StruCalc 6.0™

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.

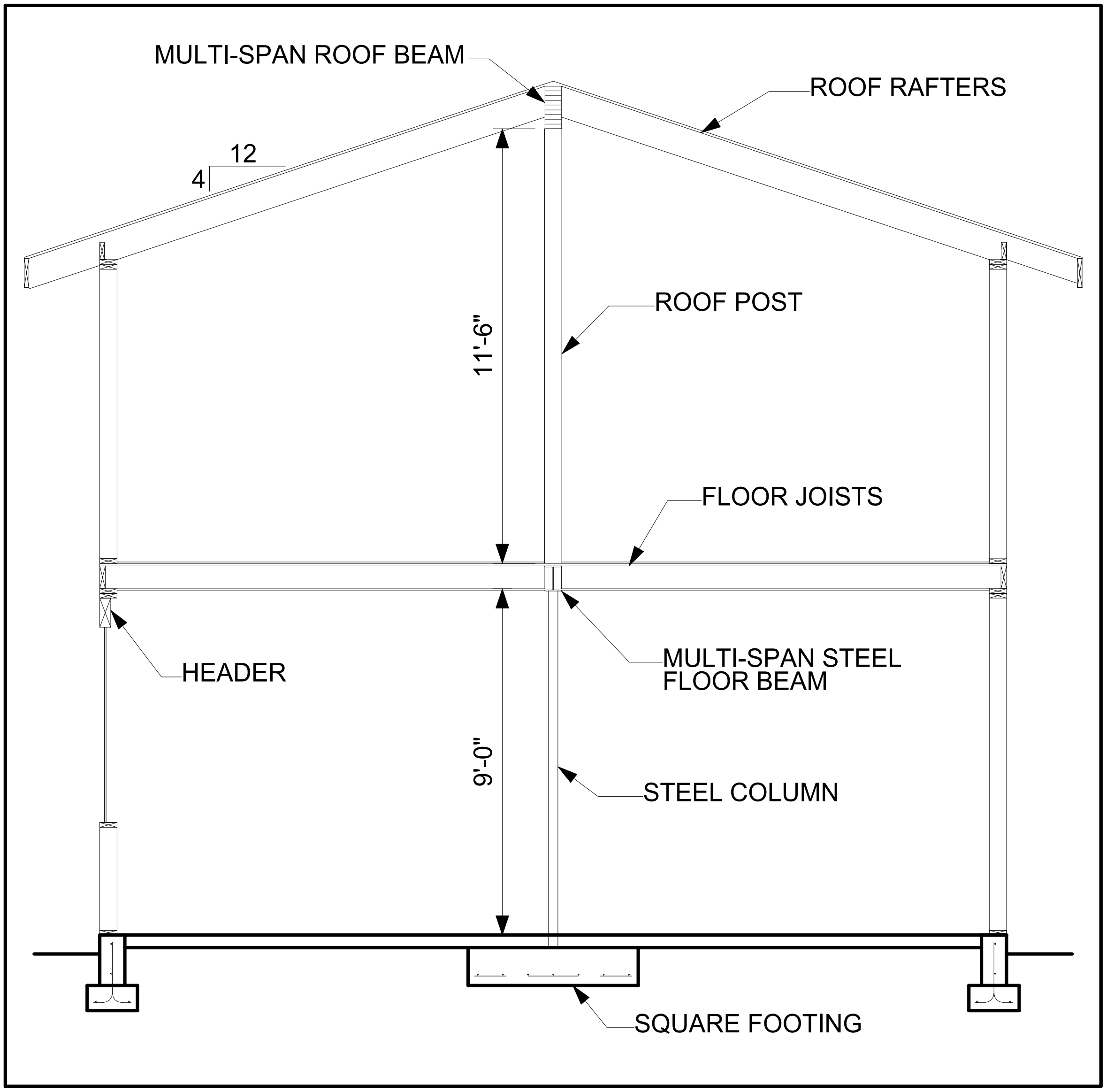


FIGURE 2-1 STRUCTURAL SECTION

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

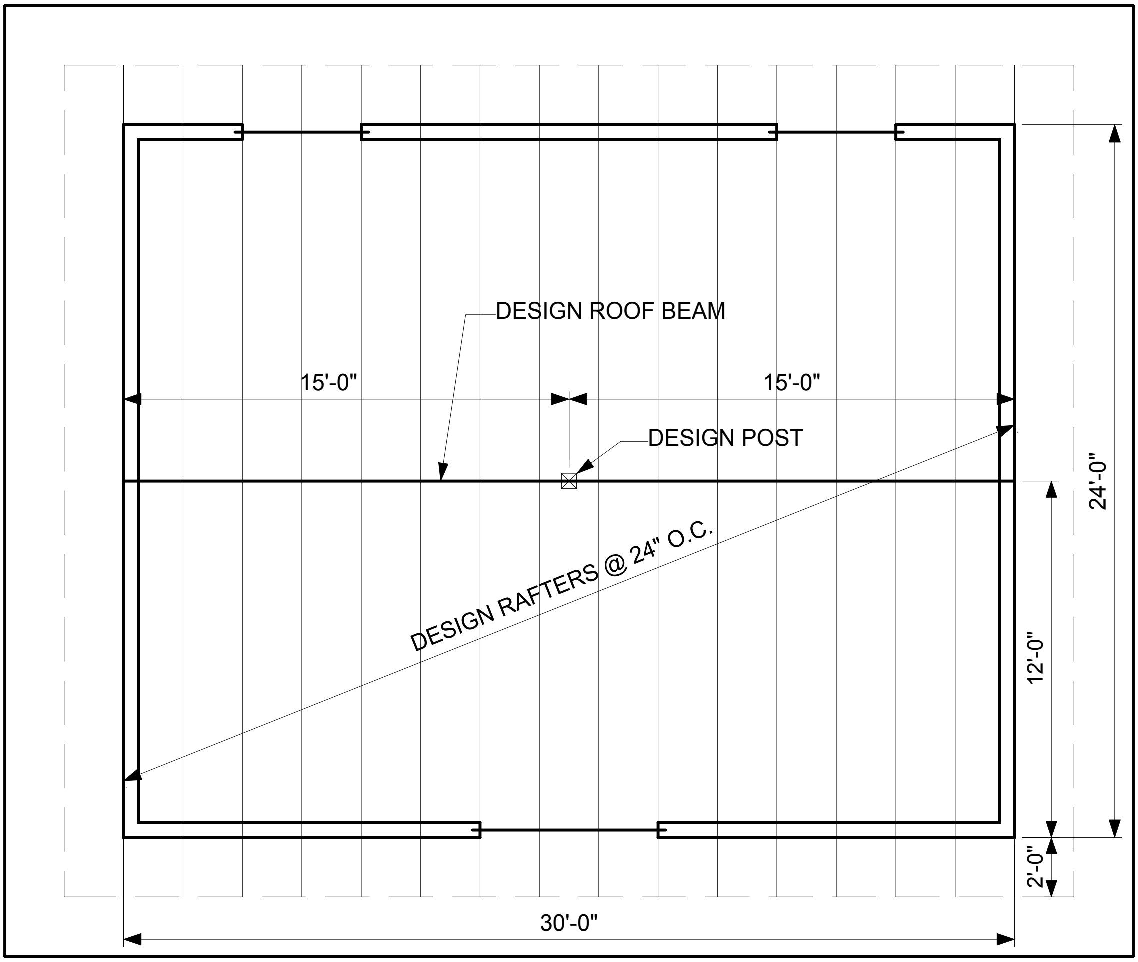


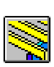
FIGURE 2-2 ROOF FRAMING PLAN

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:

