



for WINDOWS™

6.0 TUTORIAL

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1. TUTORIAL

1.1 INTRODUCTION

This tutorial is intended for the first time user of StruCalc, or for any user who needs a review on how the program works. In addition, this tutorial is intended to illustrate the ease in which StruCalc can be used to design structural members.

We will be designing several structural members found in a typical residence using the 2000 International Building Code. See figure 2-1. First we will design the roof framing members and then we will systematically work our way through the floor framing and then down to the footings.

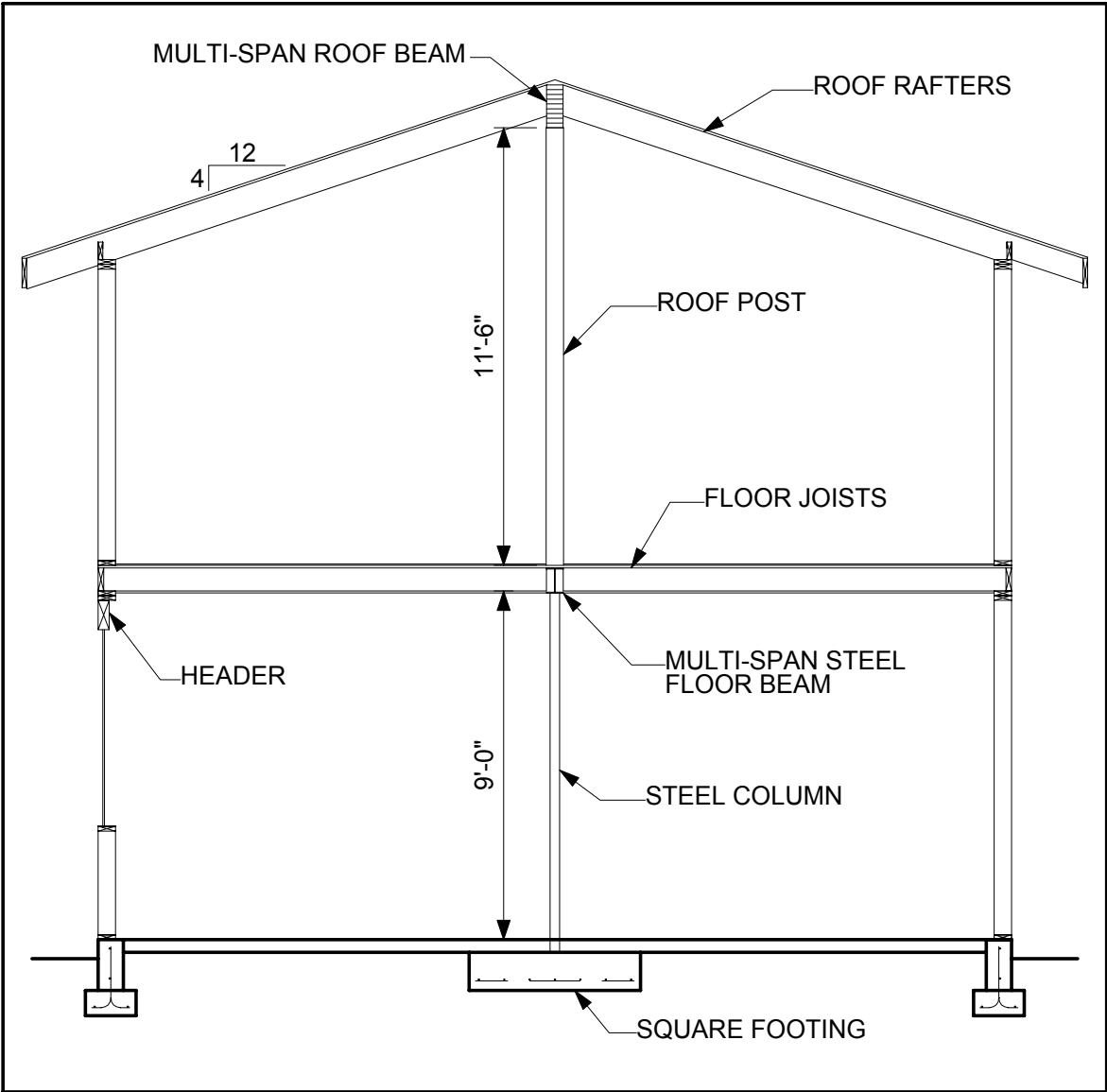


FIGURE 2-1 STRUCTURAL SECTION

1.2 ROOF FRAMING DESIGN

To start off the structural analysis of the residence we will design three roof framing members: the roof rafters, a continuous roof beam, and a wood post. See figure 2-2

