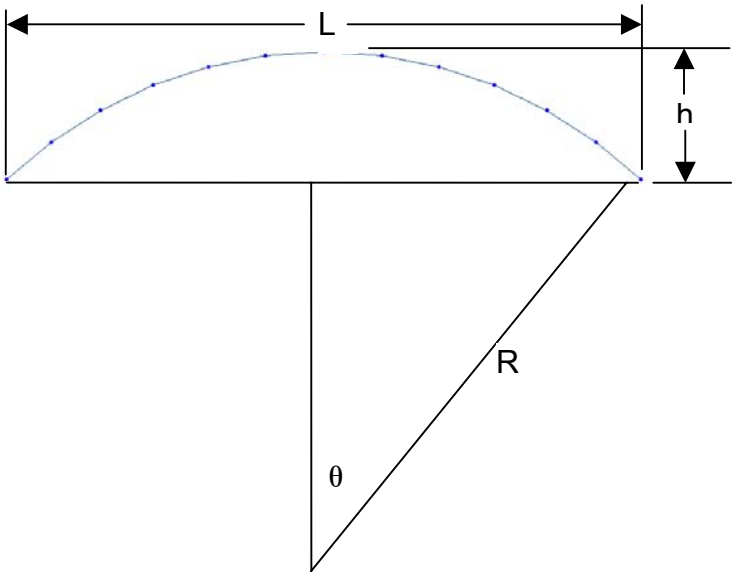
SAP2000 TUTORIAL → ARCHES

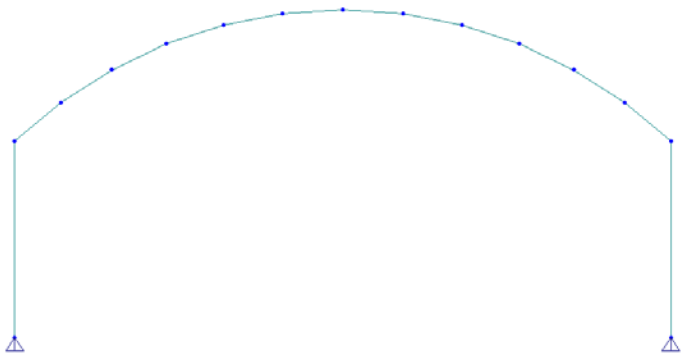
The first step in the process of modeling an arch is to determine the Radius (R) and the angle theta (θ) using the following equations:

$$R = \frac{L^2 + 4h^2}{8h} \qquad \theta = \sin^{-1}\frac{L/2}{R}$$



The arch that will be modeled in the tutorial is shown below: it has a height (h) of 8 ft., sits on columns that are twelve feet high and the distance between them (L) is 40 ft.

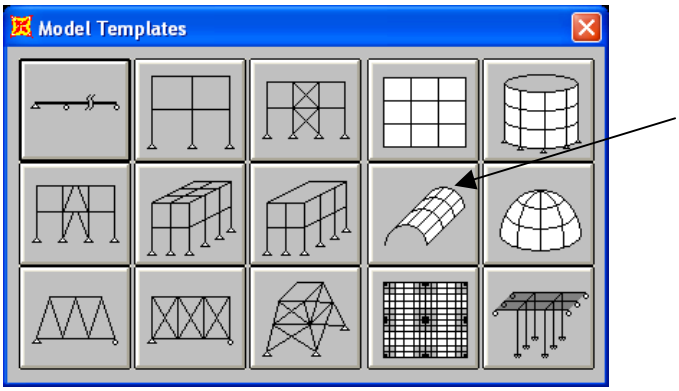
Calculating the radius (R) gives a value of 29 ft. and the angle theta (θ) is 43.6°.



