1.0
Introduction

Gable ends are those upper triangular walls that rest on rectangular walls. They don't have horizontal eaves; instead their overhangs follow the slope of the roof. The triangles may be of various proportions and may be triangles with a section cutoff. Figures 1 through 6 show a variety of gable ends. The only gable ends for which retrofitting is addressed in this guide are those that include an attic. This guide does not address gable end walls where the room behind the wall has a cathedral or vaulted ceiling. Gable ends with attics that have headroom greater than 3' are the ones that typically need to be retrofitted. Fortunately, retrofitting is usually practical when this amount of headroom is available.

Figure 1.1 **House with large and small gable ends**

Figure 1.2 **Large Gable at end with partially exposed gable where house is wider**

Figure 1.3 **Gable end with attached chimney**

Figure 1.4 **Cut off gable over garage with covered entry to side**

Figure 1.5 **Gable end with intersecting shed roof**

Figure 1.6 **Gable end over garage and living area**

Who should use this guide? Homeowners whose house has a gable end wall that is 3' or higher above the rectangular wall. Their house may well be at risk in a hurricane, and will almost certainly be at risk if the house was not built to high wind standards. In most of Florida that means anything built before 1997 and some built between 1997 and 2002. Homeowners should scan through this guide to gain an understanding of the methods of gable end retrofitting. Experienced handy homeowners may be up to the task and can perform their own gable end retrofits. Homeowners who hire others to do the work should be familiar with the methods described in this guide and the building code that pertains to gable end retrofits. Why? Because many contractors, architects and engineers may not be familiar with these easy and cost effective methods of retrofitting gable ends. There are some traditional methods, which rely on diagonals that are not completely effective. This guide will also help you determine if the person you hire is performing the work correctly. Another advantage of this guide is that you can give it to your contractor so he knows a code approved method for making gable end retrofits. The methodology is so new that many contractors have never actually done one. Finally, at this point in time, most building inspectors and building departments have not been exposed to this technique. So it behooves the homeowner to be knowledgeable.

Wind Forces on Gable Ends: Many people think of hurricane winds as pushing against buildings; inward, like the wolf did to the house of the three little pigs. However, engineers know that hurricanes push (inward acting) and pull (outward acting) through the wind pressures that are applied to the house. In fact, the outward acting negative pressures can be slightly higher on walls than inward acting pressures, and the outward acting negative pressures that cause uplift on roofs can be much larger than the inward or downward acting pressures. Because hurricanes swirl, a house near the track of the storm will see strong winds from a wide range of directions. If the eye of the hurricane passes over the house, it will be subjected to winds approximately half the time from one direction and half the time from the opposite direction. It is difficult to determine which gable end will see the highest wind pressures and whether the pressures will be inward or outward. Consequently, it is prudent to retrofit the largest gable ends first and work down towards the smaller ones.

Typical Traditional Construction Practices: Because of a lack of appreciation of outward and inward acting wind pressures on gable ends and periods of low hurricane activity, building codes and carpenters of the past did not pay as much attention to holding gable end walls onto buildings as they do now. Gable end walls were not necessarily built to withstand the pressures that hurricanes can impose. In fact, before air conditioning, a key to comfort in Florida houses was ventilation and in particular attic ventilation. Attics with lots of ventilation were valued because they kept houses cooler. Sometimes gable ends were built to allow cooling of the attic space and consequently they did not have structural wall sheathing. Instead, they had siding boards with horizontal gaps below each board or large louvered gable end vents to facilitate the flow of air while shedding rain.

The belief that nothing could be done to strengthen gable ends further compounded the problem. However, knowledge of weather, increased media coverage of the dangers of hurricanes, advances in building science, and engineering analysis and research have significantly changed things. Efforts to learn more about buildings was accelerated by the devastation wrought by Hurricane Andrew. Building science research has shown that buildings can be built to withstand hurricanes. Something **can** be done. Consequently, building codes were changed to require stronger connections between the parts of the house. Today, building codes are read more carefully, are better understood, and better enforced. Consequently, buildings are being better built.

Gable ends of older homes are vulnerable to the loss of roof sheathing which then expose these houses to severe breaches because gable ends are blown into attics or come off walls. However, Hurricane Charley demonstrated that homes built after 1996 suffered very little structural damage and that their gable ends survived. It is clear that gable ends on older homes can pose a real threat to the welfare of the home, the contents of the home and the safety of its occupants. The good news is that correcting gable ends is relatively easy and affordable.

What Holds Gable End Walls on Houses: In short, there is usually not much holding gable ends on houses. Hurricanes push or pull gable end walls to the point where they separate from the rectangular wall below, resulting in catastrophic damage to the house and rainwater intrusion. For houses not built to high wind standards, the tops of gable end walls are often weakly connected to roof sheathing, and their bottoms are held in place by little more than gravity. At their bottoms there may be 2x4s that extend into the attic and are attached to the gable end walls; but, the attachment to the gable end wall is particularly poor when it comes to resisting outward forces. In newer houses straps may be used to strengthen this connection. However, even these connections may be inadequate unless the houses were built to high wind standards.