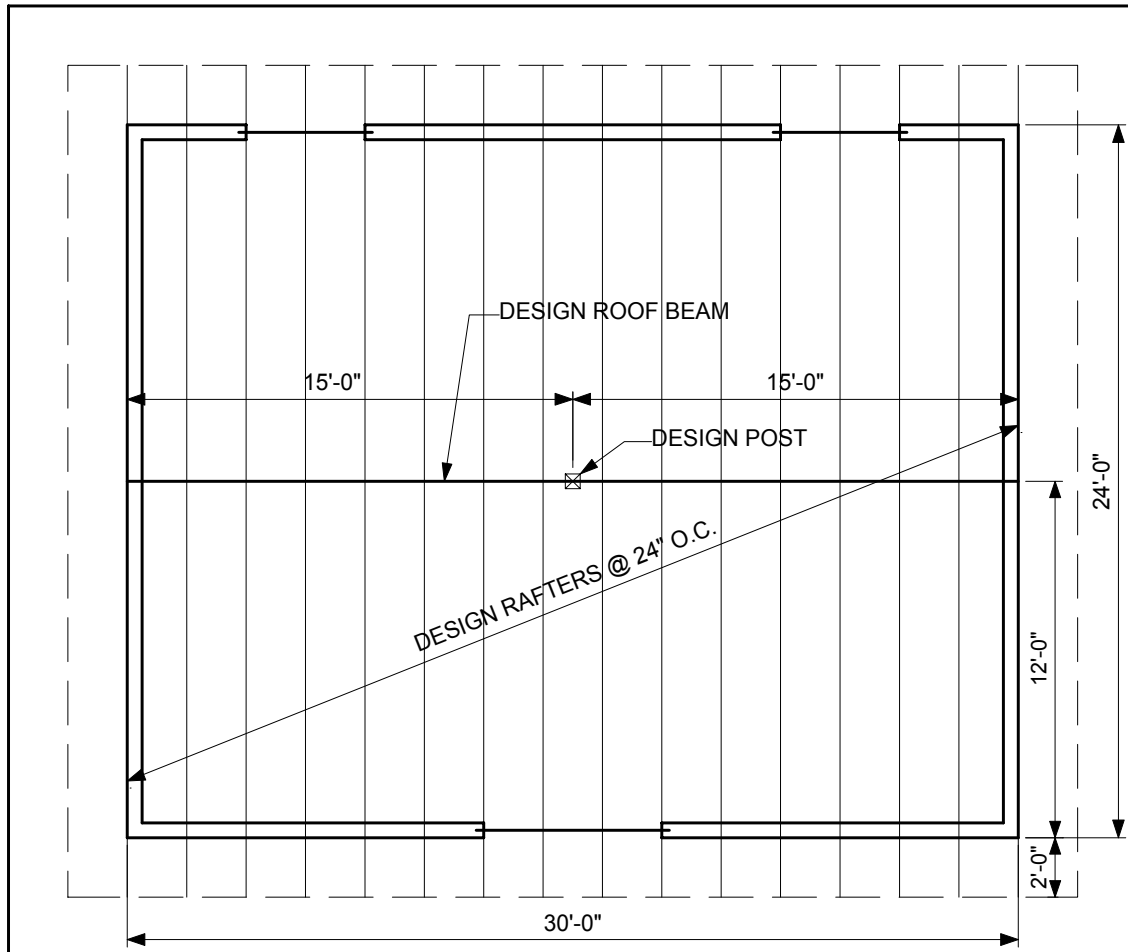


FIGURE 2-2 ROOF FRAMING PLAN

1.2.1 ROOF RAFTER DESIGN

The interior span length of the roof rafters in figure 2-2 is 12 feet and the eave span length is two feet. The unbraced length of the rafters is zero, because the rafters are continuously supported by the roof sheathing. The roof dead load is the combined weight of the roofing materials and the rafters, in this situation it is 15 pounds per square foot. The region and applicable building code determine the roof live load, for this case it will be 25 pounds per square foot. (snow zone)

To design the rafters using StruCalc perform the following steps:

1. Start **StruCalc 6.0 for Windows**.

2.  Click the **Roof Rafter** button.

3. Change the **Member Toolbar** to the following:

Dry	Solid Sawn	Douglas Fir-Larch	#2	Dimensional Lumber
-----	------------	-------------------	----	--------------------

4. Change the **Section Toolbar** to the following:

1	-	1.5	By	5.5	@	24	In. O.C.	Stress Values
---	---	-----	----	-----	---	----	----------	---------------

5. Change the **Roof Rafter Module** inputs to the following (note that you can quickly move through the input boxes by pressing the tab key):

Roof Rafter [2000 International Building Code (97 NDS)]	
Project	TUTORIAL
Location	ROOF RAFTERS
Interior Span Length	12 ft
Eave Span Length	2 ft
Roof Pitch	4 :12
Roof Live Load	25 psf
Roof Dead Load	15 psf
Peak Notch Depth	0 in
Base Notch Depth	0 in
<input checked="" type="checkbox"/> Snow <input type="checkbox"/> Non-snow	
<input checked="" type="checkbox"/> Check Unbalanced Loads	
<input type="checkbox"/> Apply Incising Factor	
<input checked="" type="checkbox"/> Bracing Applied to Bottom of Rafters	
<input checked="" type="checkbox"/> Double Live Load on Eave	

6.  Click the **Calculate** button or *press* Enter.

The design is inadequate.

Inadequate By 38.2 % Controlling Factor: Moment of Inertia / Depth Required 6.34 In Click for more info. >>>
--

7.  Click the **Autosize** button.

- Highlight the #2 grade name and click the **AutoSize** button.

AutoSize- Roof Rafter[2000 International Building Code [97 NDS]]

Solid Sawn Douglas Fir-Larch

Choose one or more and click AutoSize Section Required

Select Structural

#1	
#2	

Buttons: AutoSize, Select and Return, Cancel, Exit

- Highlight the 5th entry and click **Select and Return**.

AutoSize- Roof Rafter[2000 International Building Code [97 NDS]]

Solid Sawn Douglas Fir-Larch

Choose one and click Select and Return Section Required

#2	1.5 x 5.5 @ 8
#2	1.5 x 5.5 @ 12
#2	1.5 x 5.5 @ 16
#2	1.5 x 7.25 @ 19.2
#2	1.5 x 7.25 @ 24
#2	1.5 x 9.25 @ 32
#2	3.5 x 5.5 @ 8
#2	3.5 x 5.5 @ 12
#2	3.5 x 5.5 @ 16
#2	3.5 x 5.5 @ 19.2
#2	3.5 x 5.5 @ 24
#2	3.5 x 5.5 @ 32

Buttons: AutoSize, Select and Return, Cancel, Exit

The design is adequate.

Adequate By 8.8 % Controlling Factor: Section Modulus / Depth Required 6.95 In

1.2.2 MULTI-SPAN ROOF BEAM DESIGN

The length of the continuous beam in the center of the roof system is 30 feet. See figure 2-2. The beam is supported at the midpoint and therefore has two equal spans of 15 feet. The unbraced length of the top of the beam is two feet, because the roof rafters at that spacing laterally support the beam. The unbraced length of the bottom of the beam is the distance between supports. The roof dead load is the combined weight of the roofing materials and the rafters and in this situation is 15 pounds per square foot. Beam self-weight is taken into account by the program. The region and applicable building code determine the roof live load, for this case it will be 25 pounds per square foot (snow zone). The beam is supporting a roof tributary width of six feet on both sides and the roof pitch is 4:12.

To design this beam using StruCalc perform the following steps:


1.  Click the **Multi-Span Roof Beam** button.
2. Change the **Member Toolbar** to the following:

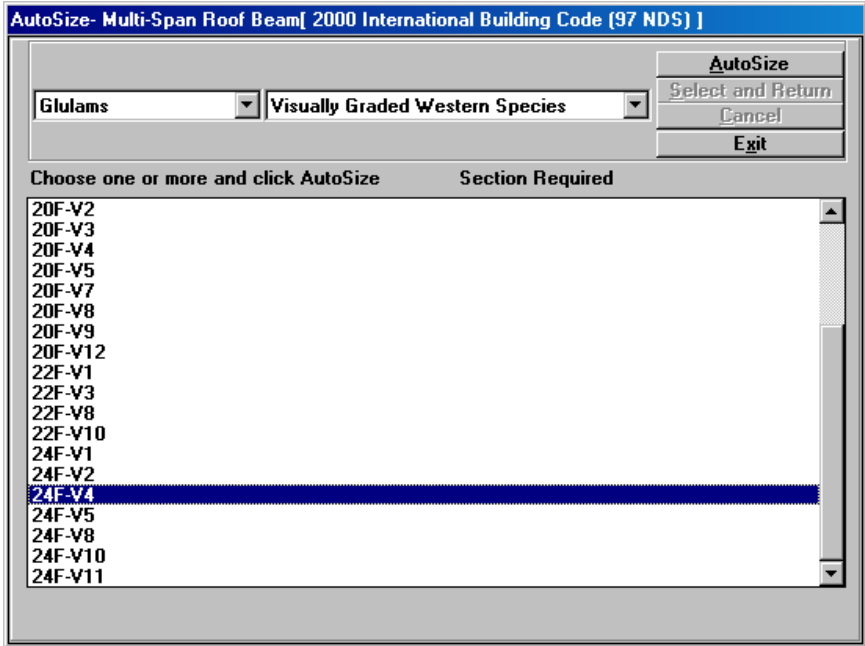
Dry	Glulams	Visually Graded Western Species	16F-V1	Glulam
-----	---------	---------------------------------	--------	--------

Note: In this case we have chosen to use an unbalanced glulam, 24F-V4, for a multi-span situation. Generally, we would choose a balanced glulam, 24F-V8, for a multi-span situation because it is much more efficient. However, when designing glulam beams for small projects, the cost of a 24F-V8 and the time it takes to get one (lumber yards usually have to special order them) is often times not justified.