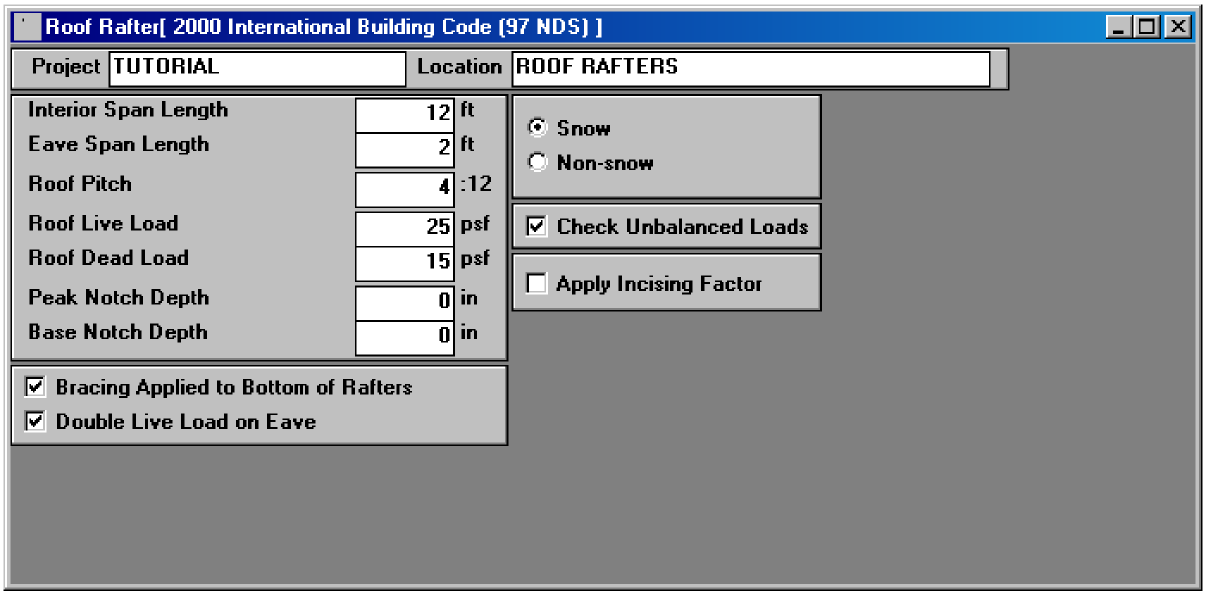
1. Start **StruCalc 6.0 for Windows**.

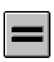
2.  *Click* the **Roof Rafter** button.

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

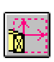
4. Change the **Section Toolbar** to the following:

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):

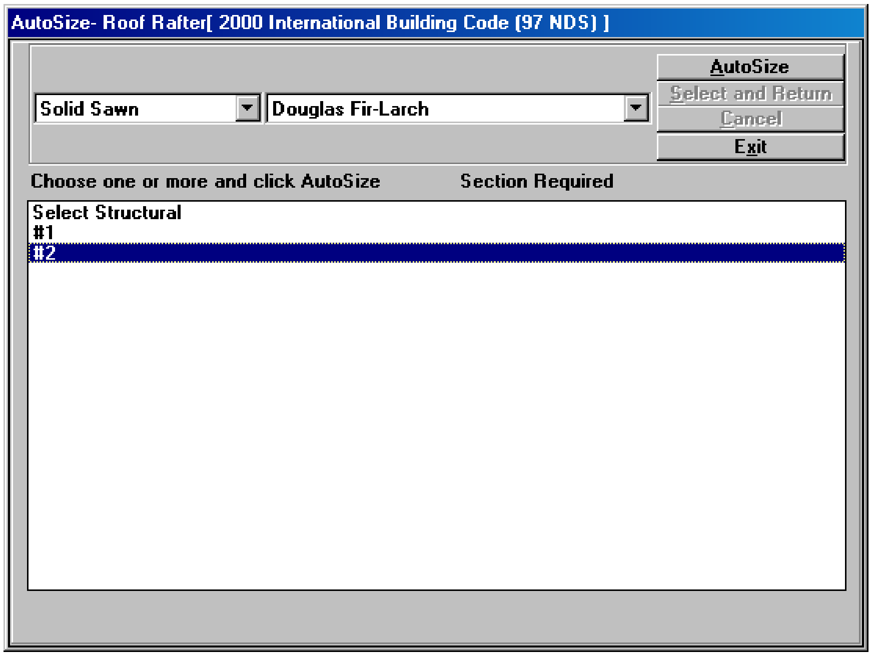


6.  *Click* the **Calculate** button or *press* Enter.

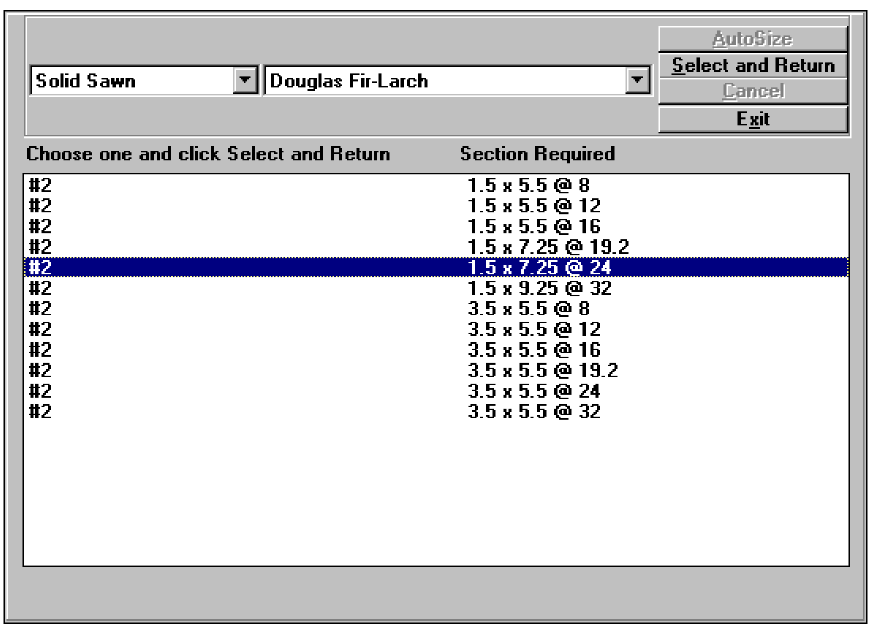
   The design is inadequate.

7.  *Click* the **Autosize** button.

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



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



The design is adequate.

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.

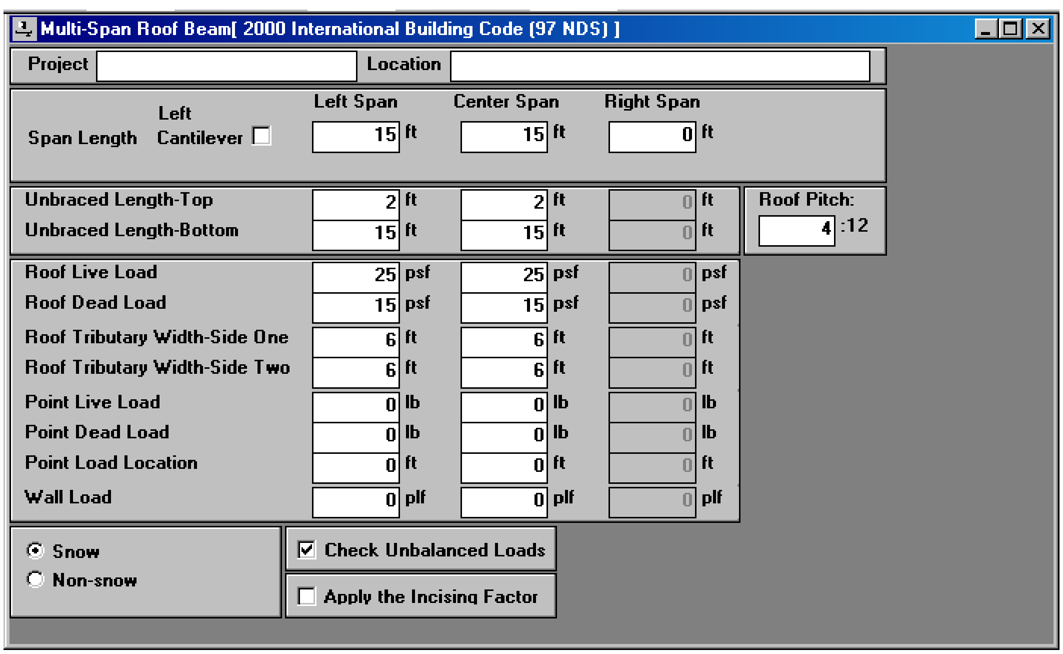
To design this beam using StruCalc perform the following steps:

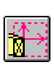
1.  *Click* the **Multi-Span Roof Beam** button.

