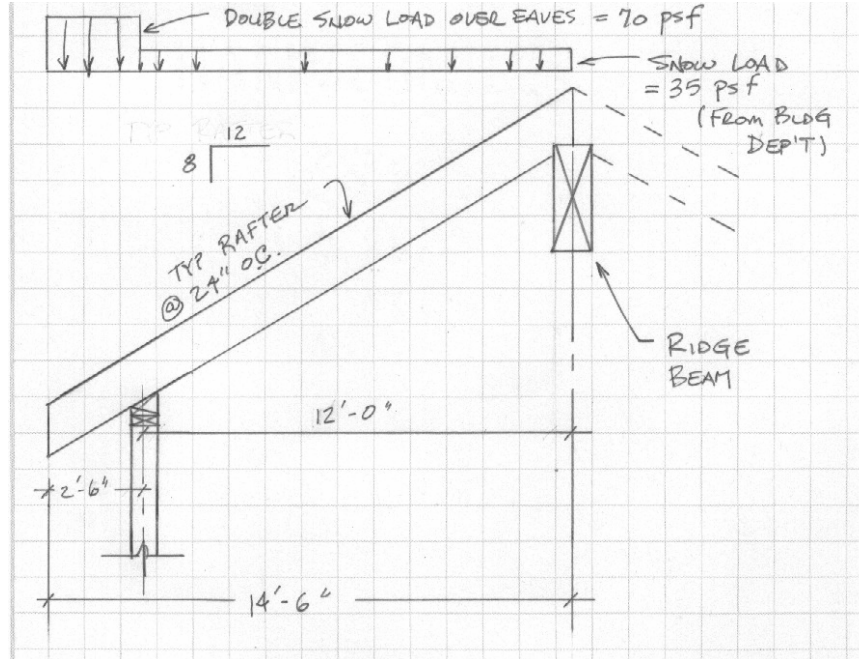


Example Rafter Design Using ConstructionCalc ProBeam Software

Note: The following example assumes you are a beginner. You should expect this to go slowly at first. However, with a little practice, getting solutions with ConstructionCalc is about a one minute job. Awesome.

1) **General.** This member is a rafter with an overhang (cantilever).



- 2) Open **ConstructionCalc ProBeam** from Microsoft Excel, then File – Open.
- 3) **Part 1 – General Input.**

Your Company, Inc.

Assumptions: Compliant with 2003 IBC, 1997 UBC, and 2001 National Design Spec for W supports and cantilever end. Bending in strong axis only. No wet, high moisture, or high t

Disclaimer: All users of this software shall comply with State Engineering Law, which sp

Job Name:	Example rafter with overhang	
Beam I.D.:	12' span, 35 psf snow	
Other Info.:	by tkg, 9/22/2005	

PART 1 - General Input

Main Span, L = 12.00 ft

Main Span Max. Allowed Live Defl: L / 360 = 0.40 in

Main Span Max. Allowed Total Defl: L / 240 = 0.60 in

Cantilever (Overhang) Exists? Yes

Right Cantilever, C_R = 2.50 ft

Cantilever Max Allowed Live Defl: C_R / 360 = 0.08 in

Cantilever Max Allowed Total Defl: C_R / 240 = 0.13 in

Pitch if Sloped: 8.0 : 12

Load Duration: Two Months (Snow)

