My Roof Is Sagging!

Until homeowners see the ridge of their roof sagging or a big dip in the plane of the roof, they care little about how their roof is framed. When they observe a sag or dip in their roof they begin to wonder why this has appeared after all these years. The sag or dip is then often related, correctly or incorrectly, to the big snow storm of last month, last year, or 1996.

So what causes a roof to sag?

First, let us understand how common rafter framing performs. Single-family roof framing is commonly comprised of rafters, which are the sloped members that the roof deck is nailed to, and ceiling joists or rafter ties, which are the horizontal members. When you are standing or sitting in an attic the rafters are seen above you and the ceiling joists below you. These members are commonly configured such that they form a triangle with two sloped top sides and one flat bottom side. The triangle is a very interesting shape because no matter which direction you apply a load or a pressure, the other two members will provide support.

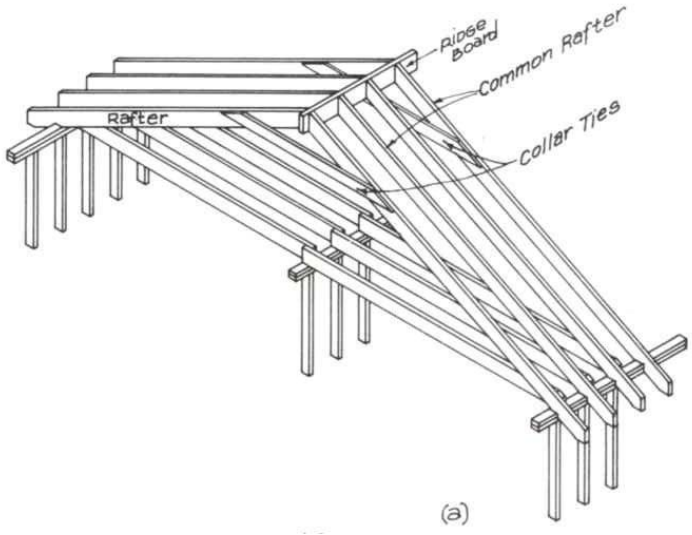

Figure 1 Typical rafter framing.[1]

For example, when rafters support the weight of the roof and the snow they push against the opposing rafters (at the ridge board) and push (thrust) outward at the supporting wall (Figure 1). The ceiling joists not only provide vertical support for the weight of the ceiling as a beam, but they also resist the outward horizontal thrust of the rafters at the top of the wall. That is, the ceiling joists (or rafter ties) restrain the end of the rafters and the top of the wall from moving outward. The restraint by the ceiling joist at one side of the dwelling is countered by the outward thrust of the rafter and the restraint of the ceiling joist at the opposite end (Figure 2).

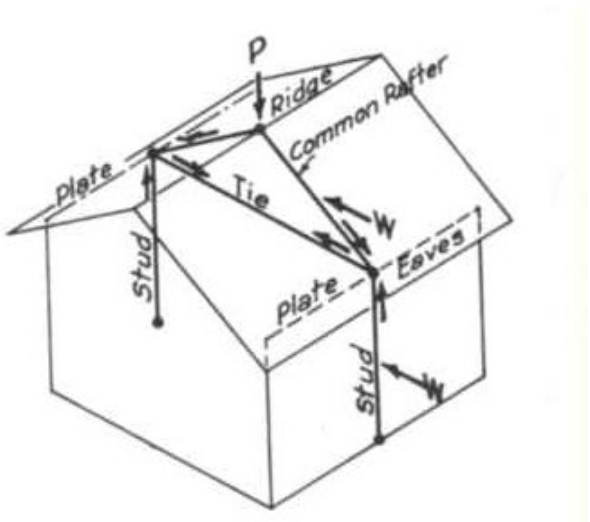

Figure 2 Schematic sketch of how rafters support a roof.[2]

So what could go wrong?

If the ceiling joists are long, they are usually comprised of more than one member. The ceiling joists are commonly lapped over a wall near the center of the home (Figure 3). If the two members are not adequately lapped and fastened to each other, they will pull apart. The separation between the ceiling joists allows the top of the outside wall to move outward. The outward movement at the top of the wall will cause the end of the rafter to move outward. The outward movement of the rafter causes the end of the rafter at the ridge board to drop. Thus, the ridge board drops. Cracking may also appear in the drywall ceiling, usually near where the ceiling joists pulled apart.

