

## Extra for Experts

### User Defining (UD) the Effective Length of a Member (Re: Page 8-7)

ModelSmart3D assumes that you will provide lateral support, both in plane and perpendicular to the plane of the screen (monitor), for all joints in the model.

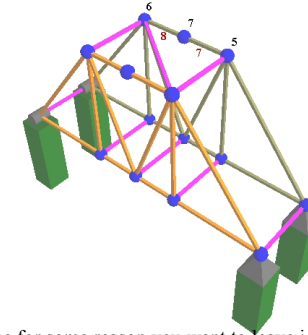
ModelSmart3D also assumes that the effective length (column mode buckling length) of a member is the distance between joints.

Unless you plan to use the “Advanced Features” in ModelSmart3D to user define (UD) the effective length, do not place unbraced joints in the model.

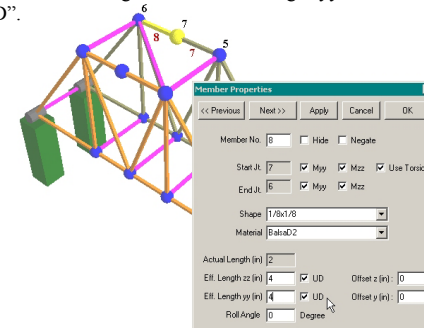
#### A Bridge Example

Consider the two horizontal members 7 & 8 in the figure on the next page. The unbraced joint “7” causes ModelSmart3D to incorrectly assume that the effective length of member “7” is the distance from joint “5” to joint “7”. In addition, ModelSmart3D will incorrectly assume the effective length of member “8” is the distance from joint “7” to joint “6”. This is a modeling error!

To fix this error, either remove the joint replacing the two members “7” and “8” with a single member spanning from joint 5 to joint 6 or use the advanced options to correct the model by user defining (UD) the effective (buckling) length of the members.



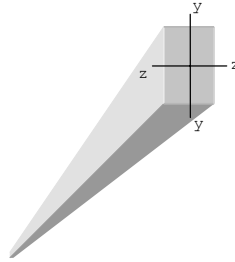
Let’s assume for some reason you want to leave joint “7” in the model unbraced. First, turn on “Advanced Options” by selecting the “View|Advanced Options...” menu option. Next select the “Member|Properties...” menu option. Click on the member “8”. Change the effective length yy to 4” and check “UD”.



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If member 8 were to fail in compression by buckling it would fail together with member 7, therefore we need to change what ModelSmart3D assumes as the effective length from the member's actual length (2") to the total length of both members (4"). Actually, since the member can buckle in either the vertical or horizontal plane, this must be done for the zz effective and the yy effective length. (The zz and yy notations define the member's local bending axes. See below.)



With the member in its default orientation (no roll angle) bending about the zz local member axes corresponds to buckling in the vertical (XY) plane and bending about the yy axis corresponds to buckling in the horizontal (XZ) plane.

The effective lengths of both members 7 and 8 must be set to 4" for both the yy and zz bending axes. Once this is done, ModelSmart3D will know that the members 7 and 8 can buckle as a unit (in either direction) and you will get a better prediction of the actual failure load for the model.

**Remember, unless you brace a joint in two orthogonal planes, you will need to manually "user define" (UD) the effective length(s).**

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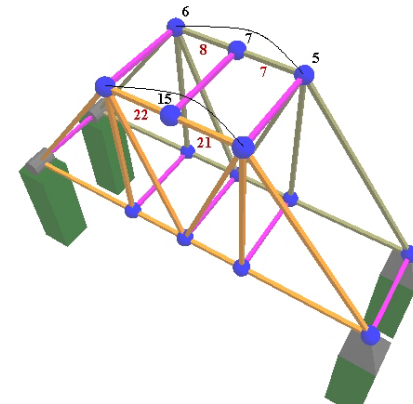
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### Extra for Experts

The other end of the bracing member must also be braced!

Suppose you want to provide lateral bracing for joint 7 so that you do not have to increase the effective length of members 7 and 8 (or members 21 and 22). (Let's consider bracing in the XZ plane first.) If you only provide a single horizontal member extending from joint 7 to joint 15 all you will accomplish is ensuring that both members buckle at the same time with no increase in strength.



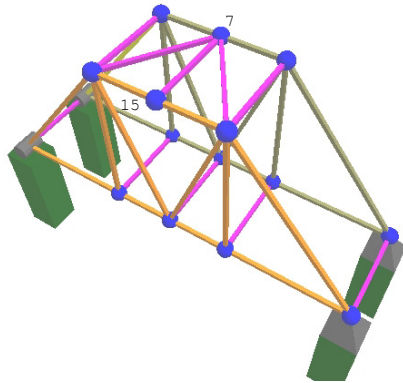
If you wanted to brace joints 7 (and 15) in the horizontal plane you would need to provide some diagonal bracing in that plane.

