

Metal Retrofit: The Structural Nuances of Purlins and Subpurlins You Should Not Overlook

By Dale Nelson

WHEN AN EXISTING metal roof has reached the end of its life, retrofitting often proves to be the easiest, least invasive, and most cost-effective way to replace it. Beneath the surface of any successful retrofit, however, lies a structural story worth exploring. Understanding the framing components—especially the roles of purlins and subpurlins—is key to ensuring a high-quality, code-compliant, and long-lasting new roof.

In older pre-engineered buildings, purlins are typically 5 ft (1.5 m) on center (o.c.), 8 in. (203 mm) deep, Z-shaped members that span from frame to frame (or “bents,” for those who remember the old terminology). These members (purlins) commonly cover spans of 25 ft (7.6 m) to 30 ft (9.1 m) and are generally made from 16 ga (1.5 mm) or heavier steel, depending on the structural design (**Fig. 1**). Most, but not all, are installed as continuous-span members by extending the purlins beyond the centerline of each frame and overlapping them with the adjacent purlin by a specified distance. When fastened to one another, they act continuously to distribute the load.



Figure 1. Typical metal building framing with purlins spaced at 5-ft (1.5 m) on center and a 25 ft (7.6 m) bay spacing.

These purlins may be either flange-mounted directly to the frame or supported by clips attached to the frame (**Fig. 2**). Their bracing requirements depend on the type of roof installed above them. Through-fastened roof systems can offer substantial diaphragm strength, often reducing the need for additional purlin bracing. In contrast, standing-seam roofs provide minimal diaphragm support, necessitating significantly more bracing to maintain structural stability. This difference is also why a through-fastened roof cannot simply be removed and then replaced with a standing-seam system without first adding extensive purlin bracing.

When undertaking a metal-over-metal retrofit, two key structural considerations must be addressed:

- **Performance:** What are the structural and performance characteristics of the new roof panels being installed? A clip analysis should be run to determine proper fastener/clip spacing for code compliant attachment. Additionally, it is important to compare how these panels behave when attached to subpurlins versus full-depth, solid purlins—performance can and does vary notably between the two.
- **Weight:** How much additional load will the retrofit add to the existing system? Is the client adding photovoltaics or other equipment? It is also critical to account for any supplemental equipment or systems that may have been installed and supported by the purlins over time—these could significantly reduce the available capacity for new roofing loads.

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Figure 2. Continuous clip-mounted purlin lap over frame.

When executing a metal-over-metal retrofit, there are several framing methods available for installation over existing panels—options include hat-over-hat, Z-over-Z, inverted notched hats, tall clips, and notched subpurlins, among others. Notched subpurlins—modified Z-shaped members with portions of the base flange and vertical web cut away to accommodate panel ribs (**Fig. 3** and **4**)—are often the most cost-effective solution. Keeping subframing height to a minimum helps reduce both material costs and added dead load. Technically, the subpurlin system can clear the existing panel ribs by just $\frac{1}{4}$ (6 mm) to $\frac{1}{2}$ in. (13 mm).

However, other project needs may dictate additional height. These include requirements for reduced corner and edge attachment spacing, increased insulation depth, or the need to improve the structural capacity of the existing purlins.

It is important to remember: Subpurlins are *not* the same as purlins. Purlins are typically made from high-strength Grade 50, 60 ksi to 65 ksi tensile strength (414 MPa to 448 MPa) steel, usually 8 in. (203 mm) deep or more, braced, often continuous in span, and usually feature large, symmetrical flanges. Subpurlins, by contrast, are low-profile members that *should* also be Grade 50 (though not all are). Subpurlins include notches to accommodate panel ribs, and have smaller, non-symmetrical flanges. So, do purlins and subpurlins perform the same under uplift and dead-load testing (**Fig. 5**)? As you might have guessed, absolutely not. Further complicating things some suppliers some suppliers utilize 16 ga. (1.5 mm) lower yield strength Grade 30 steel. Pull out values can



Figure 3. Notched subpurlins over standing seam roof with rigid insulation.

be reduced by as much as 50%, flange and web deflection will be greater (**Table 1**).

This is where *system testing* becomes absolutely critical. What happens when a 24 in. o.c. (610 mm) trapezoidal standing-seam panel is mounted on subpurlins over 12 in. o.c. (305 mm) R-panels? Or when 16 in. (406 mm) o.c. panels are placed over 24 in. o.c. trapezoidal panels? What if the original roof was standing seam installed on tall clips? The new and old panel combinations are endless as are the size and number of the cutouts in the subpurlins and only through system testing across multiple

assemblies can a test laboratory provide the performance data needed to make informed decisions.

The same principle applies when evaluating whether subpurlins add strength to existing framing. Do notched subpurlins increase capacity? In most cases, yes, but not always, and assumptions can be costly. Would a 16 ga. 0.060 in. (1.5 mm) subpurlin enhance the performance of a much heavier 12 ga. 0.105 in. (2.7 mm) purlin? Maybe, but do not count on it. In one test we conducted for a tennis court building that had 12 ga. purlins and 20 ft (6.1 m)