Add Self Wt.? Yes No

Loads Other Than Uniform Loads? Yes

Getting Started. Hover Cursor Here

- a) **General.** With all ConstructionCalc programs you can type in a name of the member you're designing, job name, date, etc. in the three cells at the top. Also, you can type in your company name at the very top of the sheet.
 - b) **Span:** Main span is the horizontal distance from bearing wall to ridge beam, in our case, 12'. See sketch. Note, we could use inside of bearing distances instead, 11', but to make it simple, we'll conservatively use distances to the center of bearing. Also note: only enter numbers, no symbols, spaces, or units – the program does that for you.
 - c) **Maximum Allowed Deflection:** This is the amount of deflection (sag) we're willing to allow for the main span of our rafter (see red triangle note for more). Let's use the default values of L/360 for live load deflection and L/240 for total deflection.
 - d) **Cantilever Exists?** Yes, the eaves overhang.
 - e) **Right Cantilever, Cr:** This is the overhang horizontal distance, 2.5' (always use decimal feet, not feet and inches). It doesn't matter whether the cantilever is on the right or left.
 - f) **Cantilever Deflection:** This is the amount of deflection (sag) we're willing to allow at the cantilever end of the rafter. Let's use the default values of L/360 for live load deflection and L/240 for total deflection.
 - g) **Pitch if Sloped:** Our rafter is sloped, it's pitch is 8:12. Enter 8 (the ":12" fills in automatically).
 - h) **Load Duration:** Since we're designing roof rafters which will see their worst live loading from snow, select Two months (snow).
 - i) **Add Self-Weight?** Since the rafter's self-weight is already included in the 15 psf dead load we'll use in a minute, and we don't want to add it twice, select No.
 - j) **Loads Other Than Uniform Loads?** The loading over the cantilever (code-required double snow load on rafter overhangs) is different than over the rest of the member, so we select Yes.
- 4) **Part 2 – Loads Input.** Here are the loads we need. Note unused load sections may be hidden via the Hide / Show Loads dropdown at the top of screen.

Uniform Loads Over Full Length of Member						
	Live, psf	Dead, psf	Tributary Width, ft	Uniform Live Load, plf	Reduced Live Load, plf	Uniform Dead Load, plf
Roof Loads (not including snow)	16 psf	15 psf	2.00 ft	-	-	36.1 lb/ft (Adj'd for pitch)
Roof Snow (only)	35 psf		2.00 ft	70.0 lb/ft	70.0 lb/ft	
Floor 3 Loads						
Floor 2 Loads						
Floor Loads						
Wall Dead Load						
Other 'psf' load and trib. width						
Additional 'plf' Unif. Live Loads	Descript'n, opt!:					
Additional 'plf' Unif. Dead Loads	Descript'n, opt!:					
	Load Subtotals			70.0 lb/ft	70.0 lb/ft	36.1 lb/ft
	Total Uniform Loads			$w_L = 70.0 \text{ lb/ft}$		$w_D = 36.1 \text{ lb/ft}$
	Combined Total Uniform Load			$w_U = 106.1 \text{ lb/ft}$		

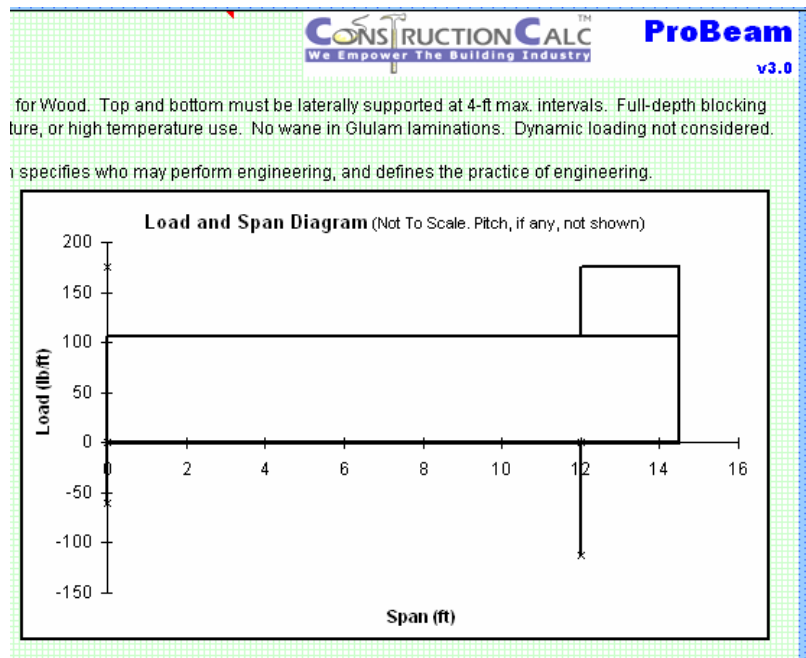
Uniform Loads On Cantilever Only						
	Live Load, psf	Dead Load, psf	Tributary width, ft	Live Load, plf	Dead Load, plf	Comb'd Load, plf
Cant. Load A	35 psf	0 psf	2.00 ft	70.0 lb/ft		70.0 lb/ft
Cant. Load B		Descript'n, opt!:				
Cant. Load C		Descript'n, opt!:				

