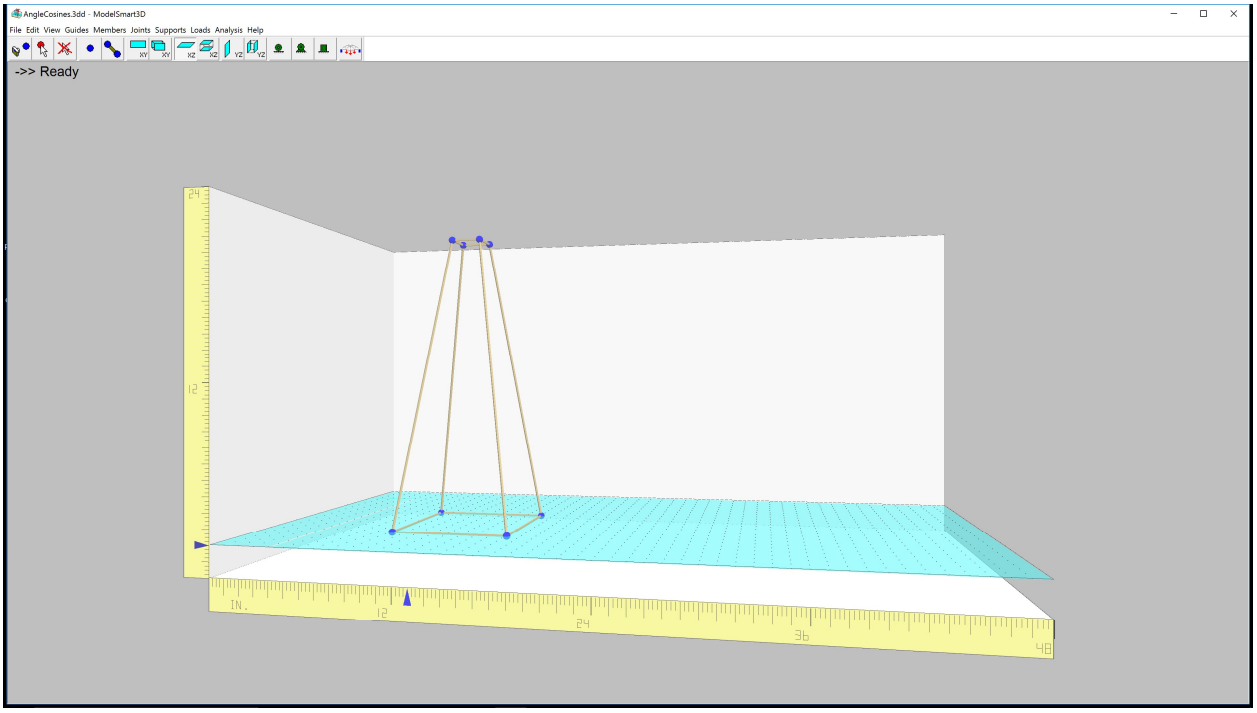