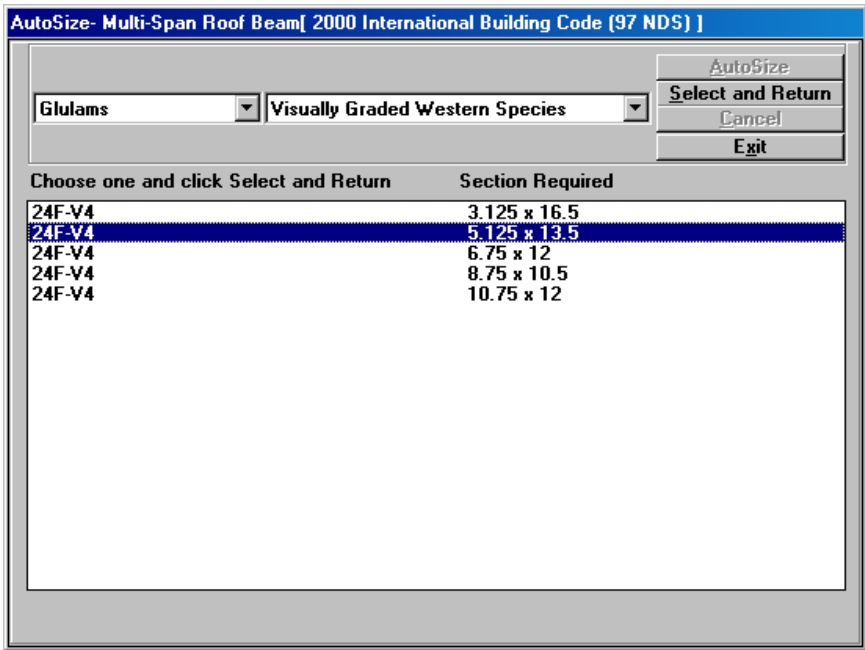
3. Change the **Multi-Span Roof Beam Module** to the following:

Multi-Span Roof Beam [2000 International Building Code (97 NDS)]				
Project	Location			
Span Length	Left Cantilever <input type="checkbox"/>	Left Span 15 ft	Center Span 15 ft	Right Span 0 ft
Unbraced Length-Top		2 ft	2 ft	0 ft
Unbraced Length-Bottom		15 ft	15 ft	0 ft
				Roof Pitch: 4 :12
Roof Live Load		25 psf	25 psf	0 psf
Roof Dead Load		15 psf	15 psf	0 psf
Roof Tributary Width-Side One		6 ft	6 ft	0 ft
Roof Tributary Width-Side Two		6 ft	6 ft	0 ft
Point Live Load		0 lb	0 lb	0 lb
Point Dead Load		0 lb	0 lb	0 lb
Point Load Location		0 ft	0 ft	0 ft
Wall Load		0 plf	0 plf	0 plf
<input checked="" type="radio"/> Snow <input type="radio"/> Non-snow	<input checked="" type="checkbox"/> Check Unbalanced Loads <input type="checkbox"/> Apply the Incising Factor			

4.  Click the **Autosize** button.
5. *Highlight* the 24F-V4 grade name and *click* the **Autosize** button.



6. Highlight the 2nd entry and click **Select and Return**.



The design is adequate.

Adequate By 23.7 % Controlling Factor: Section Modulus / Depth Required 12.14 In

1.2.3 ROOF COLUMN DESIGN

The length of the column supporting the multi-span roof beam is approximately 11 ½ feet. See figure 2-1. The unbraced length is 11 ½ feet in both the X and Y direction. For this design we will assume a pinned-pinned condition, therefore K_e is equal to one. The live (snow) load on the column is 5625 lbs and the dead load is 3873 lbs as shown in figure 2-3 below under Reactions “Line B”. The load eccentricity is zero in both directions and the duration factor is 1.15 due to the roof snow load.

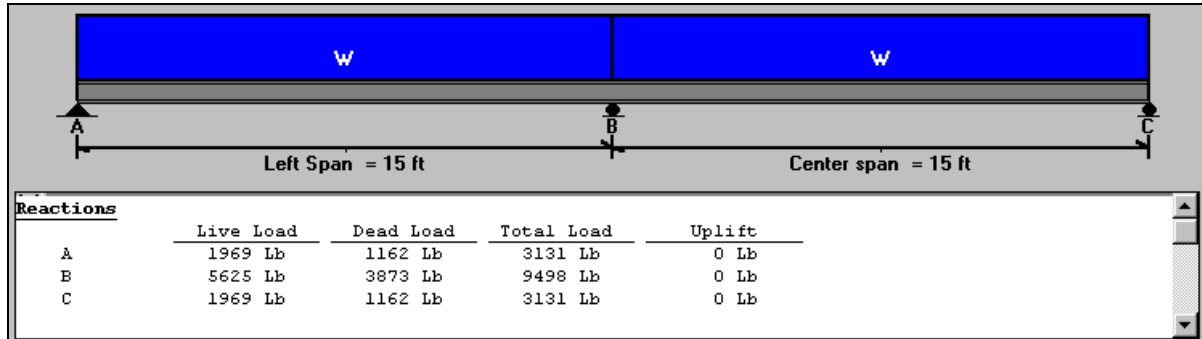



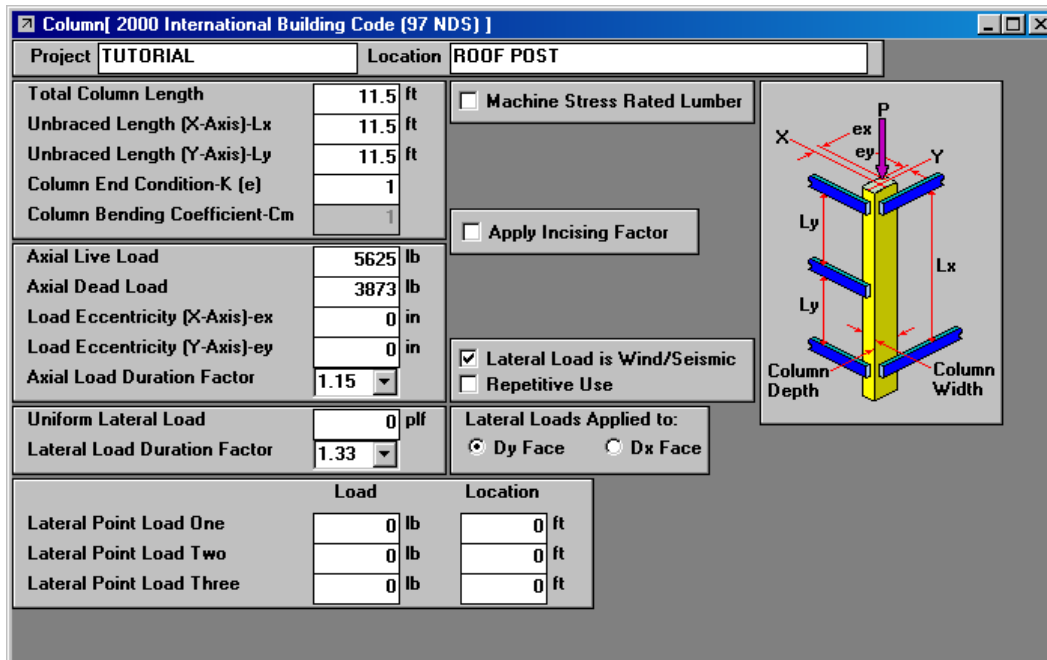
FIGURE 2-3 MULTI-SPAN ROOF BEAM LOADING DIAGRAM