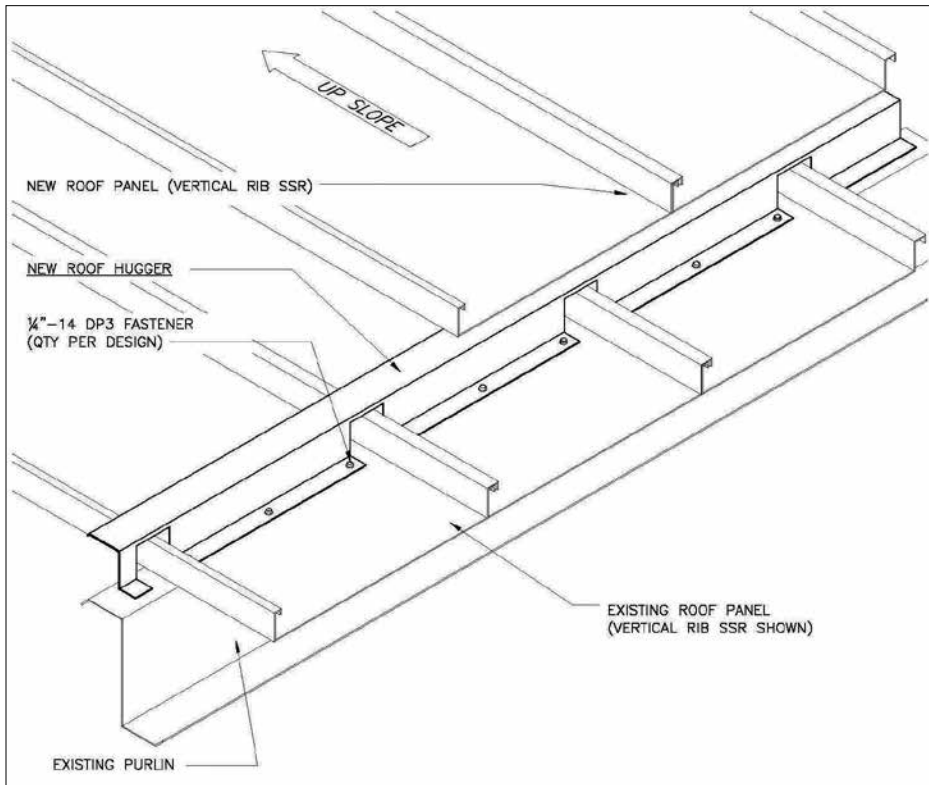


Figure 4. Section detail: Existing purlin, roof, notched zee, and new standing seam roof.



Figure 5. Performing ASTM E1592, Standard Test Method for Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference, on panels mounted on notched zeeps.

bay spacing we found no gain in purlin capacity even with 12 ga. subpurlins. (Fig. 6 and 7).² Many companies rely on computer-based finite element analysis to make performance claims. But without actual, validated test data,

such simulations remain just that: simulations. These computer-calculated results must be cross checked against actual test data. Variables must be accounted for in the existing building purlins such as: flange mounted or

clip mounted, gauge, simple or continuous span, lap length, bay spacing, and more. Then the subpurlin framing variables such as: type, gauge, depth, flange sizes, and cut-out pattern. Each must be accounted for to determine the amount of additional purlin capacity the retrofit can provide.

METAL ROOF RETROFIT: RECAPPING THE BASICS

Retrofitting an old metal roof is usually a pretty straightforward job. Here's what you need to think about:

Choosing the New Roofing Material

- You've got options: single-ply membranes, liquid-applied roofing, or new metal panels.
- Metal is the top choice—especially aluminum-zinc alloy (Galvalume or equal)—because it warrantied to 50 years, can meet the toughest building code or building hardening requirements and has the lowest lifetime cost.
- It is ideal if you're adding solar panels, since the roof material that will outlast them.
- Single-ply systems have half the expected life or less and can't handle extra weight from snow or solar gear.

Panels and Framing

- Look at the existing roof panel shape—this determines what kind of support subframing you'll need.
- Select a strong new roof panel, review the testing. The stronger the new panels, the less sub-framing you'll need. That saves time and money.

Checking Purlin Spacing

- Older metal buildings usually have framing spaced 5 ft (1.5 m) apart, confirm this.
- You'll need to attach new subframing directly to these existing supports.
- Using notched subpurlins is the easiest way to beef up the structure without having to open up the building and disrupt ongoing operations.

Managing Extra Weight

- A new metal-over-metal roof adds about 1.5 to 2.5 lb (0.68 to 1.13 kg) per square foot (0.093 square meter).
- Building codes allow up to 3 lb/ft² (144 Pa) additional weight without the need for a full structural review.
- If you're adding solar panels, HVAC units, or have increased snow loads, a professional should check if your existing supports can handle it.

TABLE 1. Pullout load comparison: Grade 30 versus Grade 50 steel based on published data for self-drilling screws in steel substrates

Screw size	Nominal diameter, in.	Estimated pullout strength	
		Grade 30 steel	Grade 50 steel
#10 to #16	0.190	290 to 500 lbf	504 to 1,311 lbf
#12 to #14	0.216	330 to 600 lbf	573 to 1,611 lbf
¼ to #14	0.250	383 to 700 lbf	633 to 1,865 lbf

Note: 1 in. = 25.4 mm; 1 lbf = 4.448 N; 1 ksi = 6.895 MPa.



Figure 6. Gravity load base test of continuous purlins in 50-ft (15-m) long test chamber before applying loads according to AISI S908.



Figure 7. Same specimen and test chamber from Figure 6, after testing to failure.

- Notched subpurlins will likely be able to add enough or more capacity to handle these increases if needed.

Trust Real Testing, Not Just Theory

Computer simulations can be helpful tools, and we use them frequently—but only when anchored to real, test-confirmed data. When you are selecting a system for a metal-over-metal retrofit, choose a supplier that understands panel performance, purlin capacities and subframing strengths/limitations and supports its designs with actual product testing, not just engineering speculation. 

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