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

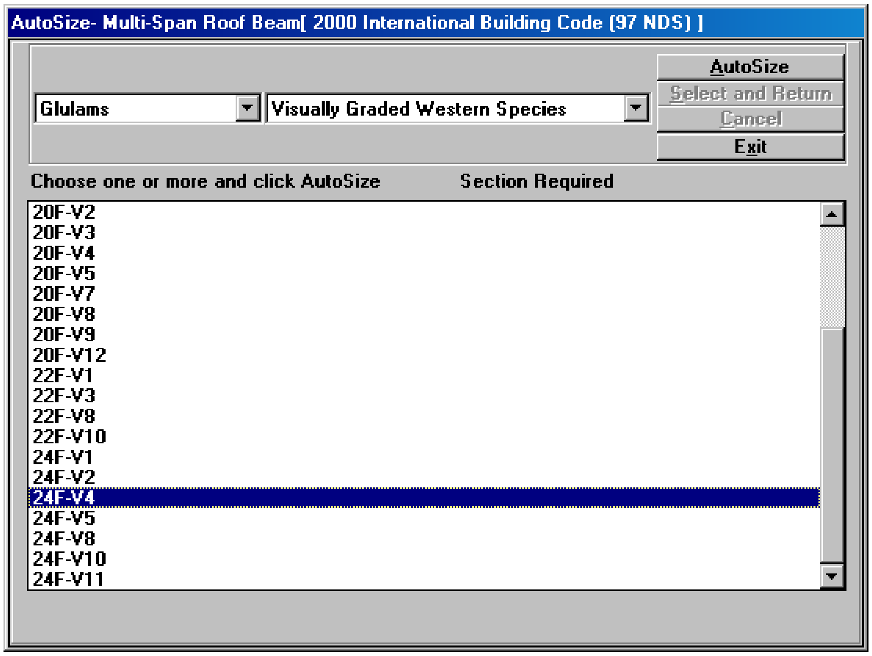
Note: In this case we have chosen to use an unbalanced glulam, 24F-V4, for a multi-span situation. Generally, we would choose a balanced glulam, 24F-V8, for a multi-span situation because it is much more efficient. However, when designing glulam beams for small projects, the cost of a 24F-V8 and the 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:

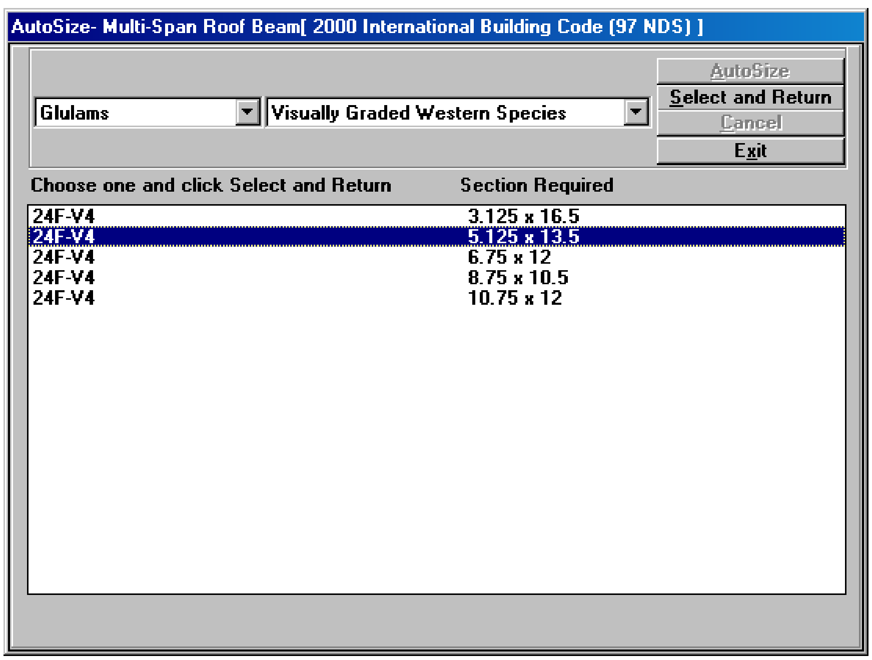


4.  *Click* the **Autosize** button.

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.

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 Ke 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.

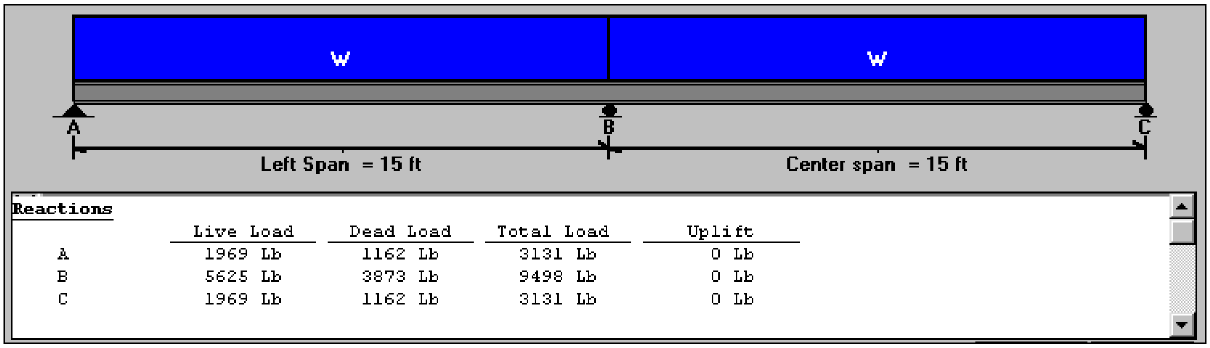
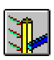
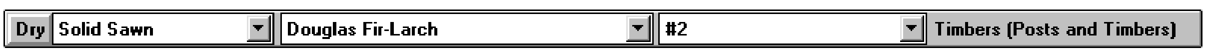


FIGURE 2-3 MULTI-SPAN ROOF BEAM LOADING DIAGRAM

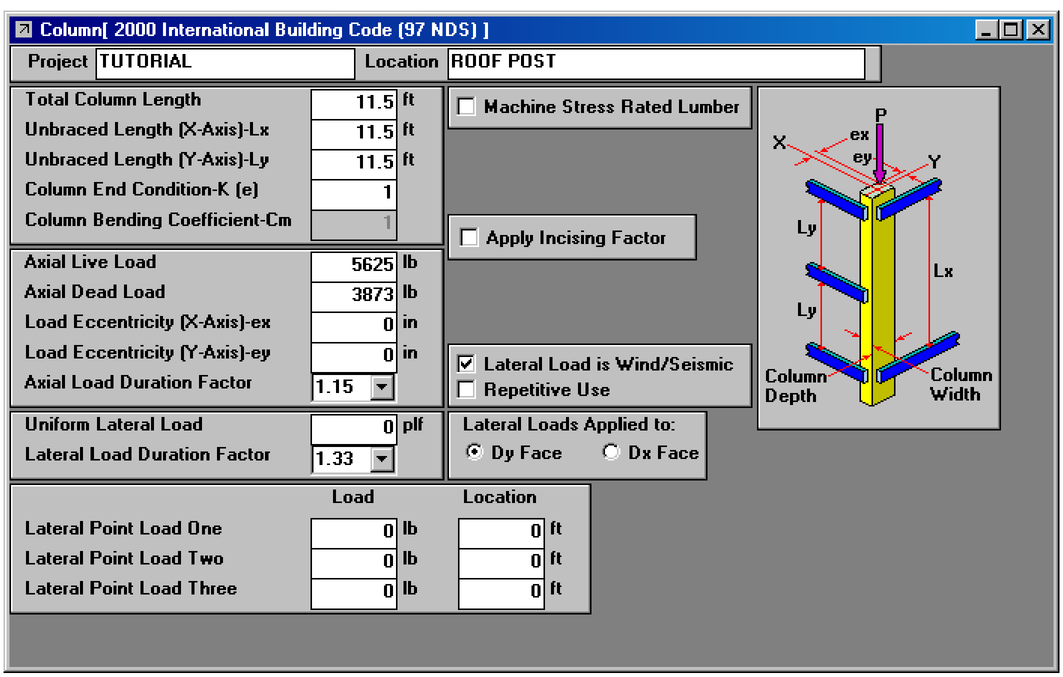
To design this column using StruCalc perform the following steps:

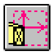
1.  *Click* the **Column** button.