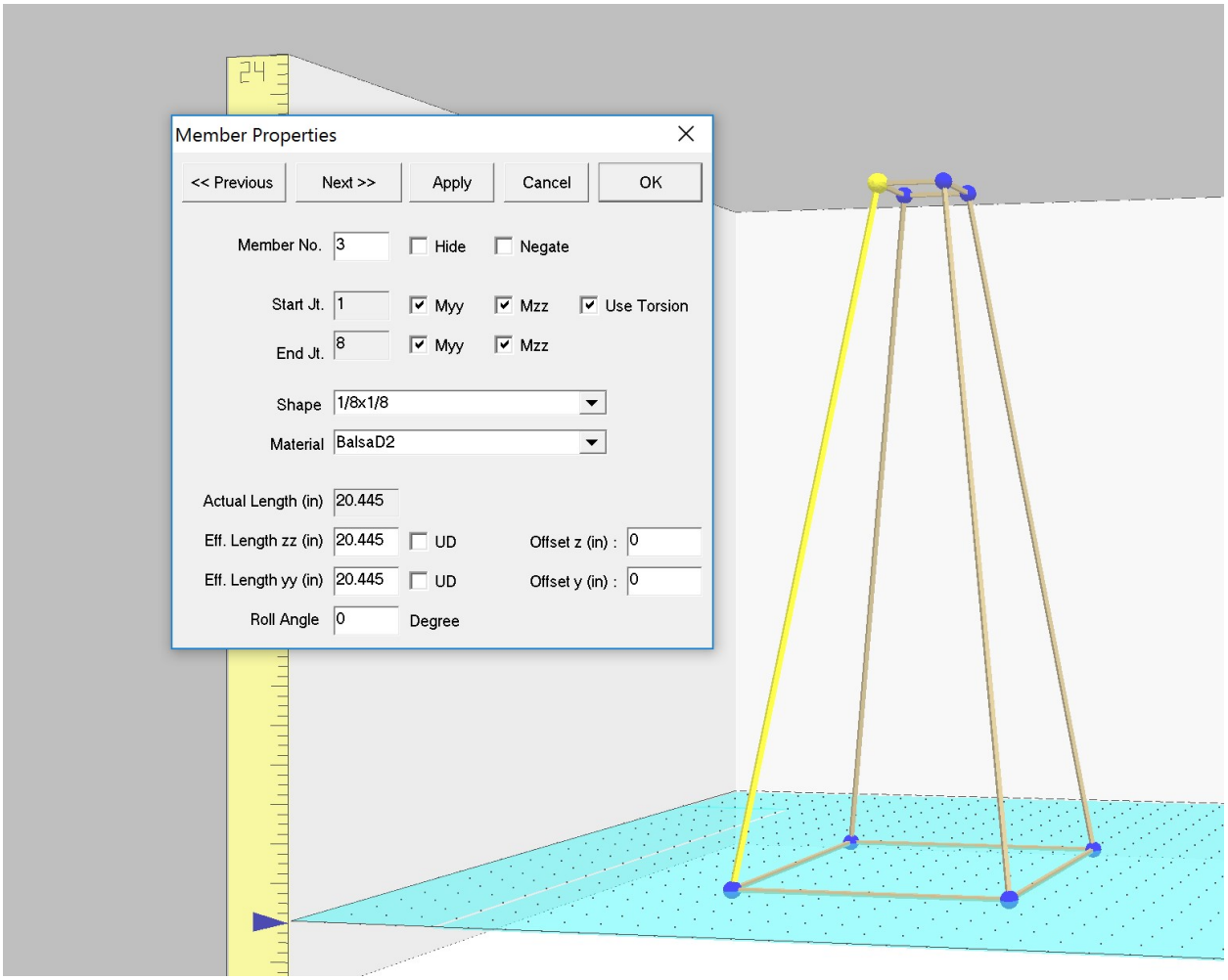
Model Geometry