To design this column using StruCalc perform the following steps:

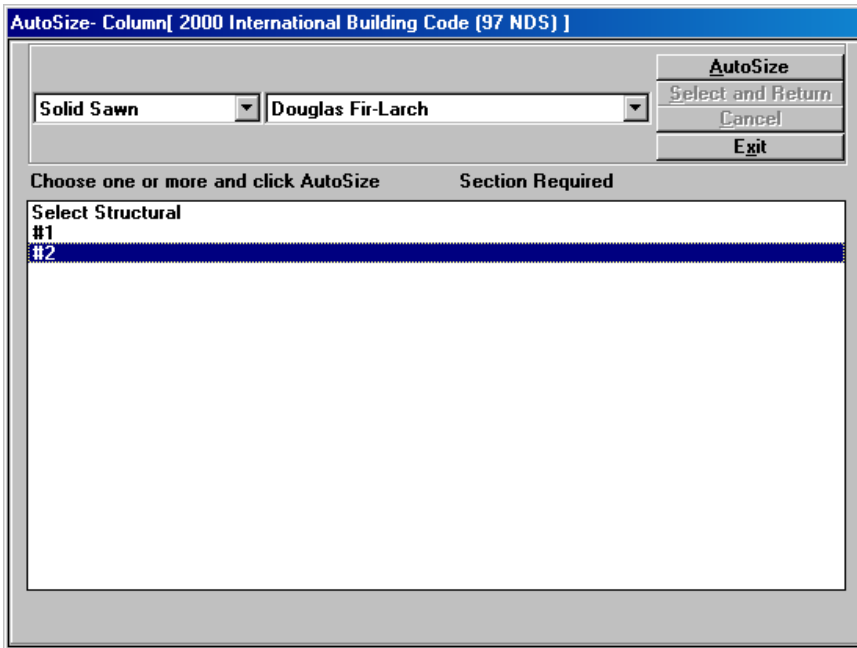
1.  Click the **Column** button.
2. Change the **Member Toolbar** to the following:



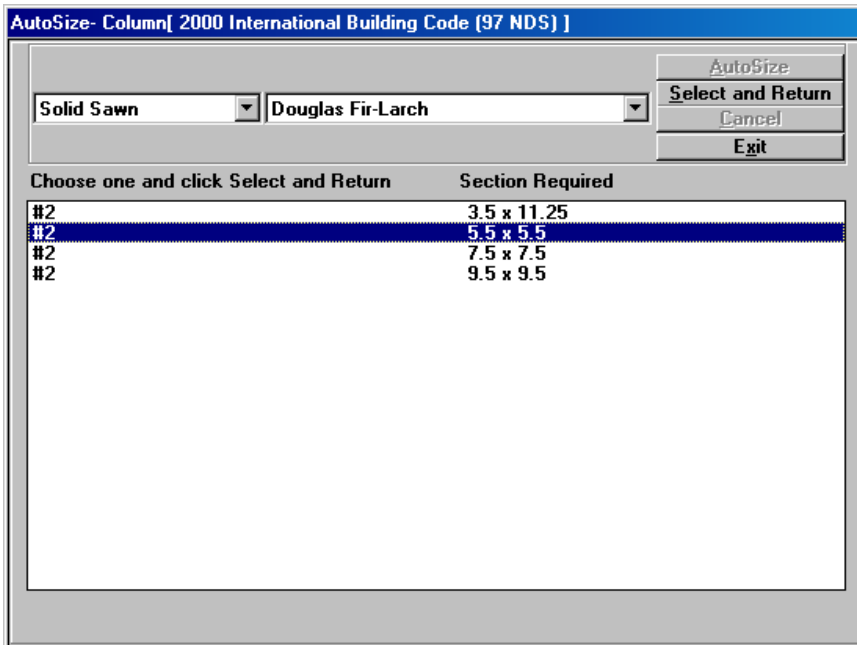
3. Change the **Column Module** to the following:



4.  Click the **Autosize** button.
5. Highlight the #2 grade name and click the **Autosize** button.



6. Highlight the 2nd entry and click **Select and Return**.



The design is adequate:



Congratulations! You have finished designing the roof members now move on to the floor framing.

1.3 FLOOR FRAMING DESIGN

Now we will design four floor framing members: the floor joists, a header, a continuous steel floor beam, and a steel column. See figure 2-4 below.

