Technical Q & A

Upward Deflection of Truss Bottom Chords

by Ryan J. Dexter, P.E.

The condition of truss arching is explored.

Partition separation is defined by our industry as the cracking that develops at the interface between interior partition walls and ceiling or floor finishes, usually characterized by gaps that open in the winter and close in the summer. There are many reasons that cause partition separation, including what is termed "truss arching" by many in the field. From the calls we receive on this issue, truss movement is often blamed; but in actuality, truss movement causes partition separation in only a minority of the cases.

Let's take a look at why arching occurs and the degree to which it impacts truss deflection.

Truss arching is best described as an upward deflection of a truss resulting from a differential elongation or shrinkage between the top and bottom chords. Recall that wood swells as its moisture content increases and shrinks as its moisture content decreases. Therefore, an increase in the moisture content of the top chord relative to the bottom chord will cause an elongation of the top chord relative to the bottom chord. Similarly, a decrease in the moisture content of the bottom chord relative to the top chord will cause shrinkage in the bottom chord relative to the top chord. Since typically the top and bottom chords of a roof truss are firmly connected at the heel joint by a metal connector plate, if the differential movement between the chords is large enough, an "arching" or upward deflection (most pronounced at the midspan of the truss) can occur.

Truss arching has been known to occur during the winter following "close-in"; this is when the trusses were installed late in the year after having been subjected to wet or humid weather. The bottom chords of the trusses are typically enclosed in insulation and immediately begin "drying out" due to the heat from the living area below. In this scenario, the bottom chord begins to dry at a much faster rate than the top chord, causing shrinkage in the bottom chord relative to the top chord, which results in an upward movement of the trusses. If these trusses cross over interior partition walls that are nailed directly to the bottom chord of the truss, the arching of the bottom chord can cause a crack or gap to form at the corner joint between the ceiling and the top of the partition wall, or can actually lift the partition off of the floor below. In this situation, the arching will typically dissipate as the moisture content of the top and bottom chords equilibrate to the same level.

Truss arching has also been known to occur in existing structures on a seasonal basis, which usually indicates that the ventilation in the attic is inadequate, or that moisture from the house is escaping into the attic as opposed to being vented directly outdoors.

Example Calculation for Truss Arching

The following table shows the average longitudinal elongation/shrinkage values per 1% change in moisture content of three lumber species commonly used in metal plate connected wood truss construction:

Species	Changes Per 1% Loss in Moisture Content
Southern Pine	0.0127%
Douglas Fir-Larch	0.0073%
Hem-Fir	0.0063%

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at a glance

- Partition separation is often blamed on a condition known as truss arching.
- Wood may expand or shrink depending on its moisture content.
- The example given in Figure 2 shows that a 28-ft truss with 19% moisture content that dries to 7% may cause an upward deflection of about 0.7 inches.
- Many factors lead to partition separation; the only way to prove truss arching is to use a laser level to assess all the areas of potential movement in the structure.

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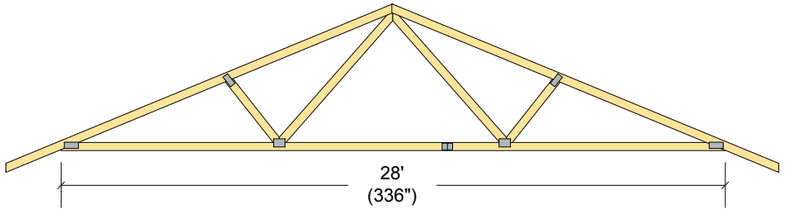

Figure 1.

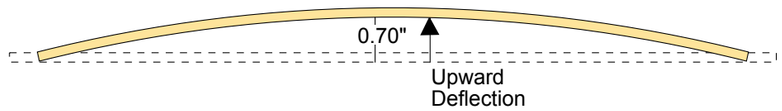

Figure 2.

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As an example of how truss arching can occur, let's assume we have a 28-ft span truss with an average moisture content of 19% that is installed in the roof of a house in northern Virginia in late November. Assume that Southern Pine is used in the chords and webs of this truss. Assume also that the house is quickly enclosed after the trusses are set with heat applied to the interior to aid with the finishing of the drywall and that the bottom chord is completely enclosed in insulation soon after (see Figure 1). Under these conditions the bottom chord dries over a couple of months from 19% to 7%. This equates to a 12% difference in moisture content. Meanwhile, the moisture content in the top chord remains relatively unchanged.

If southern pine shrinks 0.0127% per each 1% loss in moisture content, we can expect shrinkage of approximately 0.001524 in./in. due to the 12% loss (i.e., 0.000127 x 12 = 0.001524 in./in.). The bottom chord is 336 in. long (i.e., 12 in./ft. x 28 ft.). Therefore, the potential overall shrinkage of the bottom chord is approximately 0.001524 x 336 in. = 0.512 in.

Because the bottom chord is restrained by the top chord and the webs (also because the chords are typically constrained at the heels due to the bearing connection), this shortening could potentially produce an upward deflection of the bottom chord of approximately 0.70 in. using the mathematical relationships between an arch and chord of a circle (see Figure 2).

The above example is idealized. Remember that the percentages listed in Figure 1 are *averages*. This means that because of variations between species, variations between trees from different forests, the age of the trees when cut, and variations in the lumber within the same tree, elongation and shrinkage does not always take place uniformly, and sometimes does not occur at all. In addition, slight slippage of the wood around the metal teeth of the truss plate, the orientation of the growth rings in the lumber, the number of pieces used to form the lower chord, the way the trusses are fastened to the walls, the amount of ventilation, the relative humidity, and the thickness of the insulation make predicting when partition separation will occur very difficult if not impossible.

Because of all these reasons and the fact that truss movement is not typically found to be the cause when a rigorous assessment of movement in the building is made, it is generally not reasonable to blame trusses for partition separation. The only way to know for sure that truss movement is taking place is to use a laser level to assess all the areas of potential movement in the structure. The foundation must be level, the walls square, the top plates level, the floor level and so forth. Building shrinkage/movement can come from a variety of sources. Once the cause is known, remediation is easier.

Again, truss arching is just one of several factors that can cause partition separation. We have provided a way to quickly assess the amount of relative shrinkage that the lumber used in a truss may accrue. This is intended to provide information that will help the evaluation of truss movement in a building. To learn more about the factors that can cause partition separation refer to WTCA's Truss Technology on Building (TTB) brochure, *Partition Separation Prevention and Solutions*, available at www.sbcindustry.com/ttbpartsep. SBC

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