Deeper is Cheaper

By Dwaine Charbonneau, P.E. at RedBuilt

You get what you pay for. Everybody knows that. You want another glass—it's going to cost you. You want filet instead of hamburger—open your wallet. It's a simple concept anyone can understand, even folks on an empty stomach.

So what's this? In the RedBuilt Open-Web Truss Specifier's Guide, right here on page 4, it says, "Deeper Can Be More Economical." The text says, "Designing to the maximum depth allowed for the application... will produce the most economical solution." That's either the mother of all typos, or the author of said specifier's guide is something of an outlier when it comes to conventional wisdom. A deeper truss takes longer webs, and more steel means... open your wallet, right?

Well, maybe not. While conventional wisdom may hold when it comes to Red-I™ joists and RedLam™ LVL beams, the open-web truss story is a little more complicated. In defense of the specifier's guide and the unquestionable sobriety of its author, allow me to explain how you can get more truss for less money, all with the same great RedBuilt™ quality and customer service.

The Keys to Cheap

Just so we're on the same page, a brief description of the RedBuilt™ open-web truss is in order. The truss is made up of continuous wood chords, top and bottom. The web layout is Warren style with no vertical webs – a simple zig-zag between top and bottom chords. Tubular steel webs are connected to the chords with steel dowels or pins. Steel bearing clips reinforce the pin connections at each end of the truss and provide a means to fasten the truss to the supports.

The primary factors that differentiate the costs of a shallow and a deep truss, given the same span and loads, are the chord grades, pins, and labor. Bearing clips are the same regardless of depth, but the rest of the materials and labor are subject to quite a bit of variability, depending on a number of options available to the truss designer and his or her trusty design software.

Throughout this discussion let's assume we're talking about the typical parallel-chord profile spanning two supports with no overhangs. The truss is top-chord-bearing, and the design is governed by gravity loads applied mostly to the top chord. The truss experiences compression in the top chord and tension in the bottom chord.

Bottom Chord Grade

Let's start with the bottom chord because it's relatively simple. The bottom chord typically supports minimal direct-applied loading—maybe some ducts, acoustic ceiling, or insulation—leaving the top chord to shoulder most of the load. Nevertheless, wood is usually weaker in tension than in compression parallel to grain, so the bottom chord may indeed become the critical design control.

Tension in the bottom chord is directly proportional to the depth of the truss, which leads to our first key in the whole "deeper is cheaper" mystery. By making the truss deeper the designer may be able to choose a less-expensive grade of lumber in the bottom chord.

Top Chord Grade

It's bad enough to be standing in the rain, and it's frustrating when you get a flat tire, but for pure misery nothing beats getting a flat tire when it's raining. The stress just seems to be amplified as you experience the dark side of synergy.

And so it is with the top chord of our truss. It's bad enough that the chord is experiencing a tremendous amount of axial compression. Add to that the effect of the applied loads bending the chord between pins. And add to that the threat of buckling instability. It's a combination of stresses that can bring a weaker chord to its knees.

Engineers call this combination of bending and compression *interaction* or *combined stress*. To deal with it, the designer must again select the appropriate chord grade, but there is one more variable to consider: panel length. As the distance between top pins is shortened, the bending stresses and the tendency to buckle both decrease, and the chord is better able to handle the compression.

As with the bottom chord the key to permitting a lower grade of top chord is to increase the depth, thereby decreasing the compression. Coincidentally this allows for a longer panel size. And the ramifications of that are huge, as we shall see.

Webs

There is a practical limit to how tight the webs can be assembled. The minimum angle between the webs then determines how short the panels may be. This is one of the characteristics often found in a truss that is "maxed out:" lots of webs and closely-spaced pins. I'm not including the webs as one of the factors that may contribute to a more economical truss, and there's a reason for that. Web cost depends on diameter, gauge, and footage of steel tube. Unless the web angles change appreciably as you deepen the truss, there will not be an opportunity to downsize any of these things. If the truss ends up twice as deep, you'll have half as many panels but webs twice as long, which is a wash on steel footage. The axial forces will be about the same either way, which is a wash on diameter and gauge, except on long compression webs.

