Sizing Engineered Beams

by Paul Fisette

In last month's *Practical Engineering* column, we discussed how to trace load paths and translate roof, wall, and floor loads into pounds per lineal foot of supporting beam. With this information, you can then choose the right beam size and material to carry the load. In this article, we'll look at some more uniform-load case studies, then compare the performance and cost of sawn lumber with several engineered-lumber products in meeting these different applications.

Sample House

The five applications and spans that I have selected as examples of beams and headers are arbitrary but common ones (see illustration).

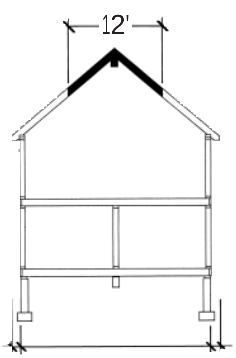
First, I worked out the uniform loads for each of the beams, following the procedure outlined in last month's article. If you don't follow the calculations, review that column. I've included calculations for two loading conditions. One design assumes a 50-pound snow load and the other is in a 20-pound non-snow climate (both loads are treated as live loads). The applications, as noted in the illustration and the chart below, are:

1) a structural ridge beam with a 20-foot span, as you might find in a cathedral-ceilinged master bedroom
2) a second-floor header with a 4-foot span, which picks up roof loads only, since there is no ceiling in that room
3) a first-floor header with an 8-foot span, which picks up roof, wall, and second-floor loads
4) a basement girder with a 15-foot span
5) a garage-door header with an 18-foot span, which picks up loads from half the truss roof

Once I knew the loads, I sized and priced the required beams and headers five different ways, to see how the options compared with one another.

Typical Beam-Loading Scenarios

RIDGE BEAM



50 LL SNOW
L/240

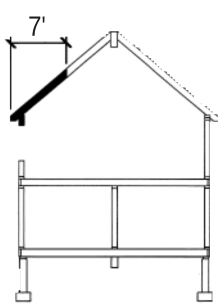
12 x 50	=	600 plf	LL*
12 x 10	=	120 plf	DL*
		720 plf	TL*

20 LL NONSNOW
L/240

12 x 20	=	240 plf	LL
12 x 10	=	120 plf	DL
		360 plf	TL

* LL = Live load
DL = Dead load
TL = Total load

4' UPPER HEADER



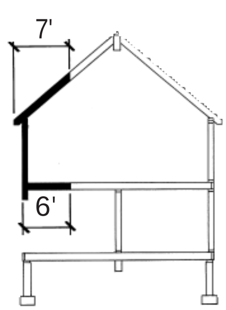
50 LL SNOW
L/240

7 x 50	=	350 plf	LL
7 x 10	=	70 plf	DL
		420 plf	TL

20 LL NONSNOW
L/240

7 x 20	=	140 plf	LL
7 x 10	=	70 plf	DL
		210 plf	TL

8' LOWER HEADER



50 LL SNOW
L/360

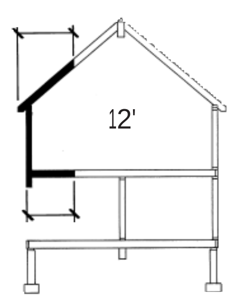
7 x 50	=	350 plf	LL
7 x 10	=	70 plf	DL
wall*	=	128 plf	DL
6 x 30	=	180 plf	LL
6 x 10	=	60 plf	DL
		788 plf	TL
		530 plf	LL

20 LL NONSNOW
L/360

7 x 20	=	140 plf	LL
7 x 10	=	70 plf	DL
wall*	=	128 plf	DL
6 x 30	=	180 plf	LL
6 x 10	=	60 plf	DL
		578 plf	TL
		320 plf	LL

*weight of 2x6 ext. wall

CENTRAL GIRDER

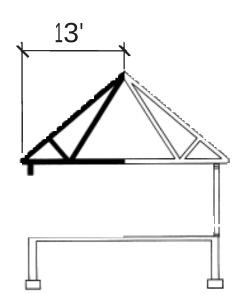


30 LL UPPER FLOOR
40 LL LOWER FLOOR
L/360

12 x 30	=	360 plf	LL
12 x 10	=	120 plf	DL
wall*	=	90 plf	DL
12 x 40	=	480 plf	LL
12 x 10	=	120 plf	DL
		1,170 plf	TL
		840 plf	LL

*weight of 2x4 int. wall

GARAGE HEADER



50 LL SNOW
L/180

13 x 50	=	650 plf	LL
13 x 15*	=	195 plf	DL
		845 plf	TL

20 LL NONSNOW
L/180

13 x 20	=	260 plf	LL
13 x 15	=	195 plf	DL
		455 plf	TL

*average weight per square foot of truss roof system; check with truss manufacturer for weight of specific trusses