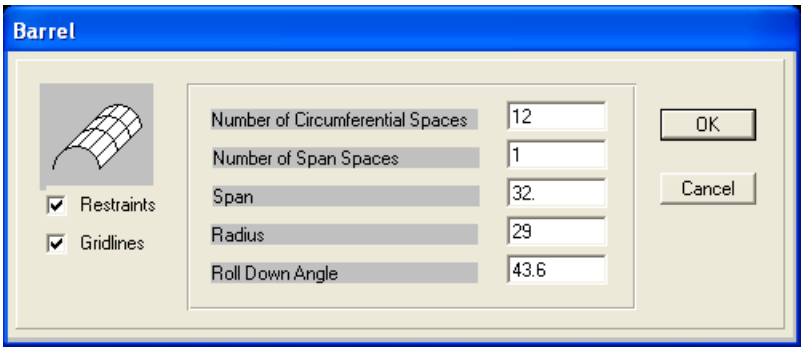
→ Putting the Arch into SAP

Modeling an arch in SAP uses a Barrel Vault Shell Template for creating the points to draw an arch and then erases the shell elements.

1. Open **SAP** and **Assign** the units → **kip-ft**
2. Go to **File → New Model From Template** to get the following screen:



3. Select the **Barrel Vault** icon to bring up the following screen:



Enter a value of at least 12 for the **Number of Circumferential Spaces**

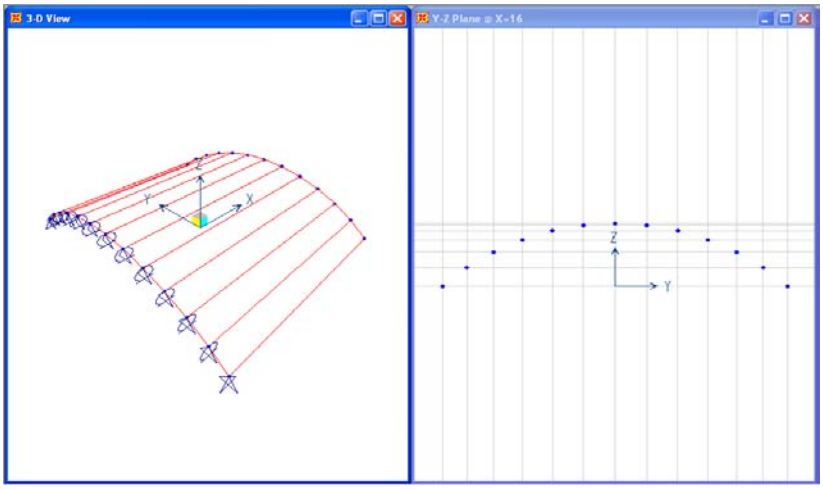
Enter a value of 1 for the **Number of Span Spaces**

Enter a value of 32 for the **Span**

Enter a value of 29 as calculated for the **Radius**

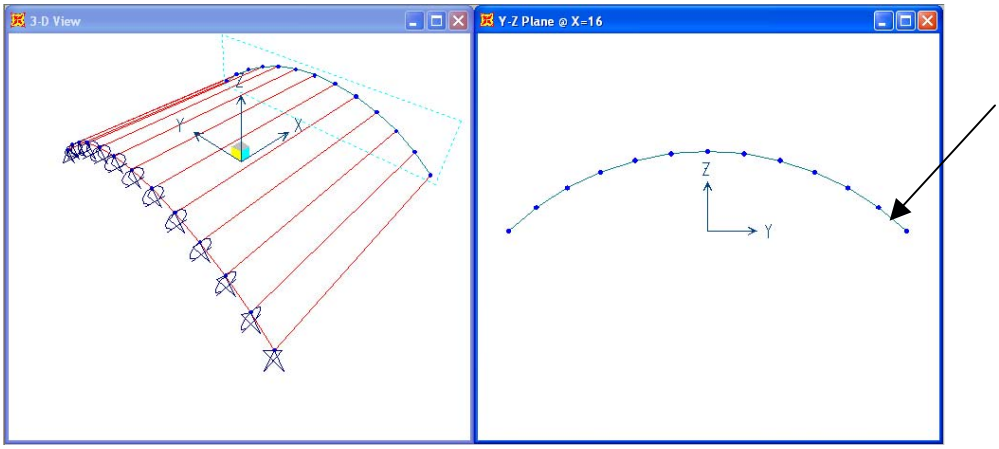
Enter a value of 43.6 as calculated for the **Roll Down Angle**

Click **OK** and the following screen will appear.