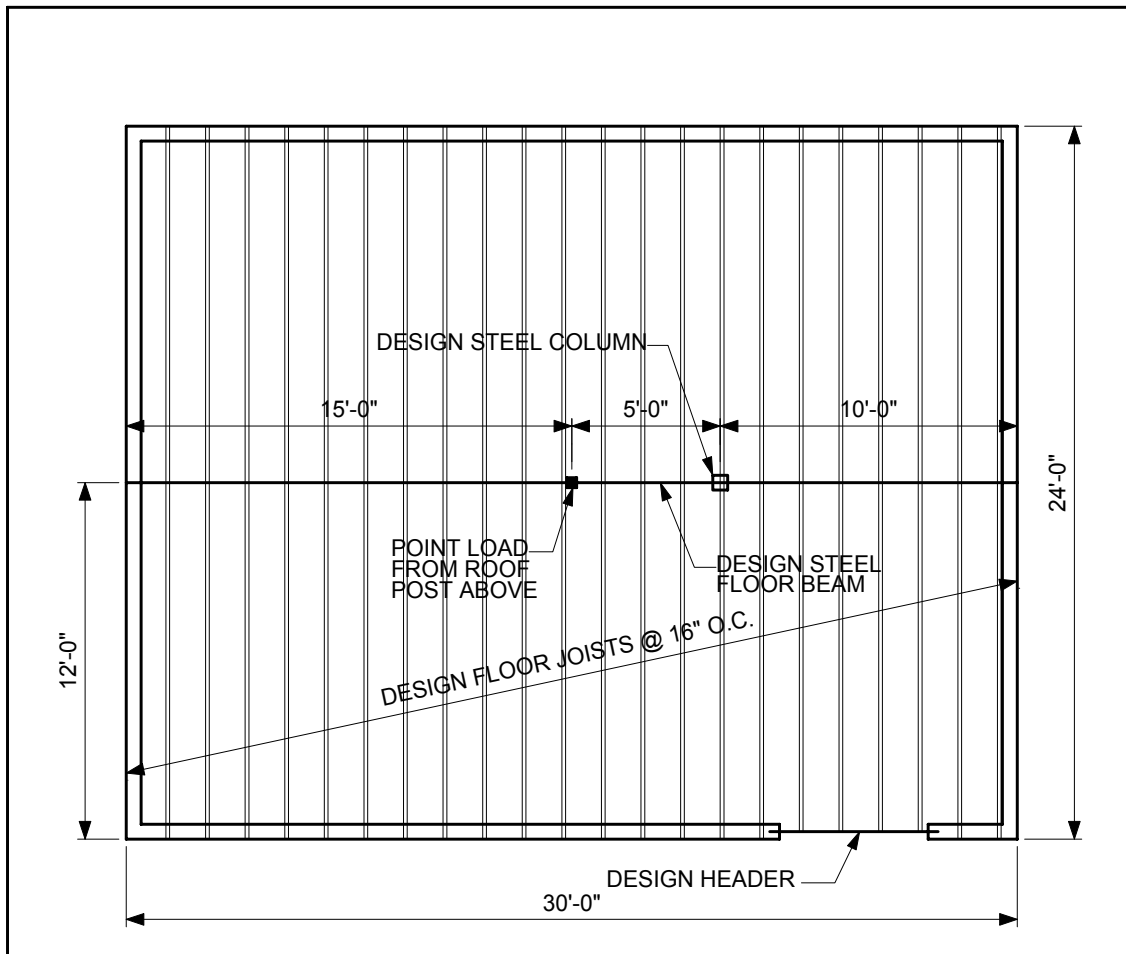


FIGURE 2-4 UPPER FLOOR FRAMING PLAN

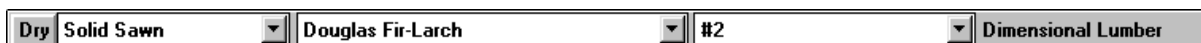
1.3.1 FLOOR JOIST DESIGN

The span length of the floor joists in figure 2-4 is 12 feet. The unbraced length of the floor joists is zero, because the joists are continuously supported by the floor sheathing. Gypsum wallboard will be applied to the bottom of the joists therefore the bottom of the joists will be fully braced. The floor dead load is the combined weight of the floor materials and the joists, in this situation it is 15 pounds per square foot. The applicable building code determines the floor live load, for this case it will be 40 pounds per square foot.

To design the floor joists using StruCalc perform the following steps:

1.  Click the **Floor Joist** button.

2. Change the **Member Toolbar** to the following:



- Change the **Floor Joist Module** to the following:


Floor Joist[2000 International Building Code (97 NDS)]

Project: TUTORIAL Location: FLOOR JOISTS

	Left Span	Center Span	Right Span
Span Length	0 ft	12 ft	0 ft
Floor Live Load	0 psf	40 psf	0 psf
Floor Dead Load	0 psf	15 psf	0 psf
Wall Live Load (Perp. to Joists)	0 plf	0 plf	0 plf
Wall Dead Load (Perp. to Joists)	0 plf	0 plf	0 plf
Wall Load Location	0 ft	0 ft	0 ft
Partially Distributed Live Load	0 psf	0 psf	0 psf
Partially Distributed Dead Load	0 psf	0 psf	0 psf
Partially Distributed Load Start	0 ft	0 ft	0 ft
Partially Distributed Load End	0 ft	0 ft	0 ft

Glued and Screwed Plywood 3/4" in
 Code Req'd Concentrated Load 0 lb
 Bracing Applied to Bottom of Joists

Check Unbalanced Loads
 Apply Incising Factor

-  Click the **Autosize** button.
- Highlight the #2 grade name and click the **Autosize** button.

AutoSize- Floor Joist[2000 International Building Code (97 NDS)]

Solid Sawn Douglas Fir-Larch

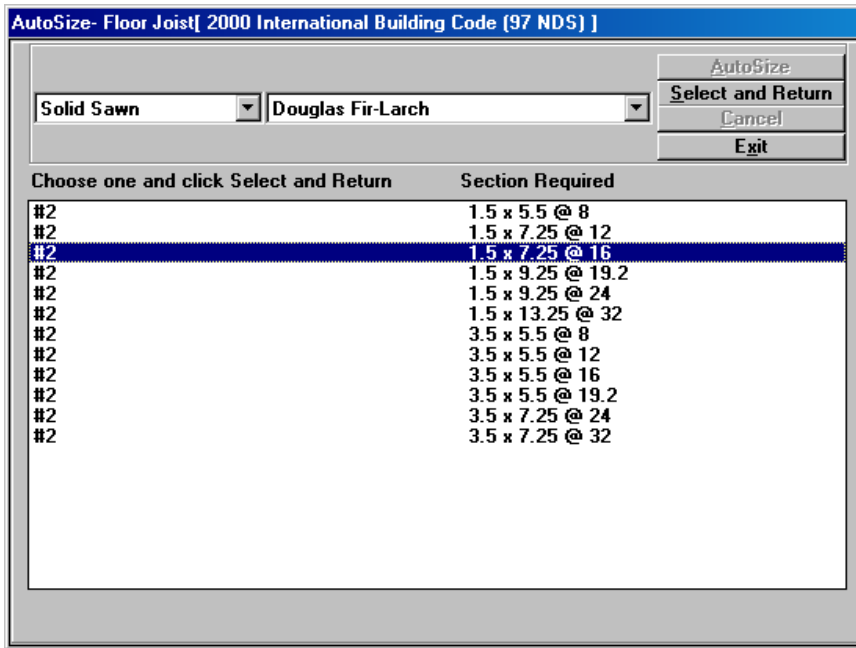
Choose one or more and click AutoSize Section Required

Select Structural

- #1
- #2

Buttons: AutoSize, Select and Return, Cancel, Exit

6. Highlight the 2nd entry and click **Select and Return**.



The design is adequate



1.3.2 HEADER DESIGN


The length of the header in figure 2-4 is five feet six inches long. The unbraced length at the top of the header is 16 inches, the same as the joist spacing. Note: If there were a knee wall above the header, then the unbraced length would be the distance between supports, not 16 inches on center. The unbraced length of the bottom of the header is the distance between supports. The floor dead load is the combined weight of the floor materials and the joists, in this situation it is 15 pounds per square foot. Beam self-weight is taken into account by the program. The applicable building code determines the floor live load, for this case it will be 40 pounds per square foot. The header is supporting a floor tributary width of six feet. The roof live load and dead load is 25 psf and 15 psf, respectively. The header is supporting a roof tributary width of 8.17 feet as shown in figure 2-5 under "Lower Equiv. Tributary Width". The roof pitch is 4:12. The wall above the header is eight feet tall and it weighs approximately 10 psf/per foot of wall height, therefore the total wall load on the header is 80 plf.