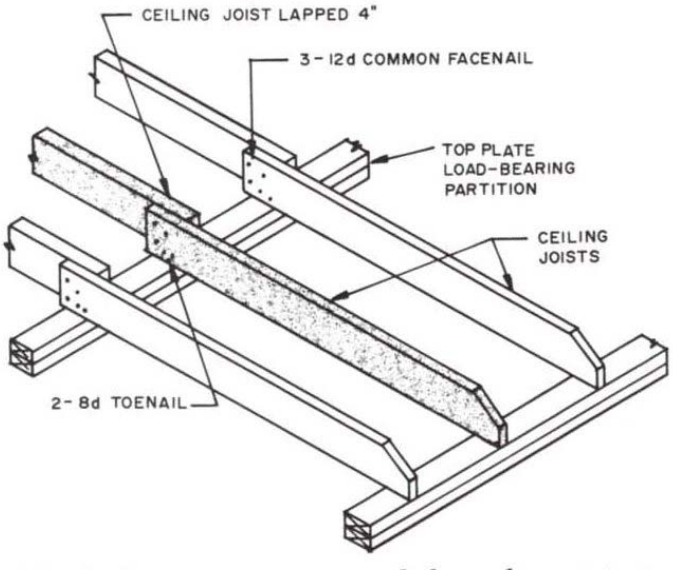

Figure 3 Ceiling joists lapped at interior wall.[3]

If the ceiling joists are not lapped, but are butted into the side of a beam that spans over an opening, they are usually not adequately fastened together (Figure 4). Thus, the ceiling joists pull away from the beam. This is usually exhibited by separations between the metal hangers and the beam or the exposure of the shanks of the nails between the end of the joist and the beam.

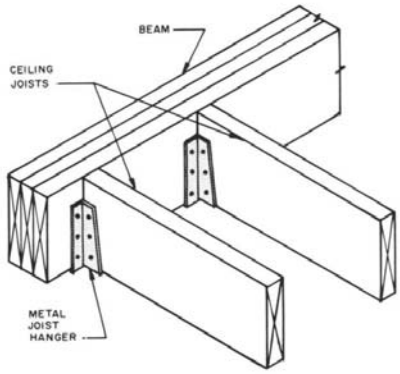

Figure 4 Ceiling joists fastened to side of beam.[4]

Sometimes the ceiling joists are not parallel to the rafters, that is, they don't run in the same direction. When this occurs, the rafter thrust is usually resisted by the drywall or plaster ceiling and/or the roof deck. Unfortunately, these are not intended to provide resistance to rafter thrust and they usually show signs of distress. When this occurs plaster and drywall will often exhibit cracking between the ceiling and the side walls and the roof deck will often become loose. This situation is common with a hip roof over ranch homes because the rafters slope down in all four directions. The solution is to turn the ceiling joists at the sides of the home to align with the rafters: this may be done for a 4 to 8 foot width.

Some believe that intermediate rafter ties will help resist the thrusting and spreading of the rafters. These are commonly set at the mid-height of the attic and are called collar ties. Collar ties can help resist the outward horizontal thrust of the rafters; however, their effectiveness depends on the distance the ties are from the peak of the roof and their spacing. The closer they are to the peak (ridge), the less effective they are.

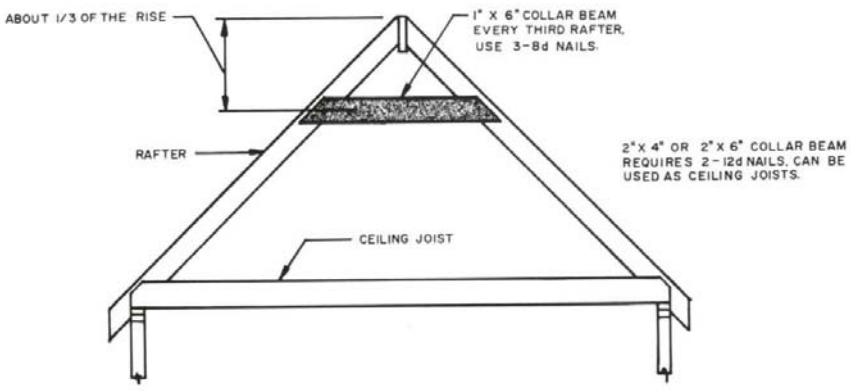

Figure 5 Collar ties.[5]