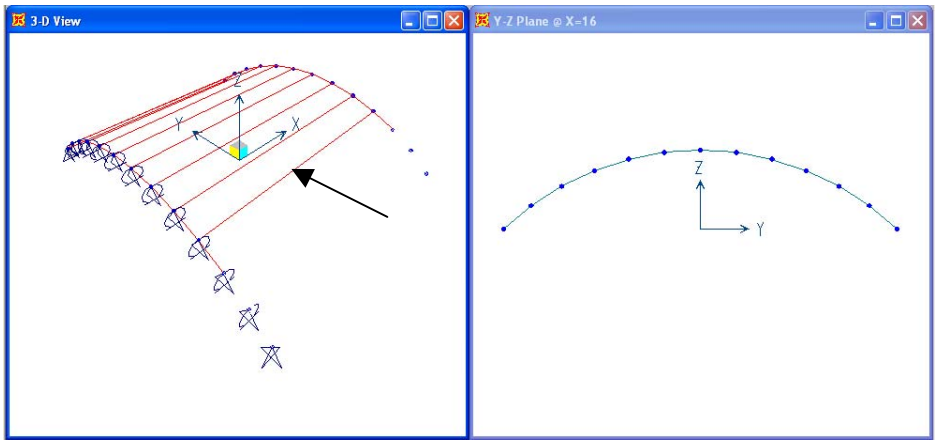


4. Make the **Y-Z Plane** screen active and turn off the gridlines by pressing **F7** or go to **View → Show Axes**.

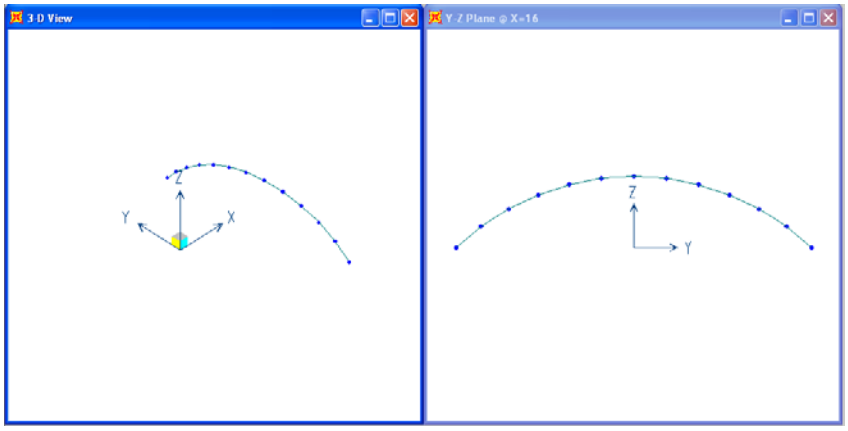
   Using the **Draw Frame Element** tool, connect the dots to make the arch.



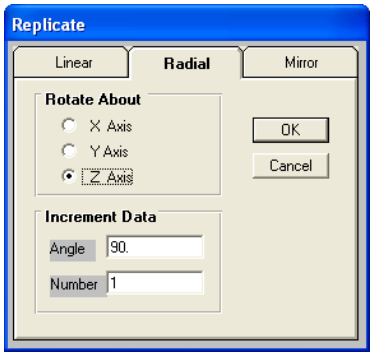
5. Make the **3-D View** window active, select the shell elements and press **Delete** on the keyboard or go to **Edit → Delete**. Continue deleting until all of the shell elements are gone – use the **Pencil** icon to refresh the page as needed.



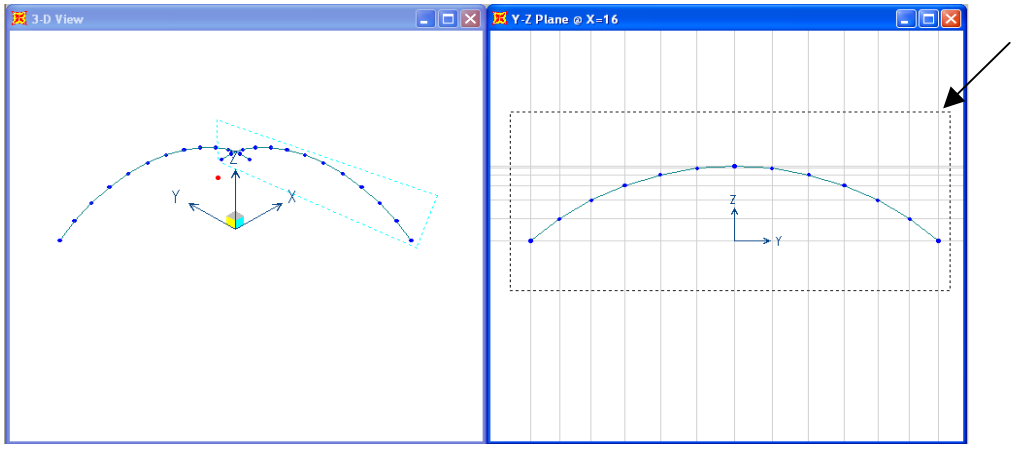
6. The following screen results at the end of this process. However, the arch is drawn in the Y-Z Plane and it needs to be rotated to the X-Z Plane.