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

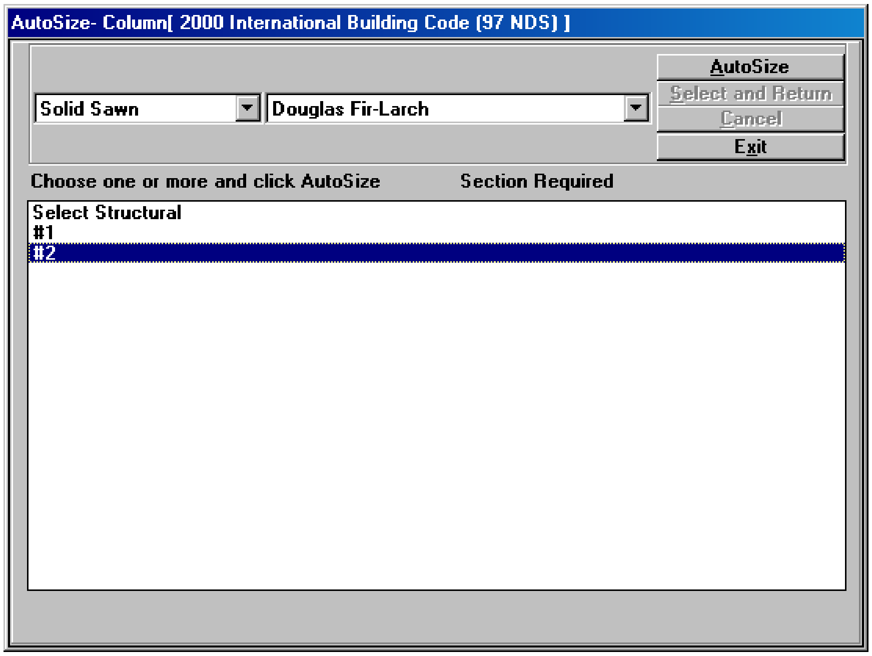


3. Change the **Column Module** to the following:

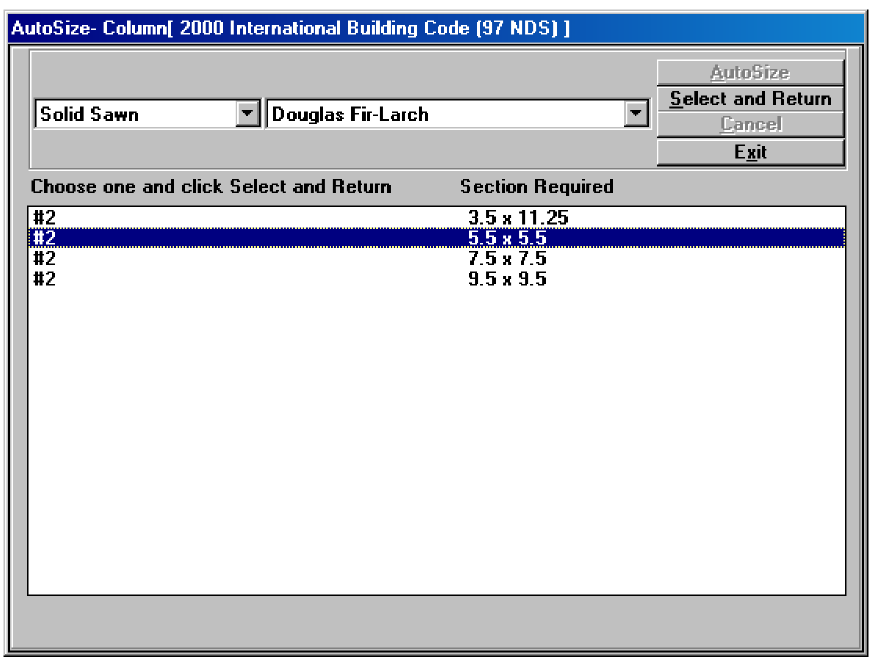


4.  *Click* the **Autosize** button.

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.

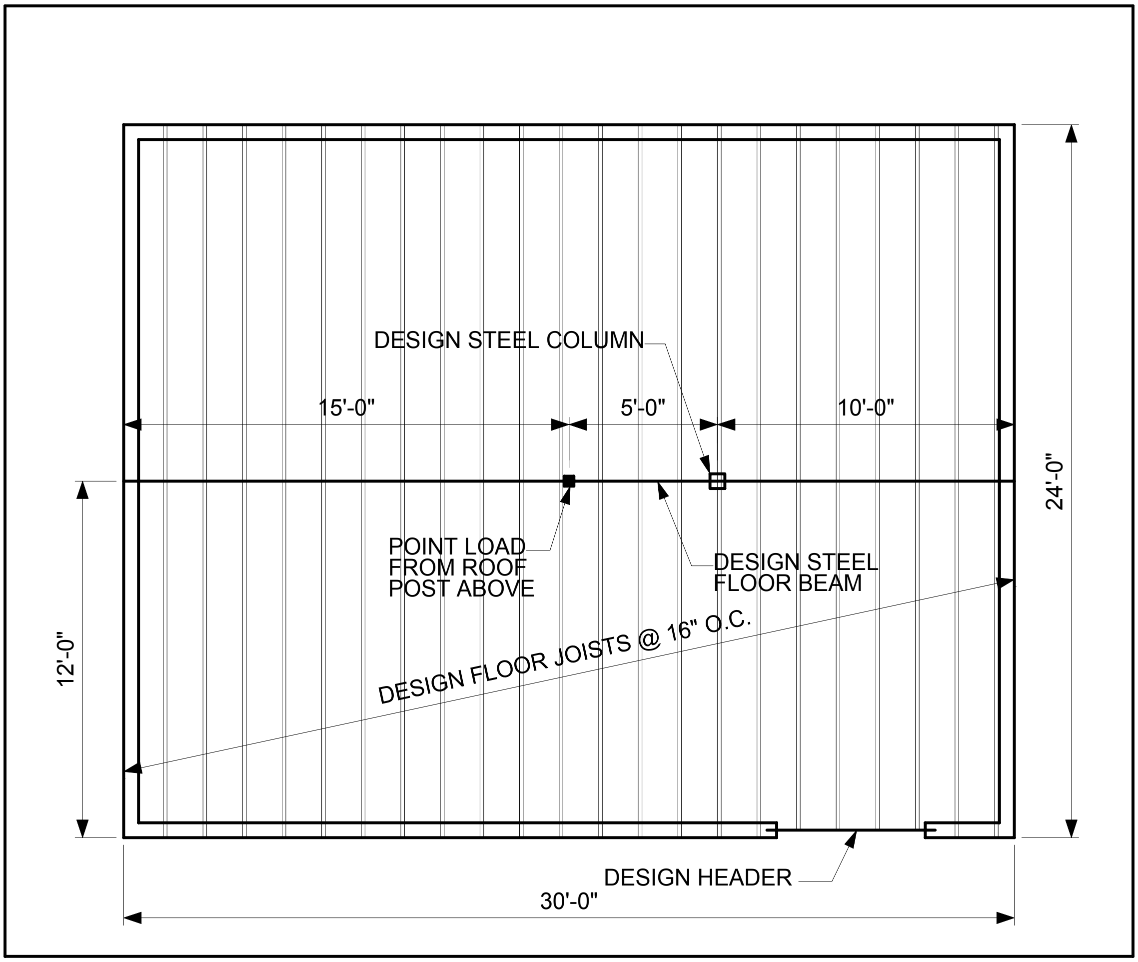
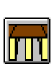


FIGURE 2-4 UPPER FLOOR FRAMING PLAN

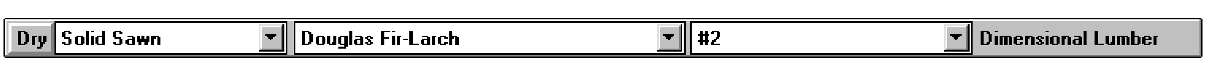
1.3.1 FLOOR JOIST DESIGN

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.