Sometimes the layout of the rafters and ceiling joists or rafter ties forms a proper triangle, but there is still sagging. In these cases the spreading of the rafters and the subsequent sagging is usually due to inadequate nailing of the ceiling joists or rafter ties to the side of the rafter. The 2006 edition of the Ohio Residential Code (and industry standards) recommend three 8d nails to fasten each ceiling joist or tie to the side of the rafter, three 8d toe nails (nailed at an angle) to fasten each ceiling joist or tie to the top plate of the wall, and two 16d toe nails to fasten each rafter to the top plate of the wall. Fewer nails than this will allow the connection to loosen and slip over time as the wood shrinks and swells.

Figure 6 Ceiling tie fastened with one nail pulls away.

To determine whether or not the sagging has occurred recently, one needs to examine the condition of the cracking and the separations. Sharpness on the edges of the cracking and a relatively clean fracture surface in the cracking indicate it is relatively new: however, previous patching or paint in the cracking indicate that it did not occur recently. Clean and shiny nail shanks in the separations between the wood members indicate that it is relatively new: however, surface corrosion or discolored nail shanks show that it did not occur recently. Clear surfaces on what appears to be recently exposed wood indicates that the movement is relatively new as shown in Figure 6: however, the presence of discoloration indicates that the separation of the members initiated years ago.

On the exterior, when the wall is pushed outward the rows of shingles will show an outward sweep (horizontal bow) with the wall. However, if the shingles are still in a straight line, the roof was bowed outward prior to the shingles being installed. Furthermore, if the shingles

exhibit an uneven exposure, that is, the shingle appears wider at the sides of the roof than at the center in one or more of the rows, the roof was bowed outward and sagged prior to the shingles being installed (Figure 7).

Figure 7 Shingle exposure varies exhibiting sag in roof.

If the sagging appears in the plane of the roof, that is, up and down between the ridge and the eave and from side to side, the sagging is probably due to deflection and creep of the rafters themselves (Figures 8 and 9). Deflection is the immediate sag produced when an object is set on a structural member. For example, it is the sag in the board that spanned the creek when Dad walked across it – he was just a little too heavy for that board. But when Dad stepped off the board, it popped back up. Creep is the permanent sag in the board when an object rests on the board for a long time. Creep is caused by the stretching and adjusting of the wood fibers to the sustained weight on rafter (shingles, sheathing, drywall, insulation and rafters). Creep develops over years. A common example of creep is the sag in a cheap wood bookshelf. When books are set on the wood shelf, it sags slightly. If the books are removed after a short time, the shelf returns to a level position. However, if the books remain on the shelf for a long time, the sag increases, and when the books are removed, the shelf does not return to its original, level position. The permanent sag is from creep.

Figure 8 Roof sags from eave to ridge.

Figure 9 Chalk line on side of rafter shows amount of sag.

Industry studies show that a relatively short term weight of snow and ice (up to four months) does not cause a permanent sag without fracturing some rafters. Studies also show that the amount of sag from creep is increased by the variation of moisture content in the wood framing and high stress in the wood. The variation in the moisture content of the wood is increased by inadequate attic ventilation. High stress in the rafter is usually due to using undersized rafters.

If a rafter and ceiling joist are properly configured and adequately nailed and the materials are in good condition, then it is possible that the damage was due to an unexpected load such as the weight of ice and snow. This can be evaluated by reviewing weather records, newspaper articles, eyewitness reports, and our own observations of the ice and snow accumulations. This evaluation is left for another discussion.

If you have any questions about rafter framing, please contact us.

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[1] Dietz, Albert G.H., *Dwelling House Construction*, fifth edition, The MIT Press, Cambridge, Massachusetts, 1991.

[2] Dietz, Albert G.H., *Dwelling House Construction*, fifth edition, The MIT Press, Cambridge, Massachusetts, 1991.

[3] Spence, William P., *Residential Framing: A Homebuilder's Construction Guide*, Sterling Publishing Co., New York, New York, 1993.

[4] Spence, William P., *Residential Framing: A Homebuilder's Construction Guide*, Sterling Publishing Co., New York, New York, 1993.

[5] Spence, William P., *Residential Framing: A Homebuilder's Construction Guide*, Sterling Publishing Co., New York, New York, 1993.