7. To rotate the arch, select all of the joints and frames and go to **Edit → Replicate** (or **Ctrl + R**) to get the dialog box. Choose the **Radial** tab, select **Z-Axis**, enter an **Angle** of 90, and **Number** of 1. Click **OK**.

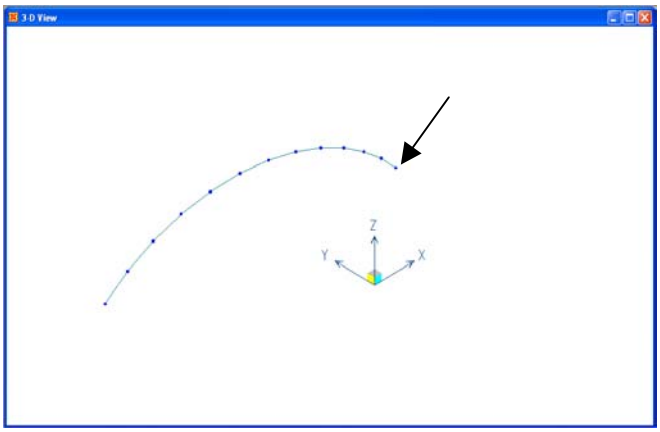


The screen will appear as below.



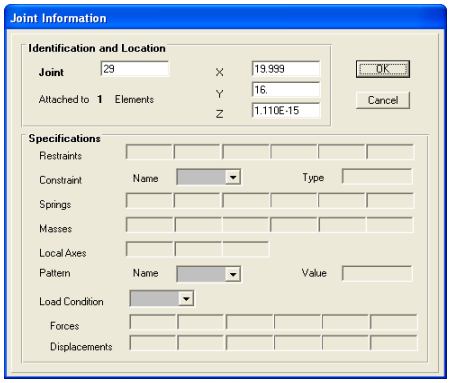
Make the **Y-Z Plane** active, select all the joints and members of the arch in that plane (drag a selection window as shown above) and then press **Delete** on the keyboard or go to **Edit → Delete**. Use the **Pencil** tool to refresh the screen in both windows.

The 3-D View screen will appear like this:



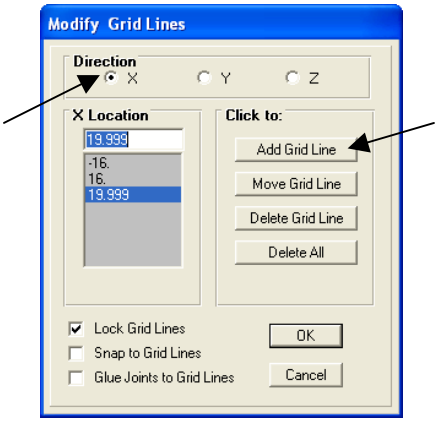
However, the arch won't be visible in the X-Z Plane because it does not coincide with any gridlines.

Right mouse click on the end joint to bring up the following screen. This shows that the joint is at X = 19.999 and Y = 16 (the opposite end of the arch will be at X = -19.999).