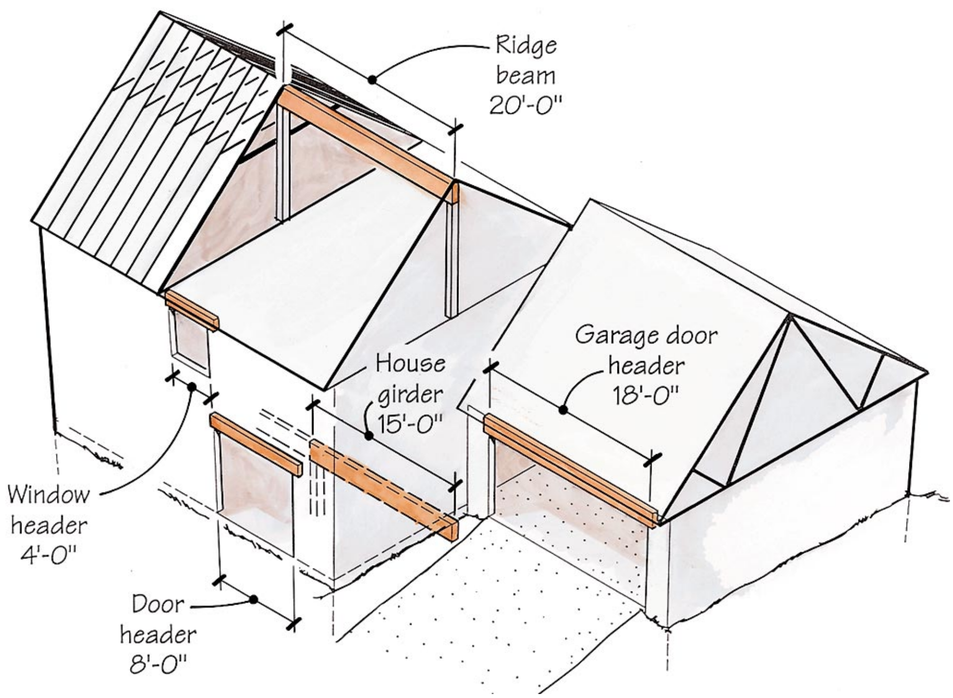
Beam Choices

There are countless choices when it comes to specifying a beam material. To simplify this presentation, I chose for comparison's sake one species of sawn lumber, Doug Fir-Larch, and four engineered beam options.

Sawn lumber has its limitations. It doesn't clear-span long distances (such as for the garage-door header), and select structural grades are not always available except by special order. Depending on the species and grade, its bending strength (*Fb*) values are often a half to a third that of engineered products. But overall, for short spans, sawn lumber is tough to beat. Note, however, that in the cases of the ridge beam and central girder, a triple 2x12 beam requires an intermediate post, which the engineered beams don't require.

Laminated veneer lumber (LVL) is strong, stiff, and versatile. It easily spans long distances, and is modular like sawn lumber: To increase load capacity, you can just bolt on a second member. Labor has to be factored in, but on the positive

Sample House



The author chose these five typical beam applications for sake of comparison. The chart on the previous page gives loading calculations for each application in two climates — one with 50-pound live (snow) loads and one with 20-pound (nonsnow) live loads. Various beam choices and their respective costs are presented in the chart below.

Solid-Sawn and Engineered Lumber Options

		SAWN		LVL		POWER BEAM		PARALLAM		TIMBERSTRAND	
		Doug Fir-Larch Sel. str. or #2		*Fb* 3,100 *E* 2.0 other options avail.		*Fb* 3,000 *E* 2.1		*Fb* 2,900 *E* 2.0		*Fb* 1,700 *E* 1.3 *Fb* 2,250 *E* 1.5	
		Size	Cost	Size	Cost	Size	Cost	Size	Cost	Size	Cost
50 LL **RIDGE**	L/240	Sel. Str. DF-L Triple 2x12 max. span 9'3"	6.36 ($/ft beam)	Double 1¾x16 span 20'	11.22 ($/ft beam)	3½x16 span 20'	11.30 ($/ft beam)	3½x16 span 20'	11.76 ($/ft beam)	3½x18 span 20' 1.5 *E*	9.72 ($/ft beam)
20 LL **RIDGE**	L/240	Sel. Str. DF-L Triple 2x12 max. span 13'2"	6.36 ($/ft beam)	Double 1¾x14 span 20'	9.78 ($/ft beam)	3½x11⅞ span 20'	8.25 ($/ft beam)	3½x14 span 20'	10.28 ($/ft beam)	3½x14 span 20' 1.5 *E*	7.55 ($/ft beam)
4'0" 50 LL **HEADER**	L/240	#2 DF-L Double 2x6	1.80 ($/ft beam)	Not practical		Not practical		Not practical		3½x4⅜ 1.3 *E*	2.36 ($/ft beam)
4'0" 20 LL **HEADER**	L/240	#2 DF-L Double 2x6	1.80 ($/ft beam)	Not practical		Not practical		Not practical		3½x4⅜ 1.3 *E*	2.36 ($/ft beam)
8'0" 50 LL **HEADER**	L/360	Sel. Str. DF-L Double 2x12	4.24 ($/ft beam)	Double 1¾x7¼ or Single 1¾x11¼	5.10 or 4.16 ($/ft beam)	3½x7¼ (smallest available)	5.75 ($/ft beam)	1¾x11¼	3.15 ($/ft beam)	3½x9½ 1.3 *E*	5.25 ($/ft beam)
8'0" 20 LL **HEADER**	L/360	Sel. Str. DF-L Double 2x10	3.54 ($/ft beam)	Double 1¾x7¼ or Single 1¾x9¼	5.10 or 3.35 ($/ft beam)	3½x7¼ (smallest available)	5.75 ($/ft beam)	1¾x9¼	2.52 ($/ft beam)	3½x8⅝ 1.3 *E*	4.65 ($/ft beam)
GIRDER	L/360	Sel. Str. 2x12 max. span 7'4"	6.36 ($/ft beam)	Triple 1¾x14 span 15'	14.67 ($/ft beam)	3½x16 span 15'	11.30 ($/ft beam)	3½x16 span 15'	11.76 ($/ft beam)	3½x18 span 15' 1.5 *E*	9.72 ($/ft beam)
18'0" 50 LL **GARAGE HEADER**	L/180	Exceeds limit		Double 1¾x16	11.22 ($/ft beam)	3½x16	11.30 ($/ft beam)	3½x16	11.76 ($/ft beam)	Exceeds limit	
18'0" 20 LL **GARAGE HEADER**	L/180	Exceeds limit		Double 1¾x11⅞	8.32 ($/ft beam)	3½x11⅞	8.25 ($/ft beam)	3½x11⅞	8.72 ($/ft beam)	3½x14 1.5 *E*	7.55 ($/ft beam)