In summary, web layout and material selection is highly variable and not a consistent contributor in the quest for the most economical truss.

Pins

This is easy: longer panels means fewer panels, which means fewer pins. The cost difference can be significant. As mentioned, a surefire way to get longer panels is to deepen the truss.

Labor

Truss quantity and span matter, of course, but when you get right down to it, the truss builder is assembling panels. Each panel is two more holes to drill and possibly rout, two more webs to press and install, and two more pins to drive in place. To the truss assembler, it's not so much how big the truss is but how many triangles it's made of.

The best way to minimize labor is to minimize the number of panels. To do this you need to make the truss deeper to decrease top chord compression.

Seeing a Pattern Here?

The common thread in all of this is plain: deeper is cheaper. If you were to visualize a "maxed out" truss, the kind that is tabulated under "Allowable Uniform Load" in our specifier's guide, you would start with the bottom chord. Reduce the depth until the most expensive grade of chord just barely works in tension. Now space the top pins out until the highest grade of top chord just barely works in combined stress. Add pins and webs in the necessary sizes, and there you have it: a hard-working truss pushed to the redline. And it isn't cheap.

Relax a little. Make the truss deeper. The chord grades drop, the number of pins is minimized, and the assembly is a breeze, relatively speaking. That's how you save money on open-web trusses.

There are other benefits that come with greater truss depth. It is much easier to run utilities through a roomy web layout as opposed to a cramped layout. And truss stiffness is roughly proportional to the square of the depth, so any increase in depth really pays off in minimizing deflection and improving floor performance.

It makes you wonder, though, if there's a limit on how deep you can go and still get a cheaper truss. In fact there is such a limit, albeit a fuzzy one. Consider the truss in the far northeast corner of the Red-L™ Truss Allowable Uniform Load Table: it's 40 inches deep on a 14-foot span. Obviously that truss is there just to fill out the table of allowable loads. Increasing it to 42 inches deep would not be a good move.

This is the perfect opportunity to make an important point about the tables of allowable loads in the literature. When you're choosing an I-joist, such tables are decent tools for selecting joist series and depth because every I-joist is built the same. If you don't max out the joist, you are leaving something on the table—no pun intended. With open-web trusses, this is not the case. Every truss is different, designed individually to support the specified loads and nothing more. The table of allowable loads is populated with trusses that are working just as hard as they possibly can, and as we have seen, that is not a particularly good thing when it comes to choosing the most economical design. This caveat is noted in red at the bottom of each load table page.

"**Consult your RedBuilt technical representative**," the note proclaims, and with good reason. Given a span and loads and any additional requirements in the way of floor performance, duct size, and so on, your tech rep is the ultimate authority for directing you to the most economical series and depth of truss and telling you what the price is.

RedSpec™ (RedBuilt's free design software) is a good place to get started. It allows you to make a trial selection of multiple truss series and set acceptable ranges of depth and spacing. The result is a list of trusses sorted with the most economical at the top. But it is strongly recommended that you consult with your RedBuilt tech rep to get the price of the most economical truss and make sure the design meets all your needs. By now you know that deeper is cheaper, but how much deeper and how much cheaper is a question for the experts.

You get what you pay for. That's true of RedBuilt™ open-web trusses, but there's more to this picture than meets the eye. If your structural design is truly limited to a shallow depth, RedBuilt can build a high-performing truss to meet your specifications. Just be aware there may be a deeper truss ready to do the same job for less money.

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About the Author:
Dwaine Charbonneau, P.E., has worked in the Engineered Wood Products industry for 16 years, lives north of Portland, Oregon near the Columbia River, and is scandalously handsome. As a RedBuilt corporate engineer, he is an expert on truss design, floor performance, and alpacas.