Note: Additional load is transferred to the lower bearing support when roof rafters have cantilevered eaves. StruCalc automatically calculates this additional load in terms of tributary width so that it can be conveniently entered into the beam modules. In this case, the equivalent tributary width (8.17') is only .17' longer than the actual tributary width (8') and therefore will make little difference in the rafter design. However, in some cases the additional load transferred to the lower bearing support because of cantilevered rafters is substantial therefore it is important to check the lower equivalent tributary width of each rafter design.

Project: TUTORIAL - Location: ROOF RAFTERS			
Summary:			
1.5 IN x 7.25 IN x 14.0 FT (12 + 2) @ 24 O.C. / #2 - Douglas Fir-Larch - Dry Use			
Section Adequate By: 8.8% Controlling Factor: Section Modulus / Depth Required 6.95 In			
Interior Span Deflections:			
Dead Load:	DLD-Interior=	0.20	IN
Live Load:	LLD-Interior=	0.34	IN = L/446
Total Load:	TLD-Interior=	0.54	IN = L/281
Eave Deflections (Positive Deflections used for design):			
Dead Load:	DLD-Eave=	0.00	IN
Live Load:	LLD-Eave=	0.05	IN = 2L/1116
Total Load:	TLD-Eave=	0.00	IN = 2L/50596440
Rafter End Loads and Reactions:			
	LOADS:	RXNS:	
Upper Live Load:	150 PLF	300 LB	
Upper Dead Load:	92 PLF	184 LB	
Upper Total Load:	242 PLF	484 LB	
Lower Live Load:	258 PLF	517 LB	
Lower Dead Load:	129 PLF	258 LB	
Lower Total Load:	387 PLF	775 LB	
Upper Equiv. Tributary Width:	UTWeq=	6.0	FT
Lower Equiv. Tributary Width:	LTWeq=	8.17	FT

FIGURE 2-5 ROOF RAFTER PRINTOUT

To design the header using StruCalc perform the following steps:

1.  Click the **Combination Roof and Floor Beam** button.
2. Change the **Member Toolbar** to the following:

Dry	Solid Sawn	Douglas Fir-Larch	#2	Dimensional Lumber
-----	------------	-------------------	----	--------------------

3. Change the **Combination Roof and Floor Beam** module to the following:

Competition Roof and Floor Beam [2000 International Building Code [97 NDS]]			
Project	TUTORIAL	Location	HEADER
Span Length	5.5 ft	<input type="checkbox"/> Apply Incising Factor	
Unbraced Length-Top	1.33 ft		
	Side One	Side Two	
Roof Live Load	25 psf	25 psf	<input checked="" type="radio"/> Snow
Roof Dead Load	15 psf	15 psf	<input type="radio"/> Non-snow
Tributary Width	8.17 ft	0 ft	
Roof Pitch	4 : 12		
Roof Duration Factor	1.15		
	Side One	Side Two	<input type="checkbox"/> Area Reduction Allowed
Floor Live Load	40 psf	40 psf	
Floor Dead Load	15 psf	15 psf	
Tributary Width	6 ft	0 ft	
Floor Duration Factor	1.00		
Wall Load	80 plf		

4.  Click the **Autosize** button.

- Highlight the #2 grade name and click the **Autosize** button.

AutoSize- Combination Roof and Floor Beam[2000 International Building Code (97 NDS)]

Solid Sawn Douglas Fir-Larch

AutoSize
Select and Return
Cancel
Exit

Choose one or more and click AutoSize Section Required

Select Structural

#1
#2

- Highlight the 1st entry and click **Select and Return**.

AutoSize- Combination Roof and Floor Beam[2000 International Building Code (97 NDS)]

Solid Sawn Douglas Fir-Larch

AutoSize
Select and Return
Cancel
Exit

Choose one and click Select and Return Section Required

#2	(1) 1.5 x 13.25
#2	(1) 3.5 x 7.25
#2	(1) 5.5 x 7.5
#2	(2) 1.5 x 9.25
#2	(3) 1.5 x 5.5
#2	(4) 1.5 x 5.5

The design is adequate

Adequate By 12.1 % Controlling Factor: Area / Depth Required 6.59 In █

1.3.3 MULTI-SPAN STEEL FLOOR BEAM DESIGN

The length of the continuous beam in the center of the floor system in figure 2-4 is 30 feet. A column supports the beam 20 feet from the left side of the residence. The beam consists of two spans: 20 feet and 10 feet. The unbraced length at the top of the beam is 16 inches because the floor joists provide lateral support at that spacing. The unbraced length at the bottom of the beam is the distance between supports. The floor dead load is the combined weight of the floor materials and the joists, in this situation it is 15 pounds per square foot. The beam self-weight is taken into account by the program. The applicable building code determines the uniform floor live load, for this case it will be 40 pounds per square foot. There is a point load on the beam 15 feet from the left support. See figure 2-4. The live (snow) load is 5625 lbs and the dead load is 3970 lbs as shown in figure 2-6 below under “Vertical Reactions”.

Project: TUTORIAL - Location: ROOF POST			
Summary:			
5.5 IN x 5.5 IN x 11.5 FT / #2 - Douglas Fir-Larch - Dry Use			
Section Adequate By: 33.8%			
Vertical Reactions:			
Live:	Vert-LL-Rxn=	5625	LB
Dead:	Vert-DL-Rxn=	3970	LB
Total:	Vert-TL-Rxn=	9595	LB

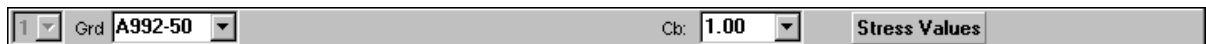
FIGURE 2-6 ROOF POST PRINTOUT

To design this beam using StruCalc perform the following steps:

1.  Click the **Multi-Span Floor Beam** button.
2. Change the **Member Toolbar** to the following:




3. Change the **Material Toolbar** to the following:



- Change the **Multi-Span Floor Beam Module** to the following:

Project		Location	
TUTORIAL		MULTI-SPAN STEEL FLOOR BEAM	
Span Length	Left Cantilever <input type="checkbox"/>	Left Span	Center Span
		20 ft	10 ft
			Right Span
			0 ft
Unbraced Length-Top		1.33 ft	1.33 ft
Unbraced Length-Bottom		20 ft	10 ft
Floor Live Load		40 psf	40 psf
Floor Dead Load		15 psf	15 psf
Floor Tributary Width-Side One		6 ft	6 ft
Floor Tributary Width-Side Two		6 ft	6 ft
Point Live Load		5625 lb	0 lb
Point Dead Load		3970 lb	0 lb
Point Load Location		15 ft	0 ft
Wall Load		0 plf	0 plf

Area Reduction Allowed Check Unbalanced Loads

-  Click the **Autosize** button.
- Highlight W8, W10, and W12 shapes and click the **Autosize** button.