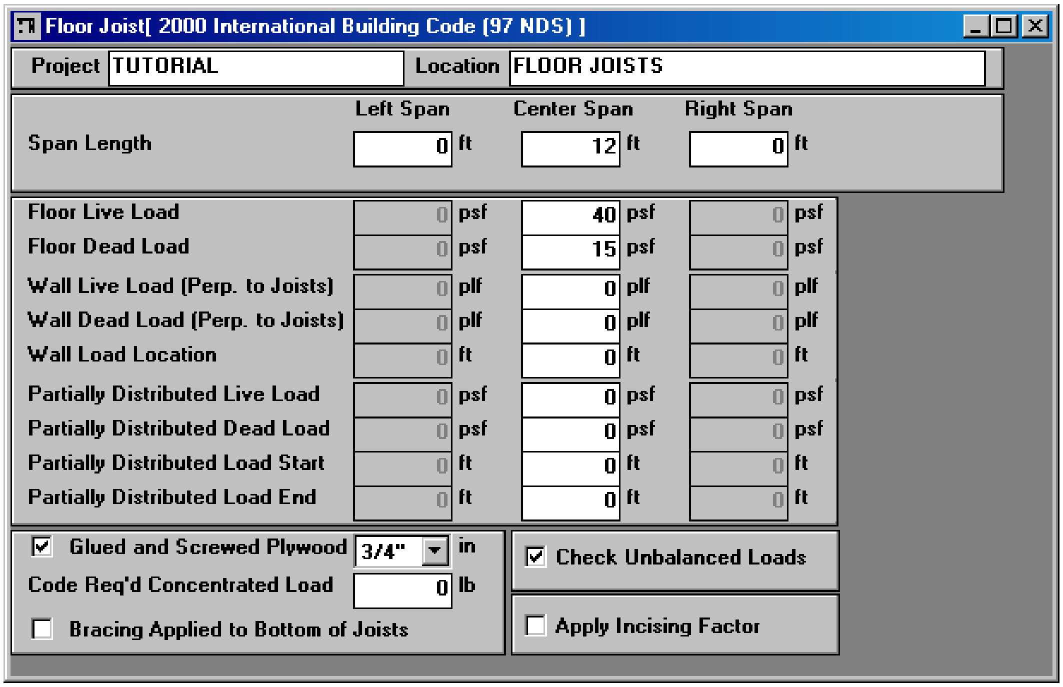
To design the floor joists using StruCalc perform the following steps:

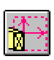
1.  *Click* the **Floor Joist** button.

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

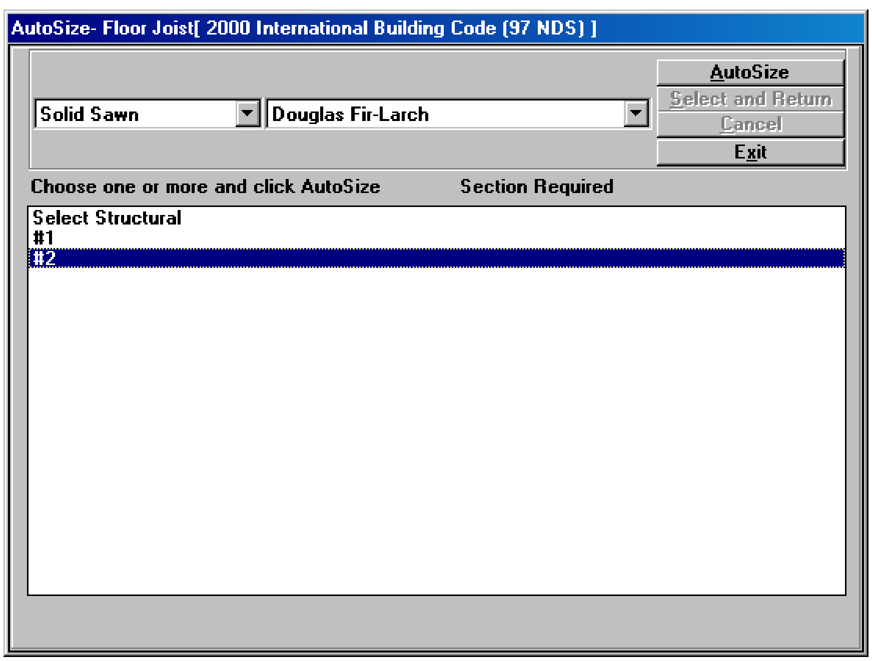


3. Change the **Floor Joist Module** to the following:

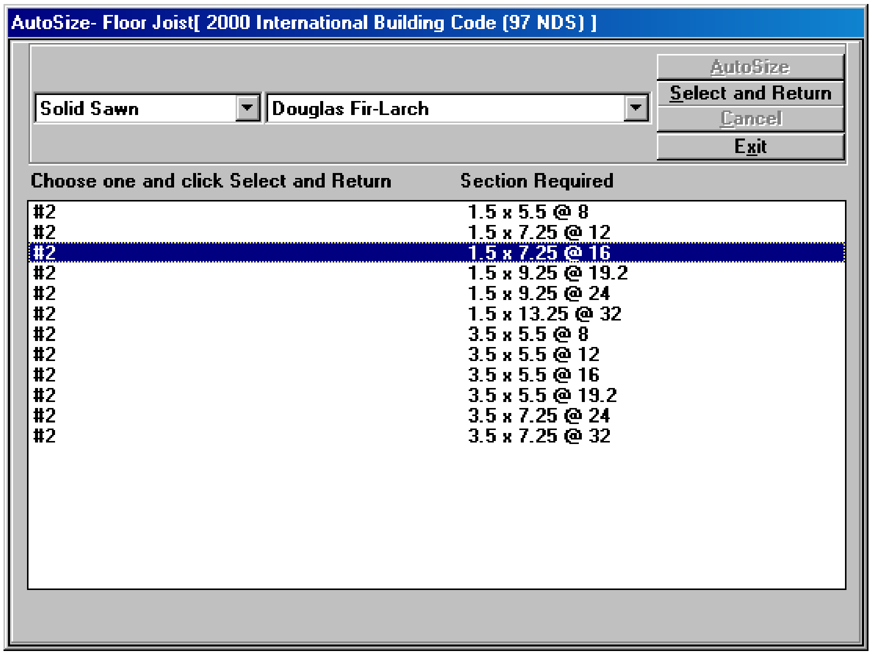


4.  *Click* the **Autosize** button.

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

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 then 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.