Calculating Angles Associated with Skewed Columns Using Vector Notation and Direction Cosines

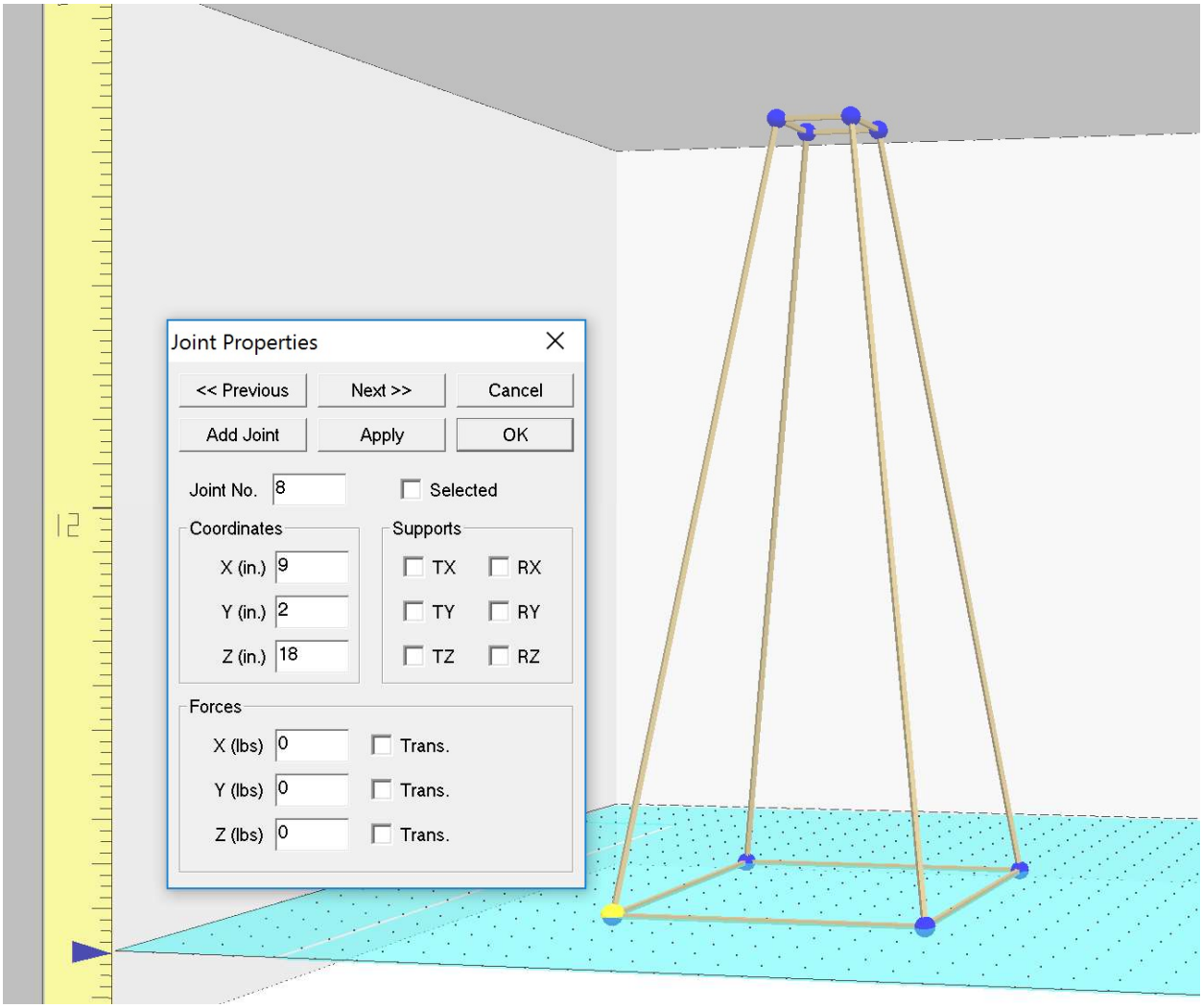


This example uses vector notation to determine the angles associated with a skewed column.



Let’s consider member number 3.

From the “Member Properties” dialog we see that this member starts at joint number 1 and ends at joint number 8. The actual length of the member is 20.445 inches.



From the “Joint Properties” dialog we see that joint number 8 has the following coordinates:

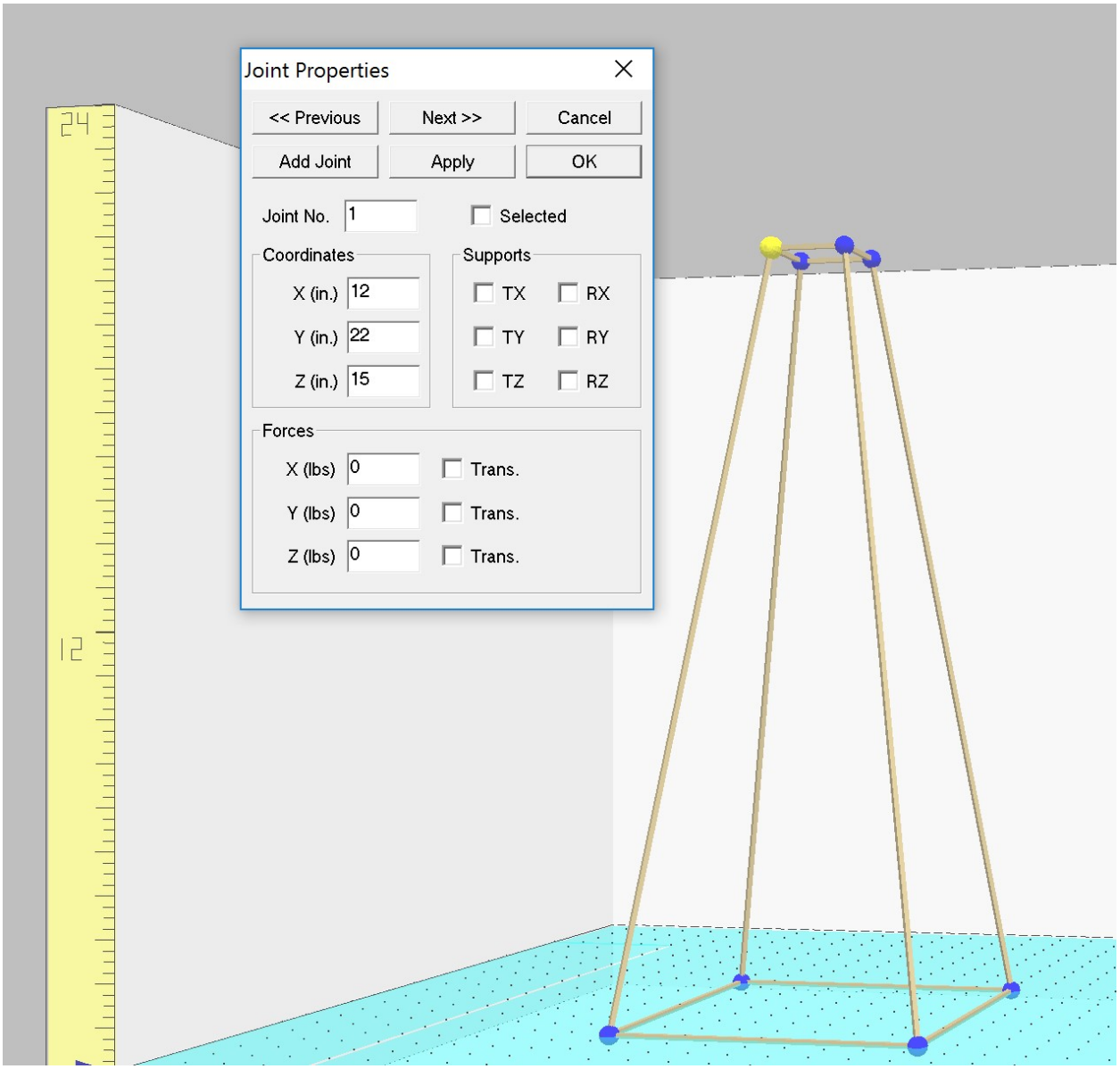
X=9

Y=2

Z=18

For the calculations let’s call this location node 1 and use the following notation:

$X_1 = 9$ $Y_1 = 2$ $Z_1 = 18$



From the “Joint Properties” dialog we see that joint number 8 has the following coordinates:

X=12

Y=22

Z=15

$X_2 = 12$ $Y_2 = 22$ $Z_2 = 15$

Using vector notation to represent the column we get the following:

$\mathbf{C}=dX\mathbf{i}+dY\mathbf{j}+dZ\mathbf{k}$

where the bold “C” denotes a vector with a change in the global “X” direction directed along a unit vector **i** pointing the global X direction.

$dX= X_2 - X_1 = 12-9 = 3$ (change in the **i** direction)

$dY= Y_2 - Y_1 = 22-2 = 20$

$dX= X_2 - X_1 = 15-18 = -3$

$\mathbf{C}=3\mathbf{i}+20\mathbf{j}-3\mathbf{k}$

The magnitude of vector **C** (denoted as C) is:

$C=\text{sqrt}((dX)^2+(dY)^2+(dZ)^2)$

$C=\text{sqrt}((3)^2+(20)^2+(-3)^2)$

$C=\text{sqrt}(418)$

$C=20.445$ (as it should)

Now convert **C** to a unit vector directed along the same axis as column 3:

$\mathbf{c} = \mathbf{C}/C = \mathbf{C}/20.445 = (3\mathbf{i}+20\mathbf{j}-3\mathbf{k})/20.445 = .14674\mathbf{i}+.97823\mathbf{j}-.14674\mathbf{k}$

The coefficients of the unit vectors **i**, **j** and **k** are the angle cosines.

Cosine^{-1}(.97823) = 11.98˚ (this is the angle in degrees from the Y direction to the column. The column is inclined by 90 -11.98 = 78.02 degrees or about 78˚

Cosine^{-1}(.14674) = 81.56˚ (this is the angle in degrees from the X direction to the column.

Cosine^{-1}(-.14674) = -98.438˚ (this is the angle in degrees from the Z direction to the column.