A Professional Corporation

Technical Bulletin

FROM SPEIGHT, MARSHALL & FRANCIS, P.C.

Structural Engineering - Special Inspections
September 2004
Bulletin No. XXV

The Gabled Roof - Part 2
Problems & Solutions

Introduction:

In Part 1 of this technical bulletin series we discussed the conventionally framed gable roof and its basic structural requirements. In summary, the roof is constructed of opposing rafters that bear against each other at the ridge and are supported on bearing walls at the eaves. No vertical support is provided at the ridge. Therefore, in order to keep the roof from collapsing, the horizontal thrust must be resisted at the eaves. The ceiling joist and its connections should be designed to resist this thrust.

In this technical bulletin, we will discuss typical problems associated with gable roofs when they are not properly designed or constructed. In addition, future bulletins will discuss more complicated roof types.

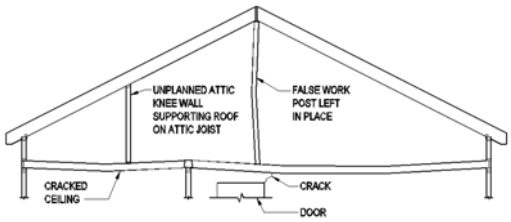
Framing Problems:

As noted in our previous technical bulletin, even when the rafter and joist are nailed directly to one another at the bearing wall, the code-prescribed three-10d nail connection is inadequate for all but the smallest roof spans. To make matters worse, in recent years the classic arrangement of rafter bearing beside the ceiling joist is becoming a rarity. Rafters typically bear on top of the ceiling joist or on top of a cripple wall.

Furthermore, ceilings are becoming more complicated, including tray ceilings, vaulted ceilings, and cathedral ceilings. These ceiling types interrupt the ceiling joist and make it a less useful thrust-resisting element. When these two trends are combined with the increased size of the modern roof, significant problems can arise. For instance, it is not uncommon to see under-designed 'false work' (or temporary shoring) left permanently in place in attics. This 'false work' transmits roof loads onto ceiling joists, interior partitions, and floors below that are not designed to support these loads. This can result in cracking in wall and ceiling finishes, racking in door openings, and sagging of interior floors.

Alternate Framing Methods:

Other framing schemes can be utilized in lieu of the classic gable framing as previously described. The rafters can be supported at their peak by a ridge beam that is supported on posts. Alternatively at longer roof spans, intermediate knee walls can be provided to support the rafters between the ridge and the eave. In both cases, the thrust at the eaves is substantially reduced or eliminated. The key is that the supporting structure below must be designed to support the reactions from these posts or knee walls.

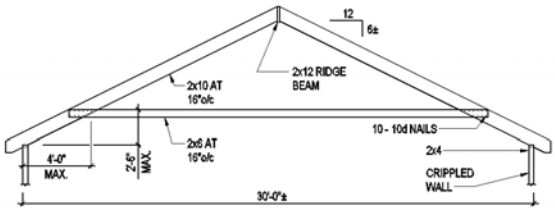


UNINTENDED SUPPORTS

One Solution - Collar Ties:

When ceiling joists are not available to resist the rafter thrust, one mechanism often suggested by designers and contractors is the use of collar ties or rafter ties to resist the thrust. The collar tie, as it is typically constructed, is a lightweight element. At best, a collar tie is provided at every other rafter and is constructed using a 2x6 fastened to the rafter with three- or four-10d nails. Its function is to provide stability to the connection between the rafters and the ridge.

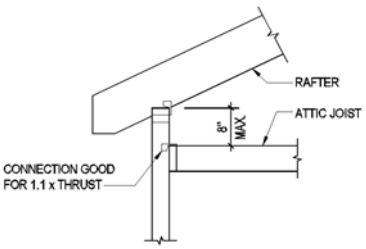
However, the typical collar tie cannot resist the thrust from the rafter at the eaves. For example, a 30-foot long, 6 on 12 pitched roof has approximately 700 lbs. of horizontal thrust. This equates to a tensile force in a rafter tie, provided at every other rafter five feet above rafter bearing of 4,200 lbs. While a high-grade 2x6 could actually resist this tension, it would have to be fastened at the rafter with a minimum of forty-10d nails. If a tie is provided at every rafter, twenty-10d nails are required. If the position of the collar tie is lowered to about two and a half feet above the rafter bearing, the connection only requires ten-10d nails (which still creates problems concerning splitting of the wood). Another restriction in the positioning of collar ties is that the rafter must cantilever to the bearing wall supporting the weight of the roof. Because of this, the collar tie can be located no more than four feet in from the bearing walls. In either case, you end up with ties spaced at 16 inches on-center and located roughly two feet above the top of the attic joist. This is not typically desirable.



RAFTER TIE

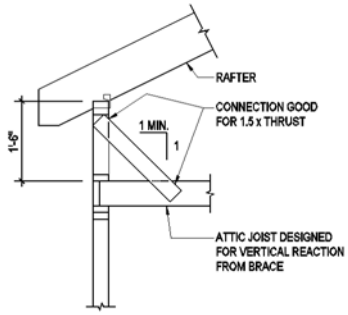
Recommended Solutions:

Two other solutions to resist the rafter thrust when the rafter bears above the attic joists are to either (1) balloon frame the wall or (2) brace the crippled wall back to the attic joist. The balloon framing works if the wall extends no more than 8" above the top of the attic joist and the connection between the wall and the joist is able to resist the thrust. This is easily accomplished, but requires special attention to detailing. A braced crippled wall can be much higher. Since the brace is at a diagonal, its connection at the top of the cripple wall and at the ceiling joist needs to be able to resist one and a half times the thrust. Also, the attic joist must be able to resist the vertical component from the brace reaction.



BALLOON FRAMING

While it is true that a gable style roof can be constructed without direct connection between the attic joist and the rafter to resist the thrust, it is not a simple matter. The solutions, to provide additional interior vertical load supporting elements or to provide an alternate means to resist the thrust from the rafters, are all too often ignored. This results in undersized elements and connections or unsupported load paths. In extreme cases, the result could be failure of the roof or an overstressed supporting element. More often, this results in cracking in the finishes, excessive deflections in the roof and floors, and other cosmetic problems.



BRACED CRIPPLED WALL

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