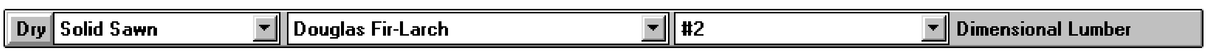
```
Project: TUTORIAL - Location: ROOF RAFTERS
Summary:
        1.5 IN x 7.25 IN x 14.0 FT (12 + 2 ) @ 24 O.C. / #2 - Douglas Fir-Larch - Dry Use
        Section Adequate By: 8.8%   Controlling Factor: Section Modulus / Depth Required 6.95 In
Interior Span Deflections:
        Dead Load:                                          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

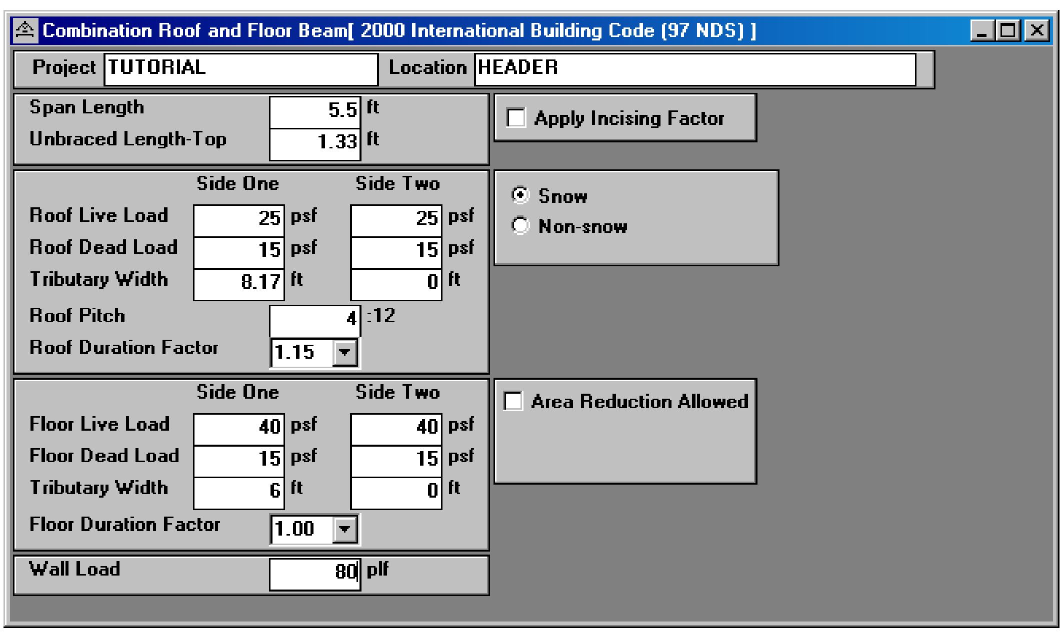
To design the header using StruCalc perform the following steps:

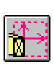
1.  *Click* the **Combination Roof and Floor Beam** button.

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

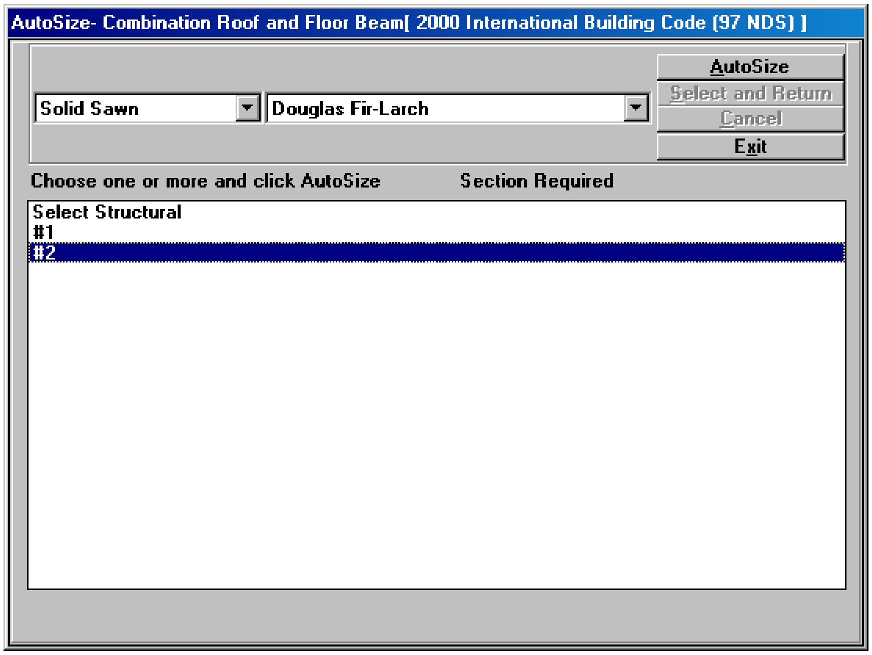


3. Change the **Combination Roof and Floor Beam** module to the following:

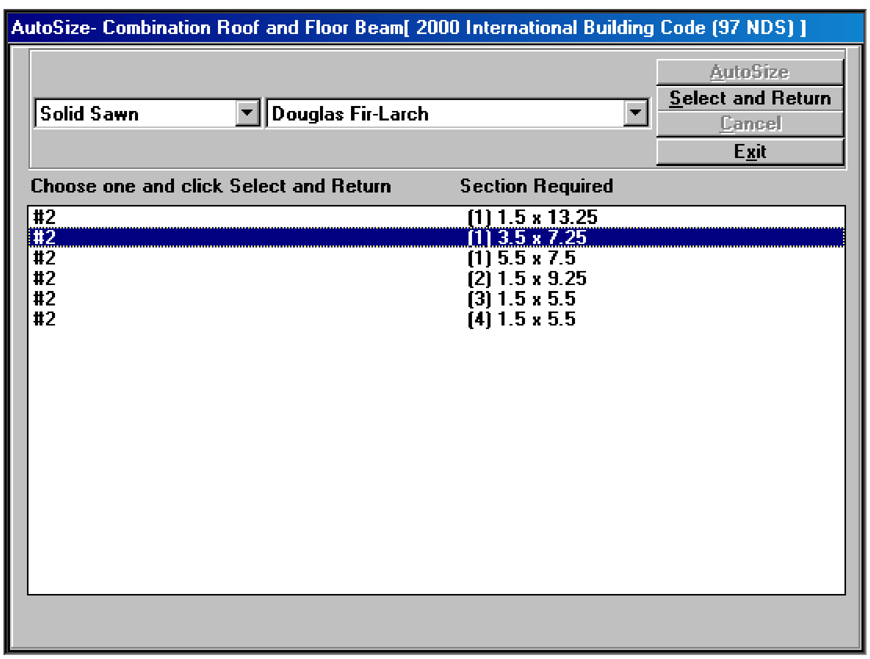


4.  *Click* the **Autosize** button.

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



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



The design is adequate

1.3.3 MULTI-SPAN STEEL FLOOR BEAM DESIGN

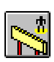
The length of the continuous beam in the center of the floor system in figure 2-4 is 30 feet. A column supports the beam 20 feet from the left side of the residence. The beam consists of two spans: 20 feet and 10 feet. The unbraced length at the top of the beam is 16 inches because the floor joists provide 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