- a) **Uniform Loads Over the Full Length of Member:** Snow and live load on rafters occurs over their entire length, so we need to use this section. Note, building codes typically require snow load to be doubled at overhangs, so we'll also use another loads section in a minute. Our load is a Roof Load, so under the top two rows enter:

- i) **Live Load:** Roof live load (not snow load – there is a mild difference) comes from workers, their tools and materials, and depends on slope. The red triangle popup note under Live, psf tells us for roof slope between 4:12 and 12:12, the live load should be 16 psf. You could have left this blank since you know that snow load will be greater and thus will control the design (the program automatically uses the greater of live or snow).
- ii) **Dead Load:** Dead load for a composition roof system is about 15 psf (see red triangle popup note under Dead, psf).
- iii) **Snow Load:** Snow load is a type of live load. You typically get this from your building department. In our example we're in an area of light to medium snowfall, so 35 psf is what we'll use.
- iv) **Tributary width** (width perpendicular to the member from which load is applied) is the rafter's spacing in feet, which in our case is 24", or 2'. From a rigorous standpoint, tributary width is actually half the distance from one joist to the next, times 2 (load comes to our joist from each side).

Cool tip: because you're using a ConstructionCalc product, to convert feet to inches, if you enter the following: =24/12 and then press Tab, you'll see 2 displayed automatically. In other words you can do math right in the cell by starting with an equals sign. Try it. Very cool, very powerful.

- b) **Uniform Loads on Cantilever Only:** We need this section to account for the doubled snow load on the overhang.
 - i) We could add uniform load on the cantilever either in psf (pounds per square foot) or plf (pounds per lineal foot) format. We're already working in psf, so we'll stick with that and use the first row, **Cant Load A**.
 - ii) **Live load** for the purposes of this section is our snow load. Remember in the above section, we applied 35 psf over the entire length of the rafter, including the overhang. So now we need to add 35 psf more, which doubles it, but to the overhang only.
 - iii) **Dead load.** Leave blank – dead load isn't doubled, only snow load is. We already accounted for dead load in the above section; we don't want to add it again.
 - iv) **Tributary width.** The tributary (loaded) width on the cantilever is the same as it is over the rest of the member, so we use 2' as before.
 - v) Ignore the other loading sections, we have no point loads, wedge loads, etc.
 - c) **Done.** Click on **Calculate Now** and let's check our results.
- 5) **Check the span and loading:** First, we want to make sure our spans and loading were input correctly, so at the upper right of the screen is a graphic showing both. You can see the main span, cantilever, uniform loads over entire length, and the extra on the cantilever. Yep, it's right.



- a) **Part 3 - Allowable Solutions:** This section shows all the types and sizes of members that will work. We're only interested in 2x material and TJIs so those sections are all we'll look at. Certainly if we wanted to use a glulam, PSL other type of member shown we could.

