SPEIGHT MARSHALL & FRANCIS
A Professional Corporation

Technical Bulletin

FROM SPEIGHT, MARSHALL & FRANCIS, P.C.

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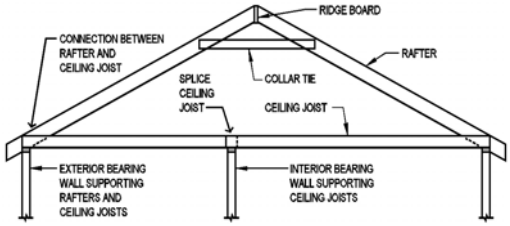
On a regular basis, we will distribute these informational leaflets about crucial - but often ambiguous - structural engineering topics. With the knowledge of our featured subjects, our goal is to help our clients improve their profitability while reducing their liability. We suggest distributing a copy of our technical bulletins throughout your office and keeping them on hand for quick reference.

Conventionally Framed Roofs - Part 1
The Gabled Roof

Introduction:

While most pitched roofs for residential and commercial buildings can be economically framed using Prefabricated Metal Plate Connected Wood Trusses, it is still common to see roofs framed using conventional wood or "stick built" framing. There are several different types of conventionally framed roofs, the most basic of which is the typical gable roof. In this technical bulletin we will discuss the gable roof and its structural requirements. In our next bulletin, we will discuss some of the problems associated with gable roofs when they are not properly designed or constructed. In future bulletins we will discuss various other and more complicated roof types.

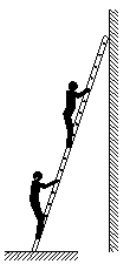


Gable Roof:

This diagram shows the classic gable roof. The roof is supported only at the exterior walls, though additional support may be required for the ceiling joists. Using common dimensioned lumber, it is possible for a gable roof to span up to 60 feet; however, a more practical limit is approximately 45 feet. A gable roof can span twice as far as its individ-ual rafters because the rafters support each other at the ridge.

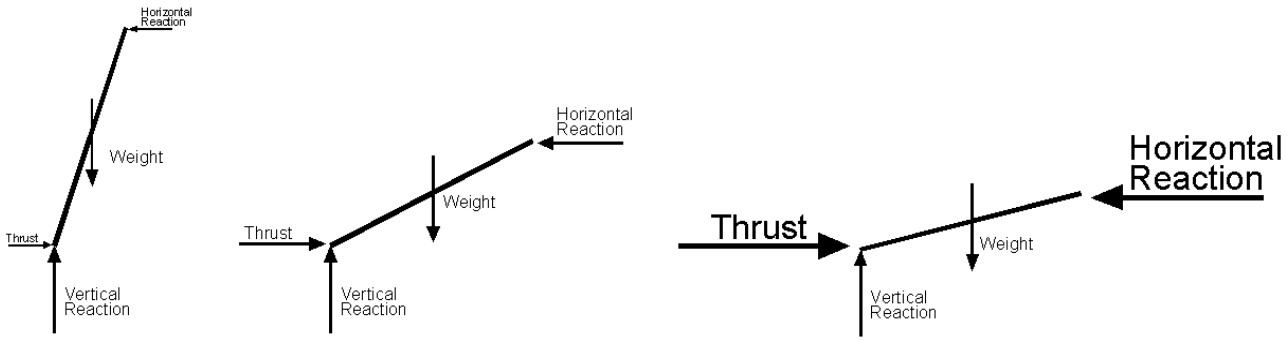
A Ladder Analogy:

To understand the way the rafter behaves in a gable roof, consider a ladder leaning against a smooth wall. The whole vertical load, the weight of the ladder and the person on it, is supported where the ladder rests on the ground. Because the ladder is inclined, there is also a horizontal reaction force that must be resisted in order to keep the ladder in place. At the top of the ladder, the wall resists this force.
The forceat the bottom of the ladder, or thrust, is equal to the force at the top of the wall, however it works in the opposite direction. This force is resisted by friction between the ladder and the ground. For a steeply inclined ladder, the amount of thrust is relatively small and the weight of the ladder and the person on the ladder produces enough friction to resist the thrust. However, as the incline of the ladder becomes less steep, the thrust increases and it becomes necessary to have another person stand on the lowest rung of the ladder to provide more friction. For shallower pitches mechanical anchorages is needed to resist the thrust since the thrust continues to increase without limit as the pitch gets shallower.



Relationship of Thrust vs. Pitch:

A rafter in a gable roof behaves exactly like a ladder. Because of the shallower pitch, the thrust at the base of



a typical rafter can be significant. For instance, on a typical 6:12 roof on a 30-foot wide house, the thrust at the base of each rafter is 700#. For a 3:12 roof, the thrust is 1400#.

With a ladder, friction at the ground resists thrust. A rafter usually rests on top of a stud wall that is incapable of resisting a horizontal thrust of more than a few tens of pounds, regardless of how well it is fastened at its base. In the gable roof construction, the ceiling joist resists the outward thrust from the rafters. Therefore, the rafters must be fastened directly or indirectly to the ceiling joist and the ceiling joist must be capable of resisting the thrust. Usually the ceiling joists are continuous from rafter bearing to rafter bearing.

Building Code Provisions:

For a gable roof system to work properly, the connection between the rafter and the ceiling joist must be capable of transmitting the thrust from the rafter to the ceiling joist. Even when applied to fairly modest and simple roofs, some provisions of the CABO code and the International Building Code for the construction of conventional roof framing are inadequate; and they are even less adequate when applied to roofs and ceilings that are larger and more complicated. For the connection between rafters and joists, these codes:

- prescribe only 3-10d nails for connections. At best, this fastening is only good for 300 pounds.
- make no effort to account for varying rafter spans or slopes, even though these are important factors.

In our practice we have observed many instances where roofs are framed using gable framing while neglecting or underestimating the large thrust from the rafters. While this seldom causes collapse, it often results in alternate and unintended load paths causing damage to the structure and finishes and creating other serviceability issues in the building.

In the next part of our technical bulletin we will discuss some of the problems associated with the misapplication of gable roof framing.

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