## **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.

Member Propertie	s	×
<< Previous	Next >> Apply Cancel OK	
Member No.	3 Hide Negate	
Start Jt.	1 Myy Mzz Use Torsio	n
End Jt.	8 V Myy V Mzz	
Shape	1/8x1/8	
Material	BalsaD2	
Actual Length (in)	20.445	
Eff. Length zz (in)	20.445 UD Offset z (in) : 0	
Eff. Length yy (in)	20.445 UD Offset y (in) : 0	
Roll Angle	0 Degree	

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.

	Joint Properties X	
	Add Joint     Apply     OK	
	Joint No. 8	
15 -	Coordinates	
-	X (in.) 9 TX RX	
	Y (in.) 2 TY RY	
	Z (in.) 18 TZ RZ	
	Forces	
	X (lbs) 0 Trans.	
	Y (lbs) 0 Trans.	
	Z (lbs) 0 Trans.	
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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:

C=dXi+dYj+dZk

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

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

C=3i+20j-3k

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

```
C=sqrt((dX)^2+(dY)^2+(dZ)^2)
C=sqrt((3)^2+(20)^2+(-3)^2)
C=sqrt(418)
C=20.445 (as it should)
```

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

c = C/C = C/20.445 = (3i+20j-3k)/20.445 = .14674i+.97823j-.14674k

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

 $Cosine^{-1}(.97823) = 11.98^{\circ}$  (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<sup>-1</sup>(.14674) =  $81.56^{\circ}$  (this is the angle in degrees from the X direction to the column.

Cosine<sup>-1</sup>(-.14674) = -98.438° (this is the angle in degrees from the Z direction to the column.