Minimum Allowable Solutions	<p>4x And Smaller (Lumber)</p> <p>Lumber Material: Douglas Fir-Larch Lumber Grade: No. 2</p> <p>Repetitive Member Use? Yes <input checked="" type="checkbox"/></p> <table border="1"> <caption>Lumber Members</caption> <tr> <td>2 x 10</td> <td>3 x 8</td> </tr> <tr> <td>(2) 2 x 8</td> <td>4 x 8</td> </tr> <tr> <td>(3) 2 x 6</td> <td></td> </tr> </table>	2 x 10	3 x 8	(2) 2 x 8	4 x 8	(3) 2 x 6		<p>5x And Larger (Timbers)</p> <p>Timber Material: Douglas Fir - Larch Timber Grade: WCLIB - No. 2</p> <p>Calculate Now</p> <table border="1"> <caption>Timber Members</caption> <tr> <td>-</td> <td>-</td> <td>-</td> </tr> <tr> <td>6 x 6</td> <td>-</td> <td>-</td> </tr> <tr> <td>-</td> <td>-</td> <td>-</td> </tr> <tr> <td>-</td> <td>-</td> <td>-</td> </tr> </table>	-	-	-	6 x 6	-	-	-	-	-	-	-	-
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	(2) 2 x 8	4 x 8																		
	(3) 2 x 6																			
-	-	-																		
6 x 6	-	-																		
-	-	-																		
-	-	-																		
<p>Glued Laminated Members</p> <p>Glulam Grade: 24F-V4 (DF/DF)</p> <table border="1"> <tr> <td>2.5" x 7.5"</td> <td>5.125" x 6"</td> </tr> <tr> <td>3" x 7.5"</td> <td>6.75" x 7.5"</td> </tr> <tr> <td>3.125" x 6"</td> <td>8.75" x 9"</td> </tr> <tr> <td>5" x 6"</td> <td></td> </tr> </table>	2.5" x 7.5"	5.125" x 6"	3" x 7.5"	6.75" x 7.5"	3.125" x 6"	8.75" x 9"	5" x 6"		<p>2.0E Parallam PSL</p> <table border="1"> <tr> <td>1-3/4" x 9-1/4"</td> <td>5-1/4" x 9-1/4"</td> </tr> <tr> <td>2-11/16" x 9-1/4"</td> <td>7" x 9-1/4"</td> </tr> <tr> <td>3-1/2" x 9-1/4"</td> <td></td> </tr> </table>	1-3/4" x 9-1/4"	5-1/4" x 9-1/4"	2-11/16" x 9-1/4"	7" x 9-1/4"	3-1/2" x 9-1/4"						
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<p>Truss-Joist MacMillan 1.9E LVL-Joists</p> <table border="1"> <tr> <td>1-3/4" x 7-1/4"</td> <td>(3) 1-3/4" x 5-1/2"</td> </tr> <tr> <td>(2) 1-3/4" x 7-1/4"</td> <td></td> </tr> </table>	1-3/4" x 7-1/4"	(3) 1-3/4" x 5-1/2"	(2) 1-3/4" x 7-1/4"		<p>Web Stiffeners? Yes <input checked="" type="checkbox"/></p> <p>Truss-Joist MacMillan I-Joists</p> <table border="1"> <tr> <td>9-1/2" TJI / Pro 150</td> <td>9-1/2" TJI 110</td> </tr> <tr> <td>9-1/2" TJI / Pro 250</td> <td>9-1/2" TJI 210</td> </tr> <tr> <td>11-7/8" TJI / Pro 350</td> <td>9-1/2" TJI 230</td> </tr> <tr> <td>11-7/8" TJI / Pro 550</td> <td>11-7/8" TJI 360</td> </tr> </table>	9-1/2" TJI / Pro 150	9-1/2" TJI 110	9-1/2" TJI / Pro 250	9-1/2" TJI 210	11-7/8" TJI / Pro 350	9-1/2" TJI 230	11-7/8" TJI / Pro 550	11-7/8" TJI 360							
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11-7/8" TJI / Pro 550	11-7/8" TJI 360																			

- b) In the Section **4x and Smaller (Lumber)**, let's select the type of lumber we want. In my neck of the woods, Douglas-Fir Larch is standard, so select that from the dropdown. Also, we know the lumber yard has lots of No 2 grade in stock, so we'll select No 2.
- c) **Repetitive Member Use?** We're designing joists which will be spaced 24" apart and will share the applied load, so we want to select Yes.
- d) We see that 2x10 will work (we could also use double 2x8's and some other odd sizes that show up in the table). Remember, our joist spacing (tributary width) from above is 2'.
- e) In the section Truss-Joist MacMillan I-Joist, we see many options. I like 9.5" TJI-110's. Note that Web Stiffeners are selected, always a good idea.

- f) **Notching.** How do you notch an I-Joist? You don't. See your local TJI representative for connection details. I would probably use a hanger at the ridge beam and ripped wood filler pieces top and bottom.

What about notching in the case of a 2x? Notching reduces a member's **shear** resistance. ProBeam assumes no notching, but what if you do anyway? I'm getting ahead of myself, but check your Final Member Results. You can see that shear overdesign is 218.9%. With that kind of extra shear capacity, I wouldn't worry about a small notch at the top and / or bottom. If shear overdesign was 30% or less, then I would be very careful about how much I notched, if any.

Final Member Results	
Bending Overdesign:	25.9%
Shear Overdesign:	218.9%
Deflection Overdesign:	25.6%
Bearing / Buckling Overdsgn:	N/A
Final member makes it by: 25.6%	
Controlling criteria is: Deflection	

- 6) **Part 4 - Final Selection.** We could stop at this point knowing a 2x10, DF #2 works, but let's continue and see how efficient that member is.