Types of Failures: Basically there are three things to be concerned about with gable end walls. First, the most common type of failure is loss of roof sheathing from the gable end that results in the gable wall losing its attachment along the top edge. This type of failure is shown in Figure 1.7. When winds blow against the gable end, they push it towards the interior of the house and push up on the roof overhanging the gable end. At the same time, the wind flowing over the top of the roof creates large negative pressures (uplift) on the roof sheathing. This combination of loads led to widespread loss of roof sheathing at gable ends and gable end failures in Hurricane Andrew, and has been frequently observed for older homes in other hurricanes. The second most common type of gable end failure is at the connection between the gable end wall and the rectangular wall below. It is rare that you actually find a failure that looks like the one shown in Figure 1.8 because usually the wall below fails and the whole end collapses as shown in Figure 1.9. The third potential weak link is the actual framing members that make up the gable end wall structure. In many houses, these members are simply the structural members of the last roof truss. Consequently, they are 2x4 lumber members installed with the wide flat part of the 2x4s parallel to the wall; the direction in which they are the weakest. In homes with rafters and ceiling joists, the gable end wall will typically be conventionally framed with 2x4s that are usually turned so that wind forces are applied to the narrow face of the 2x4s - the direction in which they are the strongest. However, they may only be toe-nailed to the rafters and ceiling joist.

When is it Important? In general, the taller the gable end triangle the greater the risk of damage in a hurricane. For gable ends with framing members shorter than about 3' (3' of head room), the forces applied by a 140 mph wind gust along the top and bottom edges of the gable end wall will be less than 100 pounds per foot of gable width. Most nailed connections can handle these forces. In addition, if the gable end is less than about 3' tall, it will be difficult for a worker to crawl out to the gable end and do much work. Consequently, it is probably not worth the effort to retrofit the connections if the gable end triangle wall is less than about 3' tall.

In homes built after 2002 to the Florida building code and homes built in the late 1990s in areas where the high wind requirements of the Standard Building Code were being enforced, you may find the gable end wall has already been braced or was built in a way that does not require bracing. In some of these homes the wall studs may continue without a break from the floor below up to the roof. This type of framing is known as balloon framing and is one of the best ways to make a very strong gable end wall. You will be able to recognize balloon framing if you don't see any joints between the gable end wall studs and the wall below. If you see any horizontal plates at the ceiling level where the studs stop and are fastened to the plate, you do not have balloon framing. The masonry alternative to balloon framing is to continue the masonry wall all the way up to the roof and to install reinforcing in the wall that extends throughout the height of the wall. If you find this situation, you will not see a wood frame wall at the gable end.

Figure 1.7 **The most common gable end failure is one where the wall looses support along its top edge because sheathing is blown off at the overhang. The wall may fold outward (see cover picture) or be blown inward.**

Figure 1.8 **The second most common type of gable end failure is at the connection between the rectangular and triangular walls – Here the failure is just at the precipice of coming off the wall. It is the negative pressure of the hurricane that pulled on the gable end wall to compromise this connection when wind blew on other faces of the house to create that negative pressure.**

Figure 1.9 The more usual result of wall connection failures is a completely detached gable end wall and the wall below. This building is in the same project as that shown in Figure 1.8. These occupants were not so lucky. Probably all the possessions in this view were saturated with rain water.

Cost Estimates: Materials needed to retrofit a single gable end range from about $150 for a small gable to about $400 for a large gable. However, material costs need to be added to the time it takes to do the work. For some gable ends it takes about an hour to retrofit a stud location and there can be from one to nine studs for small- to modest-sized gable ends depending on the roof pitch. Furthermore, additional time will need to be added for gable ends that are hard to access.

Gable Ends Not Covered in This Guide: Two types of gable ends are not covered in this guide: those over 16' high and those that are the exterior walls to rooms with vaulted ceilings. Gable ends over 16' high are probably at high risk. Such high gable ends should be evaluated by an engineer to determine retrofit measures. The engineer may prescribe measures similar to those detailed in this guide. You should expose the engineer to these methods because the engineer may not be familiar with them, and will be more comfortable with knowing they are part of the International and Florida buildings codes.

Gable end walls on rooms with vaulted or cathedral ceilings, while common (particularly when facing the coast or water), pose special problems for retrofitting. Unless the wall was provided with the bracing needed to stand up to strong winds, it is likely to fail. The structural solutions usually involve beams that either span across the width of the wall or columns that span from floor to ceiling. In many cases, when the wall was originally constructed, the builder could have used continuous members that run from the floor to the ceiling and avoided the weakness. If you have a conventionally framed gable end wall on a room with a cathedral ceiling, you probably can push on the wall and see it deflect (move). If so and you want to strengthen the wall, you need to hire a structural engineer to develop a solution for your particular situation.

Determine whether you can do a gable end retrofit: Some gable ends are inaccessible through the attic due to construction details. There may be air conditioning ducts blocking access to the gable end, or there may not be access to this part of the attic. In the latter of the two cases, you should consider making an attic access. They are frequently easy to make via a closet ceiling. In some attics it might be a challenge to get the long lumber pieces up through an access if the headroom at the access is too low. To be reasonably efficient, you need to be able to snake 8’ 2x4s into the attic. With sufficient patience you can feed a 2x4 into the attic. Once in the attic, it is easy to move lumber to a gable end. If you have to replace the siding on the gable, you will find access from the outside is particularly nice because you have plenty of light and you do not have to climb through the attic.

Building codes: An earlier version of the gable end retrofit methodology is written into the *2007 Florida Building Code for Existing Buildings*. Since then the methodology has been expanded to allow retrofitting gable ends that account for a greater variety of construction conditions found in attics that would have otherwise precluded adherence to that building code. Plus, it includes an additional method for retrofitting. The expanded methods have been incorporated into the final draft of the *2012 International Building Code for Existing Buildings* and it is expected that Florida will adopt the International code in 2012 or 2013.

You may also want to read about gable end retrofit in the building code because this guide does not give all the details contained in the code; especially where the code gives alternate solutions for locations where there are impediments. The Florida building code is available on line.