200 pounds.

A way to visualize what is needed is to think in terms of how you would connect the roof if you intended to turn the house upside down and shake it up and down. Hurricane straps are used to anchor the roof trusses or rafters to the tops of the walls. Recent storms have shown that roofs anchored using modern wind resistant connections have not failed. However, it is not enough to just connect the roof to the tops of the walls. The uplift loads have to be carried far enough down into the house so that the weight of the house including the floors becomes greater than the uplift forces caused by the wind. This is called developing a **continuous load path**.

But, wind doesn't just apply uplift forces to the roof that try to rip it off the top of the house, the wind also creates pressures that push and pull on all exposed surfaces of the house. In general, it tries to lift it up, tip it over, slide



Keeping a house together in a hurricane requires a continuous load path from the roof to the foundation - think about it as trying to keep all the parts of the house connected if you turned the house upside down and shook it.

(click image for larger version)

it sideways and suck the side walls away from the connection to the windward and leeward walls. Consequently, the walls and roof have to be tied together like a well built box and anchored to the ground with enough weight to keep it in place. In addition to these "external" wind forces, if windows, doors or garage doors fail on the side facing the wind, and allow wind pressures to build up inside the house, these pressures will try to push off the roof and push out the walls. This is another major reason it is important to protect openings. There are enough pressures being applied to the outside of the house, trying to tear it apart, without the added "help" of wind pressures from the inside.

Sorting Through the Options - Sources of Design Help:

Each home has its own features and vulnerabilities. This tends to make it difficult to prescribe a one-size-fits-all set of recommendations for retrofits, particularly structural retrofits. Consequently, this discussion of structural retrofits describes typical situations and outline the types of retrofits that will tend to raise the wind resistance of your home and bring it closer to the kinds of wind resistant construction features prescribed in modern building codes and standards. However, we have also tried to focus on what may be practical and beneficial, realizing that bringing the structure all the way up to the latest high wind requirements could entail almost rebuilding the house, which is neither cost effective nor practical unless you are rebuilding after a major event and the house is essentially gutted. With structural retrofits it is smart to work from the top of the walls downward as each retrofit will engage more and more of the weight of the house. The parts of a house do have a way of working together to help each other out when they are properly connected. By starting at the top, each retrofit you accomplish will make a difference, increasing the ability of your home to survive a hurricane.

If you do decide to take on structural retrofits that involve major changes inside your walls, this guide may be of some assistance. However, you should review some of the design guides that have been developed in recent years that have proven effective in improving the wind resistance of the structural systems in houses. Probably the least expensive and easiest guide to follow, thanks to an abundance of sketches, is the Standard Building Code Congress guide SSTD 10 that was last published in 1999. This document is available as a free download from the [International Code Council](http://www.iccsafe.org/cs/standards/is-hrc/SSTD10/index.html) website. The specific location of the download is www.iccsafe.org/cs/standards/is-hrc/SSTD10/index.html. The wind speeds used in SSTD 10 are fastest-mile wind speeds, not the gust speeds used in this guide. You can add 20 mph to the speeds listed in SSTD 10 to convert to gust speeds. Consequently, the recommendations for 90 mph are for 110 mph gusts, 100 mph correlates to 120 mph and the highest wind speeds listed in the guide, 110 mph, convert to 130 mph gust speeds. Furthermore, if what you are looking at doing is time consuming, difficult or expensive, you may benefit by having a knowledgeable structural engineer review your particular situation and help you determine what makes the most sense for your home.

Usually the easiest and least intrusive structural retrofit is strengthening a gable end wall. If your house has a gable end, click on [Gable End Walls](#) to

look at some of the options available for retrofitting this condition.

The rest of the structural retrofits are organized according to the type of walls you have in your house. If you have wood frame walls (regardless of the type of cladding from vinyl to brick) click on [Wood Frame Walls](#) to explore how to assess your wall's strength, connections and possible options for retrofitting. If you have masonry walls (concrete block) click on [Masonry Walls](#) to explore how to assess your wall's strength, connections and possible options for retrofitting.

Garages that stick out from your house and have very short walls on both sides of the garage door are a special case and area of concern because that wall has very little capacity to resist wind pressures applied to the side of the garage extension. Click on [Narrow Shear Walls Beside Garage Door Openings](#) to see what you can do for either wood frame or masonry wall garages that have this condition.



Garages with narrow walls on either side of the garage door have little structure in that wall to resist wind forces acting on the side walls

(click image for larger version)

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