Final Member:		Final Member Results	
Final Member:	Sawn Wood	Bending Overdesign:	25.9%
Beam Library:	Choose From Min. Sizes That Calc.	Shear Overdesign:	218.9%
Final Size:	2x10	Deflection Overdesign:	25.6%
Min. Bearing Lengths:	= 1.50 in. (Left) := 1.50 in. (Right)	Bearing / Buckling Overdsgn:	N/A
Vert Diff (approx):	9.67 ft	Final member okay by: 25.6%	
Actual Member Size:	1.50" x 9.25" 17.43 ft	Controlling criteria is: Deflection	
Reactions		Final Member Additional Information	
Maximums	R ₁ - Left R ₂ - Right	Location	Live Case
Live Load:	402 lb 806 lb	Max. Positive Moment:	1,853 ft-lb 5.88 ft Main Span
Dead Load:	207 lb 316 lb	Max. Negative Moment:	-550 ft-lb 12.00 ft On Cant.
Total Load:	609 lb 1,122 lb	Max Design Shear:	600 lb 12.00 ft Both
Live Case Causing Max	Main Span Both	Main Span Max. Downward Deflection (Live / Total)	0.248" / 0.362" 6.00' / 6.00' Main / Main
Minimums	R ₁ - Left R ₂ - Right	Main Span Max. Upward Deflection (Live / Total)	0.053" / 0.000" 6.96' / 0.00' Cant. / Main
Live Load:	0 lb 386 lb	Cant. Down. Defl. (Live / Tot)	0.066" / 0.000" 14.50' / 13.20' Cant. / Cant.
0.6 or 1.0 Dead :	120 lb 166 lb	Cant. Up. Defl. (Live / Tot)	0.165" / 0.233" 14.50' / 14.50' Main / Main
Net Reaction	120 lb 552 lb	Req'd El, Not Incl. Self Wt.:	1.261E+08 Actual El.: 1.583E+08
Live Case Causing Min	On Cant. On Cant.	Approx. Self Weight:	N/A Approx. Tot. Wt.: N/A
		Min. Calc'd Bearing Lengths:	= 0.65 in (Left) = 1.20 in (Right)

- Final Member:** We want to use Doug Fir Larch No. 2, which is Sawn Wood.
- Beam Library:** We want to choose from members that calc (meet code). Note, this dropdown allows us to choose any member whether it calcs or not. This can be useful at times to see how close or far a particular member comes to making it.
- Final Size:** Select 2x10 from the dropdown. When you do it is shown in large font to the right.
- Minimum Bearing Length:** This tells you how much joist length is needed for bearing at each end. Left is the ridge and right is the lower wall (remember, with ProBeam, cantilever is always on the right). In our case, each bearing point can be the code minimum 1.5" long, so a hanger at the ridge would work fine. If you chose to notch, you'd have to use a 1.5" notch.

- e) **Vert Diff (approx) and True Len (approx):** The vertical elevation difference from end to end and the member's true length are given. These are "approximate" because they are calculated from your input span, which could be inside to inside, center of bearing, or outside of bearing distances. For non-sloped members, the Vert Diff will be zero and the True Len will be the input span(s).
- f) **Bracing / Blocking Req'd For Stability.** This red note appears when you're designing a cantilever. It is just a reminder that cantilevers have different stresses than non-cantilevers and blocking is particularly important with them.
- g) **Final Member Results:** this section shows by how much the selected member calcs for the four code-required design criteria. Usually, I just look at the bold sentence that says in our case: **This member makes it by 25.6%.** A good safe design.
- h) **Reactions.** This section shows reactions, which are the downward forces brought by our Final Member to the members on which it bears – the ridge beam at top, left, and double top plate at bottom, right. Remember, with ProBeam the cantilever end is always on the right. Note that Maximum and Minimum reactions are shown. Sometimes with cantilevers, Minimums will be negative, indicating uplift and the need for holdown strapping.
- i) **Final Member Additional Information.** This section shows a bunch of engineering information that may or may not be of interest to you.
- j) **Printout.** You may want to print this design. Because this ConstructionCalc product is nothing more than a fancy Excel spreadsheet, you have lots of printing options via File, Page Setup. Also, you can hide various parts of the display via the ConstructionCalc **Hide / Show Loads** and **Miscellaneous** dropdowns at the top of the page.