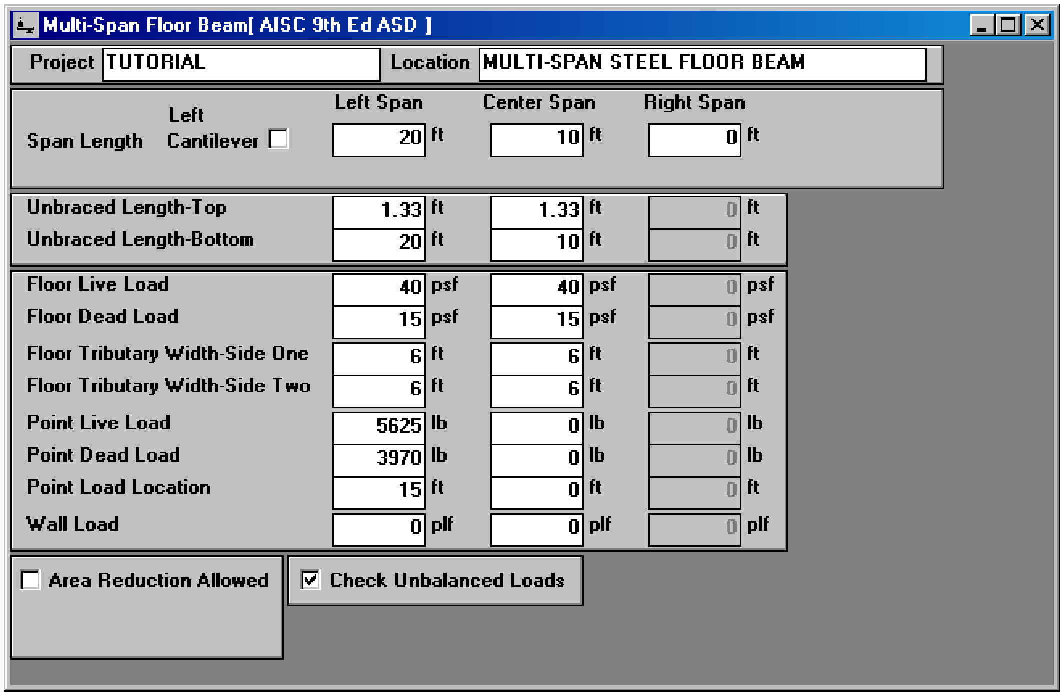
To design this beam using StruCalc perform the following steps:

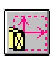
1.  *Click* the **Multi-Span Floor Beam** button.

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

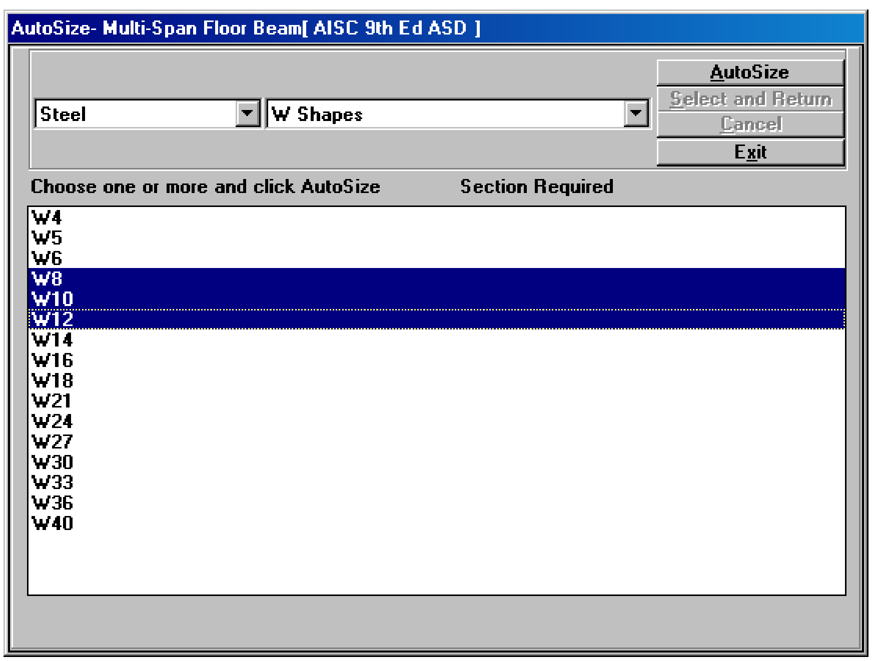
3. Change the **Material Toolbar** to the following:

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

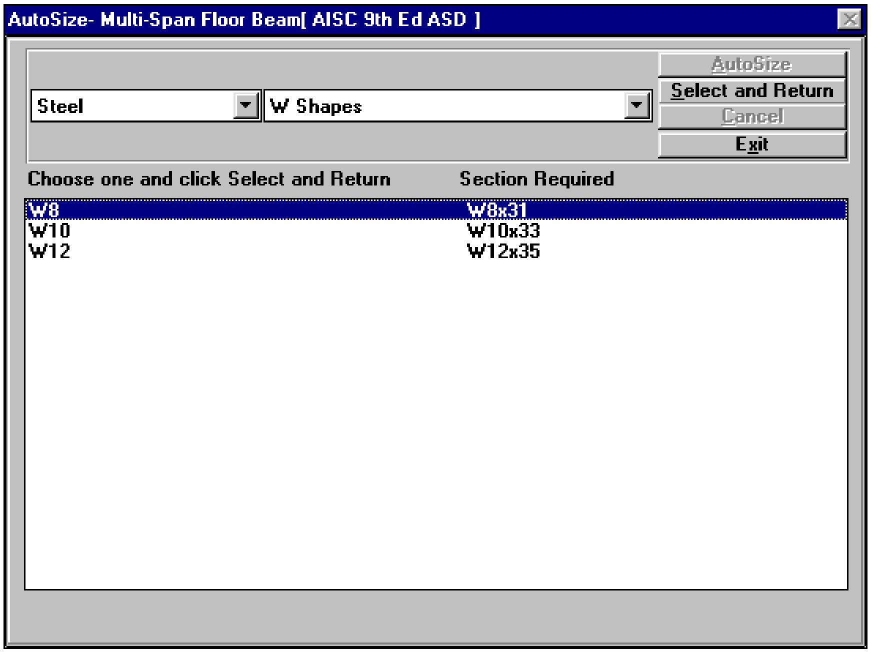


5.  *Click* the **Autosize** button.

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



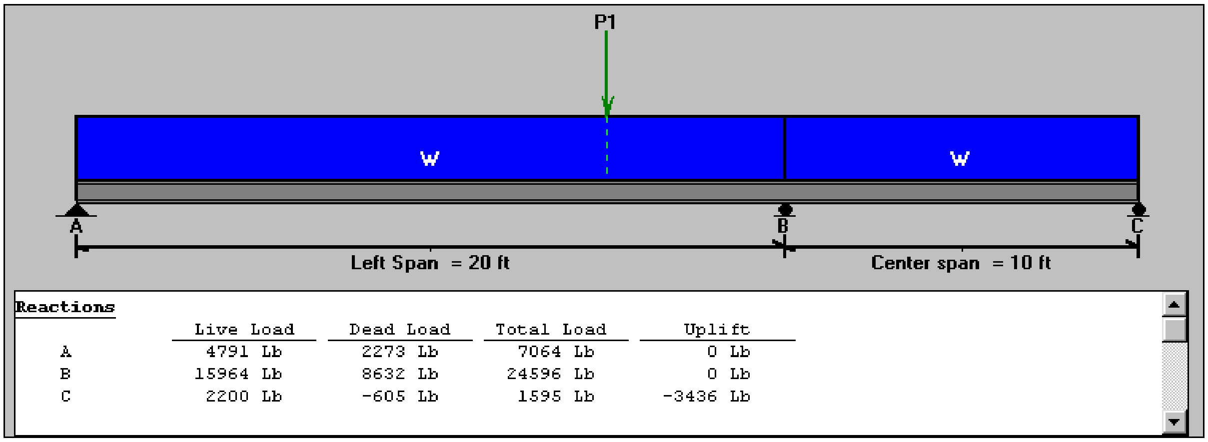
7. *Highlight* the 1st entry and *click* **Select and Return**.



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 Ke is equal to one. The exact column bending coefficient (Cm) 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 Cm 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 1/10th of the member dimension be used, whichever is greater. In this situation we will assume an eccentricity of ½” 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.



	Live Load	Dead Load	Total Load	Uplift
A	4791 Lb	2273 Lb	7064 Lb	0 Lb
B	15964 Lb	8632 Lb	24596 Lb	0 Lb
C	2200 Lb	-605 Lb	1595 Lb	-3436 Lb

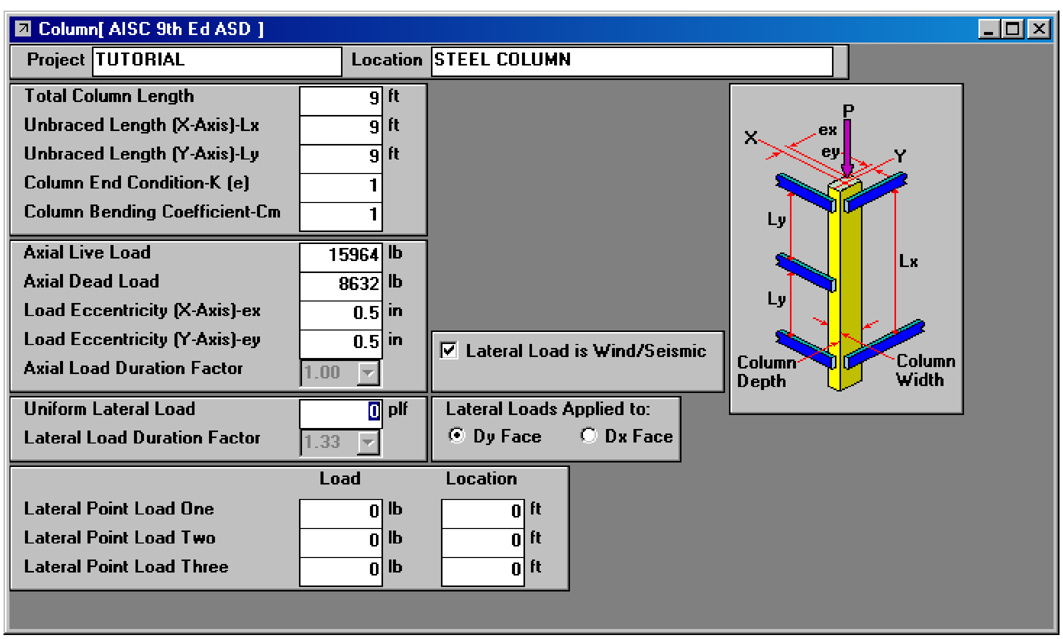
FIGURE 2-7 MULTI-SPAN FLOOR BEAM LOADING DIAGRAM