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The figure above shows a possible configuration for bracing joints 7 and 15 in the horizontal plane. The two diagonals in the horizontal plane effectively brace joints 7 and 15 so that you can use an effective length of 2" for the top chord members.

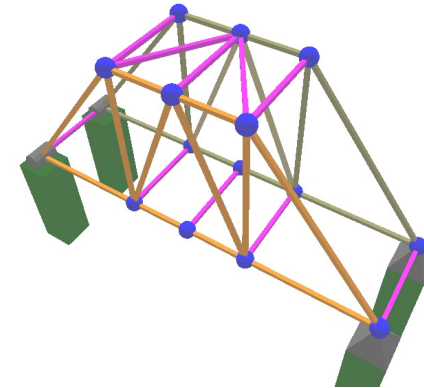
Members 7 & 8 and 21 & 22 can also buckle vertically. You would still need to change the zz effective length to 4" for all those members. Unless...

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We also provide bracing against buckling in the vertical plane as well. The addition of the diagonal web members in both the near and far main trusses provide this needed bracing. Now you can use an effective length of 2" for the top chord compression members for both yy and zz!

But what about the members in the bottom chords? There's an unbraced joint in the each of the bottom chords.

True, but the bottom chord will never go into compression. That is, if you will be loading the model with a downward load anywhere along the span.

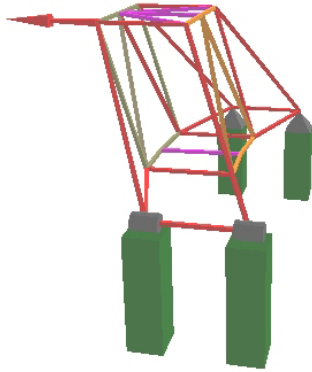
There is another bracing problem in the model!

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It racks rather easily. It can flop over. The only thing keeping it from flopping over is the stiffness of the glue joints where the upper and lower chords attach to the horizontal members connecting the two trusses.

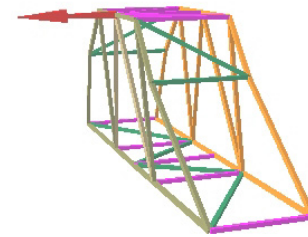
To get an idea (or “feel”) for the lateral stiffness of your bridge you should apply some notional (imaginary) forces. They don’t really exist but might arise due the secondary effect caused by unbalanced vertical load or a less than perfectly constructed bridge. As a rule of thumb, your bridge should be able to support a lateral load of approx 2-5% of the actual load in the top chords.

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The added diagonals between the bottom chords and bracing in the main end diagonals help provide additional lateral stiffness.

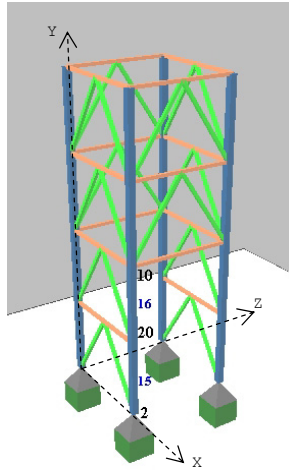
**The coordinates that you use to describe your bridge to ModelSmart3D assume that you will build you bridge perfectly.**

**ModelSmart3D will not check the lateral stiffness of the bridge without the application of some load. You should use notional loading when there is no design load specified.**

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A Tower Example



Consider member 15. What is the appropriate effective length for this member?

Remember, in a 3D analysis, there are 2 effective lengths -  $y_y$  and  $z_z$ . The  $z_z$  axis for a vertical column (with no roll angle) relates to buckling in the XY plane. This tower is fully braced at its joints in the XY plane therefore, member 15, if it buckled, would buckle between joints 2 and 20 – its actual length. Therefore, the effective length ( $z_z$ ) equals the actual distance (3" in this case) between those joints.

What about buckling in the YZ plane? Joint 20 is not braced in the YZ plane. Therefore, member 15 could buckle in the YZ plane between joints 2 and 10 ( instead of joints 2 and 20). Both members 15 and 16 should have their effective lengths ( $y_y$ ) set to the sum of the length of members 15 and 16 – 6", **at least!** If fact, when a tower is not braced against sidesway (lateral movement), the resulting deformation of the frame tends to magnify the effective length.

This magnification is a function of the relative stiffness of the connecting members. For instance (in this case), if the horizontal member 29 connecting to joint 10 is as stiff as the column then, the total actual length of members 15 and 16 would need to be magnified by a factor of 1.9!

In this case, the correct effective length ( $y_y$ ) to use for both member 15 and 16 would be:

$$(3''+3'') \times 1.9 = 11.4''$$

An 11.4 inch long 1/8"x1/8" balsa wood member supports much less load than a 1/8"x1/8"x 3" member!

**Fully bracing all sides of the tower eliminates the need to magnify the effective lengths.**