side, two or three workers can often assemble a beam in place that would otherwise require a crane to place. LVL typically comes $1^3/_4$ inches thick and ranges in depth from $7^1/_4$ inches up to 18 inches.

Anthony Power Beam (APB) is a newcomer to the glulam market, and has positioned itself to compete with LVL and Parallam. It comes in $3^1/_2$- and $5^1/_2$-inch widths; depths range from $7^1/_4$ to 18 inches. There is also a 7-inch-wide version available in depths up to $28^7/_8$ inches. APB comes as a full-size beam — that is, it requires no site lamination — so it is fairly heavy. For example, the 18-foot garage header for our sample house weighs in at 380 pounds.

Parallam, manufactured by Trus Joist MacMillan (TJM), is the only parallel-strand lumber (PSL) beam on the market. PSL is an assembly of long, thin strands of wood veneer glued together to form continuous lengths of beam. The wood fiber used is strong and stiff. Several widths from $1^3/_4$ inches to 7 inches are available in depths of $9^1/_4$ inches to 18 inches. Like APB, Parallam comes fully assembled and is relatively heavy.

TimberStrand is a "laminated strand lumber" header material from Trus Joist MacMillan. It is made by upgrading low-value aspen and poplar fiber into high-grade structural material. The *Fb* and *E* values are certainly no match for LVL, Power Beam, and Parallam, but the performance of TimberStrand is still impressive. It worked for most of the applications in our case house, although the 18-foot garage-door header pushed TimberStrand beyond its structural limit. It comes $3^1/_2$ inches wide in depths ranging from $4^3/_8$ to 18 inches. The product is new and currently somewhat hard to find.

Using Beam-Sizing Tables

I used the *Wood Structural Design Data* (available for $20 plus from the American Forest & Paper Association, 800/890-7732) to size the Doug Fir-Larch beams for this article. Consisting primarily of tables that allow you to accurately size uniformly loaded beams and headers, this is a worthwhile book for any builder to have. Engineered-lumber manufacturers will gladly send you their sizing guides for free.

Engineered-wood span tables for uniform loads are used in much the same way as span tables for sawn lumber. The code allows reductions in live loads based on duration of load. Depending on which manufacturer's literature you refer to, sometimes these reductions are already applied and sometimes not. Typically, shear values are incorporated into the tables, and the required bearing length at the end of the beam is given. Tables for most products are limited to whole-foot spans.

Sizing begins with pounds per foot of beam. But with engineered wood, unlike sawn-lumber tables, you use both the live and dead load values: Live load determines stiffness; total load determines strength. To size engineered lumber:

- determine the total load and live load per foot of beam
- identify the type of load you are supporting (roof snow, roof nonsnow, or floor) and choose the appropriate table.
- pick the span you need
- match the total load and live load values to the values listed in the tables. The thickness and depth of the member required to carry the load (or a choice of thicknesses and depths) will be listed.

No matter what product you specify, structural performance is controlled by bending strength (*Fb*) and stiffness (*E*). Builders who make up headers and girders out of multiple pieces of sawn lumber rarely think about these engineering design values. But when you start looking at engineered lumber design guides, it's a good idea to be aware of them. Just as sawn lumber of different species varies in strength and stiffness, the same can be true of engineered lumber. An LVL product that has an *Fb* of 3,100 can handle a greater load than an LVL product with an *Fb* of 2,400. So be careful when you compare products.

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