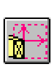
To design this column using StruCalc perform the following steps:

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

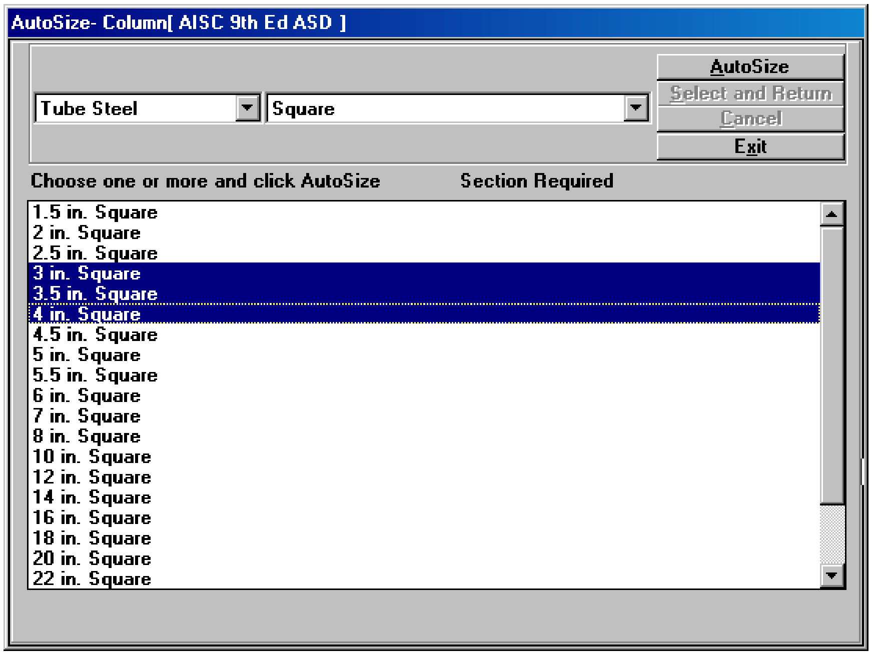
3. Change the **Material Toolbar** to the following:

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

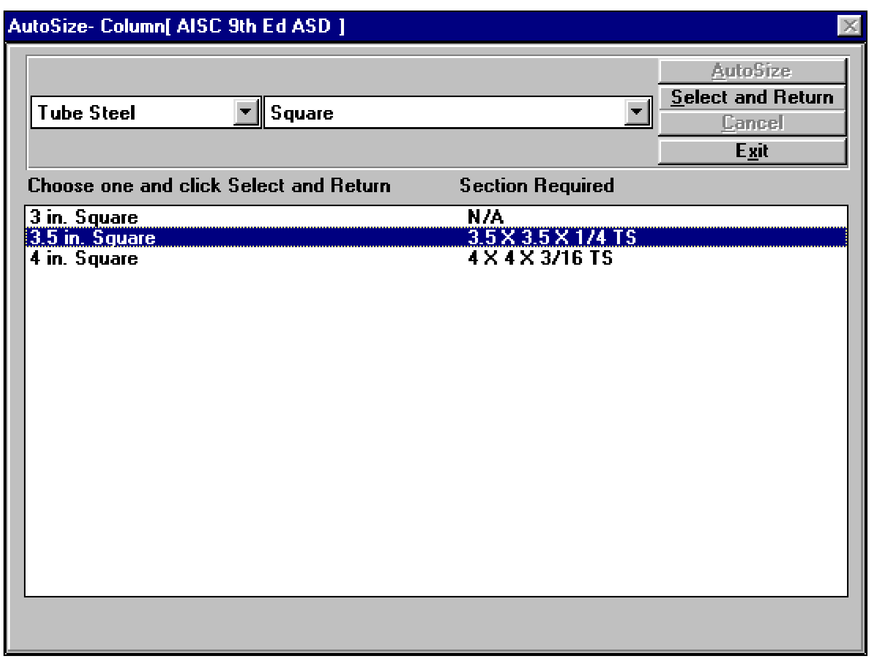


5.  *Click* the **Autosize** button.

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 ½” x 3 ½” x 1/4” tube steel column. The baseplate is a 9” x 9” x ½” 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.

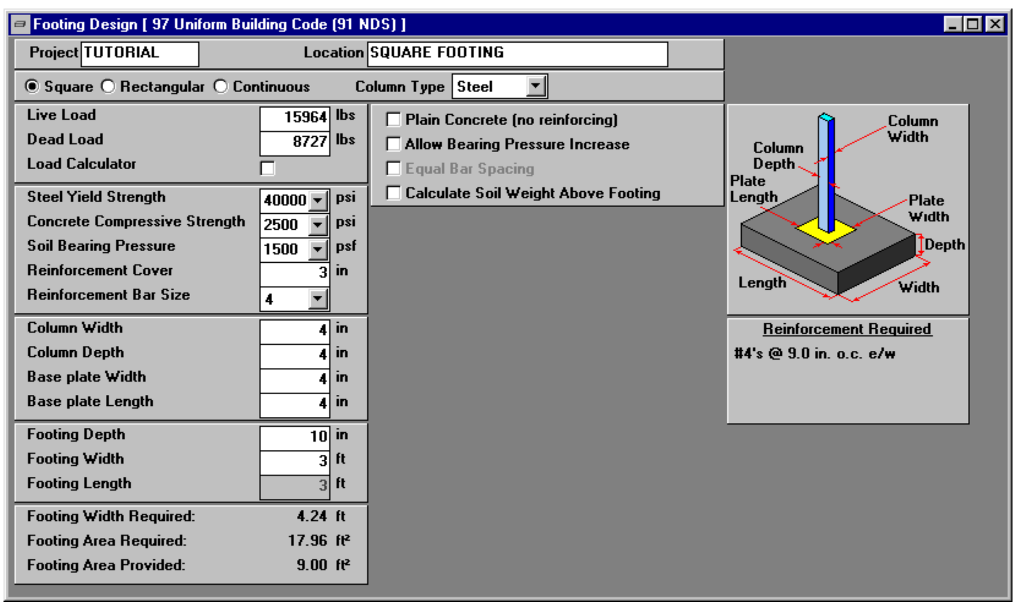
```
Project: TUTORIAL - Location: STEEL COLUMN
Summary:
        3.5 X 3.5 X 1/4 TS -ASTM A500 x 9.0 FT
        Section Adequate By: 8.4%
Vertical Reactions:
        Live:                                   Vert-LL-Rxn=    15964   LB
        Dead:                                   Vert-DL-Rxn=     8727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

FIGURE 2-8 STEEL COLUMN PRINTOUT

To design this footing using StruCalc perform the following steps:

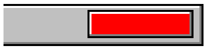
1. *Click* the **Footing** button.

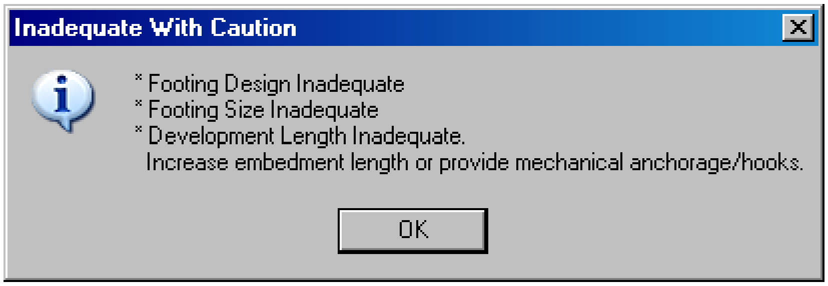
2. Change the **Footing Module** to the following and *click* the **Calculate** button:



The footing size and development length is inadequate.

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.