AutoSize- Multi-Span Floor Beam [AISC 9th Ed ASD]

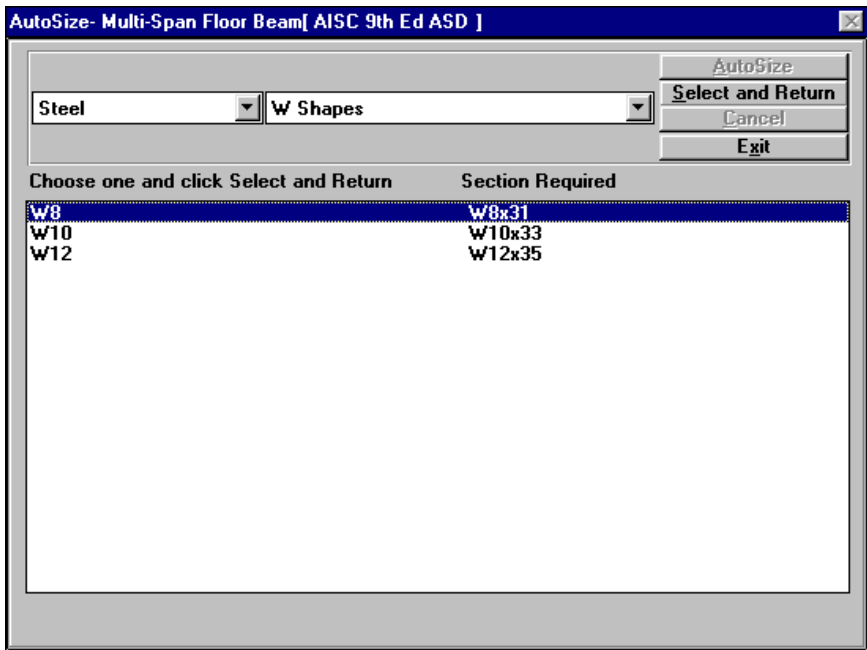
Steel W Shapes

Choose one or more and click AutoSize Section Required

- W4
- W5
- W6
- W8
- W10
- W12
- W14
- W16
- W18
- W21
- W24
- W27
- W30
- W33
- W36
- W40

AutoSize Select and Return Cancel Exit

7. Highlight the 1st entry and click **Select and Return**.



The design is adequate



1.3.4 STEEL COLUMN DESIGN

The length of the column supporting the multi-span floor beam is approximately nine feet. See figure 2-1. The unbraced length of the column is nine feet in both the X and Y direction. For this column design we will assume a pinned-pinned condition, therefore K_e is equal to one. The exact column bending coefficient (C_m) may be calculated or it may be assumed to be equal to one, which is a conservative assumption. In this case we will assume that C_m is equal to one. The live load on the column is 15964 lbs and the dead load is 8632 lbs as shown in figure 2-7 under Reactions "Line B". The load eccentricity on the post is zero in both directions. However it is recommended that a minimum eccentricity of one inch or $1/10^{\text{th}}$ of the member dimension be used, whichever is greater. In this situation we will assume an eccentricity of $1/2$ " in both directions to be conservative. Note that eccentricity will significantly affect the column design, however its inclusion is not required by any of the building codes. The duration factor of the loads on the column is 1.00.

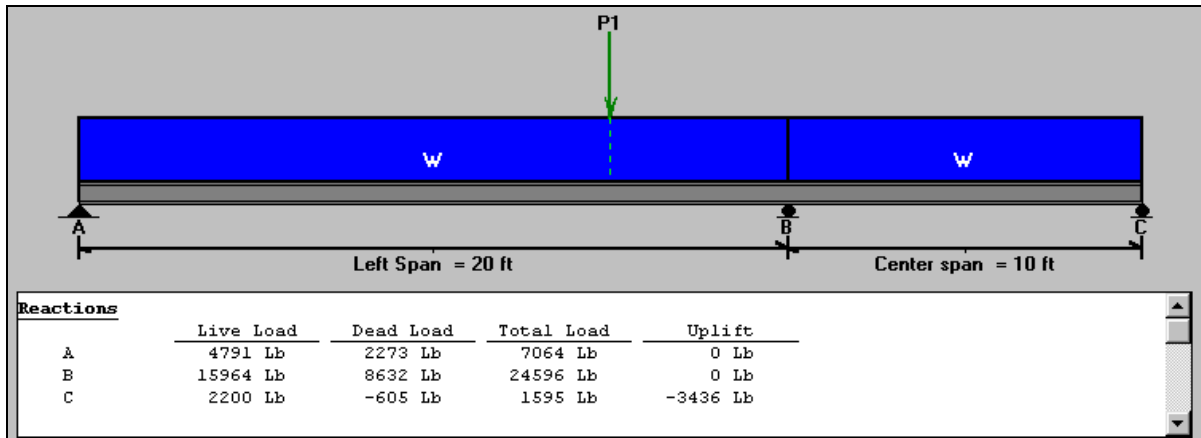



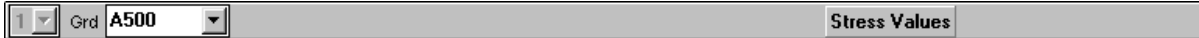
FIGURE 2-7 MULTI-SPAN FLOOR BEAM LOADING DIAGRAM

To design this column using StruCalc perform the following steps:

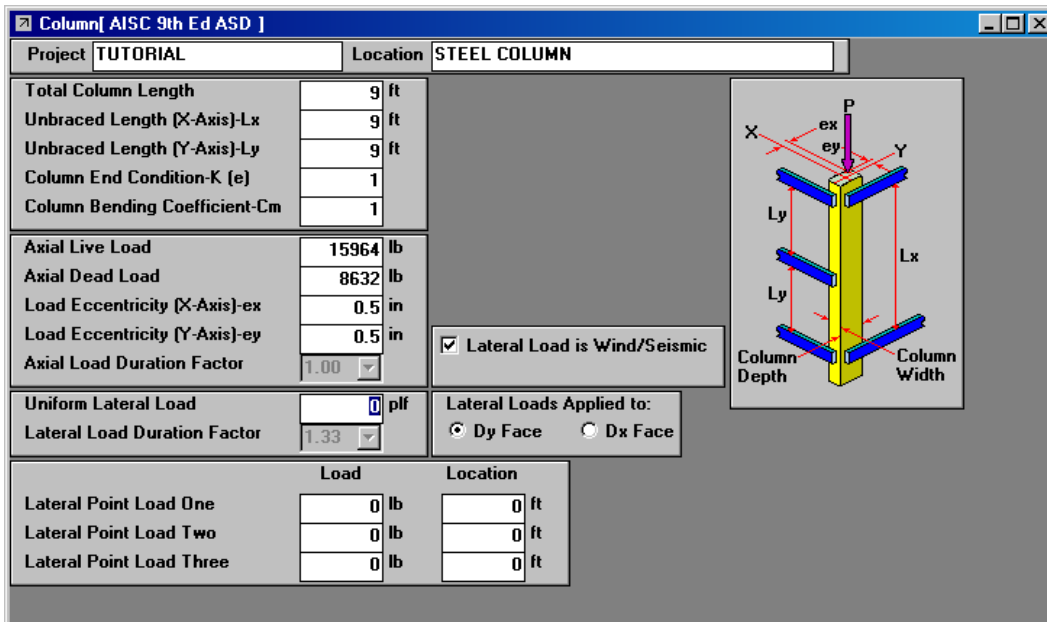
1.  Click the **Column** button.
2. Change the **Member Toolbar** to the following:



3. Change the **Material Toolbar** to the following:

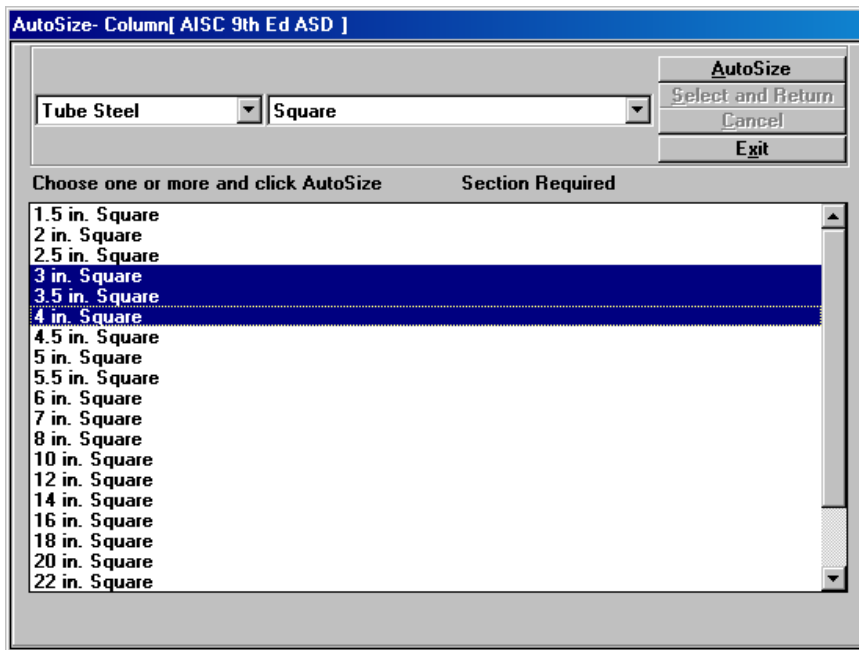


4. Change the **Column Module** to the following:

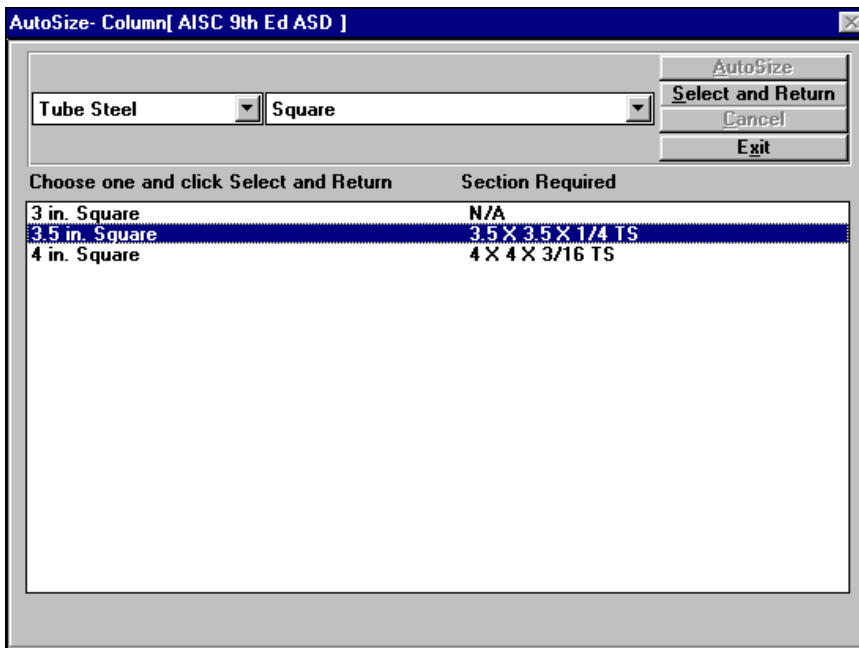


5.  Click the **Autosize** button.

6. Highlight 3 in., 3.5 in., and 4 in. Square and click the **Autosize** button.



7. Highlight the 2nd entry and click **Select and Return**.



The design is adequate



Congratulations! You have finished designing the floor framing members of the residence in this tutorial.

1.4 FOUNDATION DESIGN

To finish off this tutorial we will size a square footing to support the steel column that we just designed.



1.4.1 SQUARE FOOTING DESIGN

The footing is supporting a 3 1/2" x 3 1/2" x 1/4" tube steel column. The baseplate is a 9" x 9" x 1/2" steel plate. The allowable soil bearing pressure in this case is 1500 psf. The live load and dead load on the footing are 15964 lbs and 8727 lbs, respectively. See figure 2-8. The concrete compressive strength used in this design is 2500 psi, therefore no special inspection is required. The steel reinforcement bars are #4's with a yield strength of 40000psi.

Project: TUTORIAL - Location: STEEL COLUMN			
Summary:			
3.5 X 3.5 X 1/4 TS -ASTM A500 x 9.0 FT			
Section Adequate By: 8.4%			
Vertical Reactions:			
Live:		Vert-LL-Rxn=	15964 LB
Dead:		Vert-DL-Rxn=	8727 LB
Total:		Vert-TL-Rxn=	24691 LB

FIGURE 2-8 STEEL COLUMN PRINTOUT

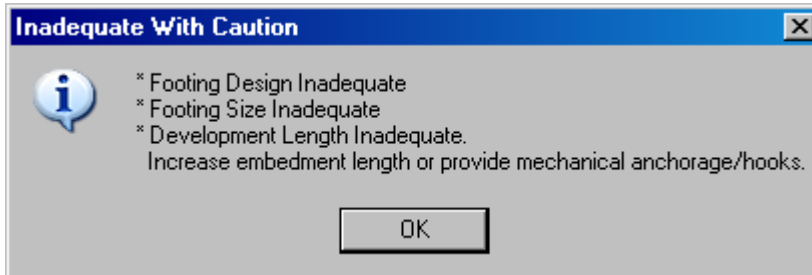
To design this footing using StruCalc perform the following steps:

1.  Click the **Footing** button.
2. Change the **Footing Module** to the following and *click* the **Calculate**  button:

The footing size and development length is inadequate.

* Footing Design Inadequate

To determine the specific factors that have affected the adequacy you can click on the adequacy button to the right of the adequacy bar:



Although there are a number of factors the first step is to change the size of the footing to provide sufficient bearing area, most of the time this will solve all of the other issues.

As you can see the footing width and footing area required are shown at the bottom of the input screen. The required footing width is 4.24 ft. Therefore, change the input box labeled "Footing Width" from 3 feet to 4.25 feet and click the calculate button again.

The footing is now adequate.



Congratulations! You have finished the StruCalc 6.0 tutorial.