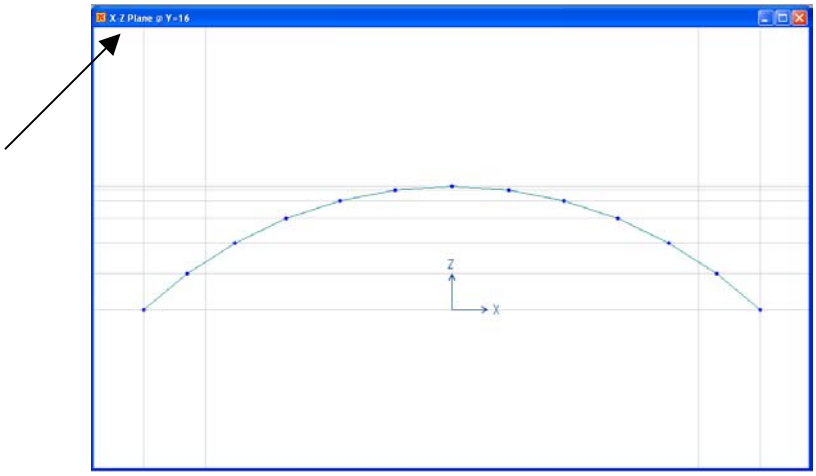


8. Go to **Draw → Edit Grid** to get the following dialog box:

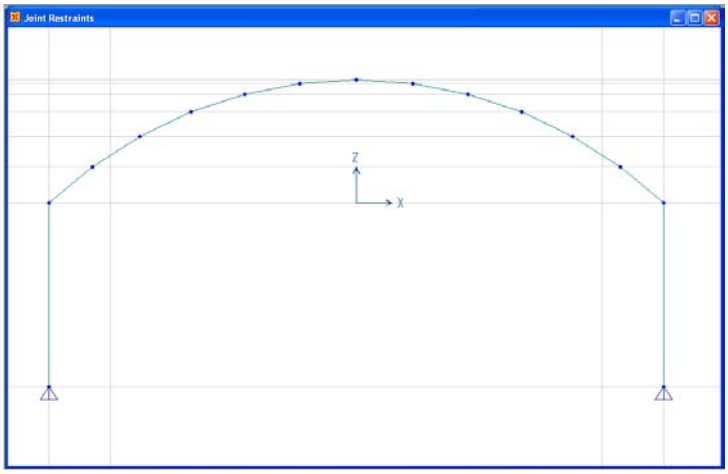
In the **X-Direction**, **Add Grid Line** at 19.999 and –19.999.
In the **Y-Direction**, **Add Grid Line** at 16.



9. Change the screen view to the X-Z Plane and scroll using the arrows to **X-Z Plane at Y=16** to get the following screen.

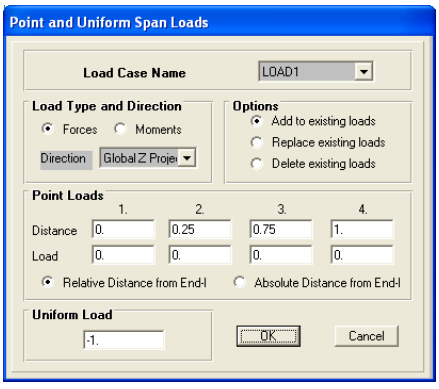


10. Add a gridline at Z= -12, **Draw** the columns, and **Assign** the Joint Restraints (pin supports).

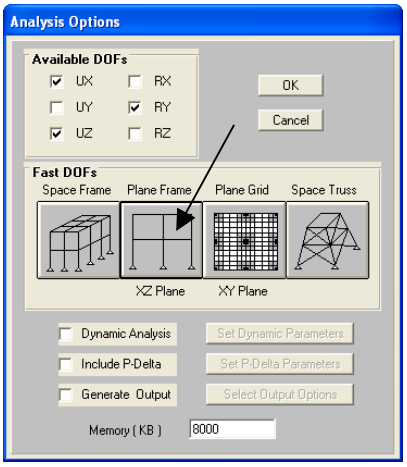


11. **Define → Static Load Cases** as before - change the **Self Weight Multiplier** to 0 and click **Change Load** and then **OK**.

12. Assign loads by choosing all the frame members of the arch and go to **Assign → Frame Static Loads → Point and Uniform** or use the **Shortcut Button**. Apply a **Uniform Load** of –1 klf on the **Global Z Projection**.



13. Set Analysis Options: go to **Analyze → Set Options** and choose **Plane Frame – XZ Plane**.



14. Analyze the model: go to **Analyze → Run**

15. Display diagrams as needed.