

Problem Z

Response Spectrum Analysis

Building Description

The building is a four-story concrete shear wall building with concrete flat slabs supported by concrete columns. There is a 30 foot high steel flagpole on the roof at one corner of the building. A 250 pound man sits on top of the flagpole.

Steel

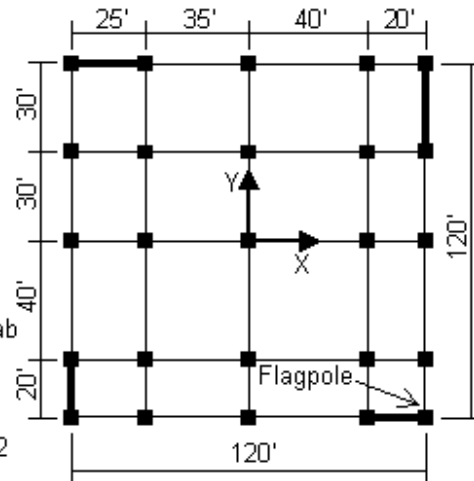
$E=29000$ ksi
Poissons Ratio = 0.3
Flagpole is 3" \varnothing standard pipe

Concrete

$E=3600$ ksi
Poissons Ratio = 0.2
Walls are 12" thick
Columns & beams are 20" x 20"
Floors & roof are 10" thick flat slab

Response Spectrum Loading

X-Dir (U1): 1994 UBC S2
Y-Dir (U2): 30% of 1994 UBC S2



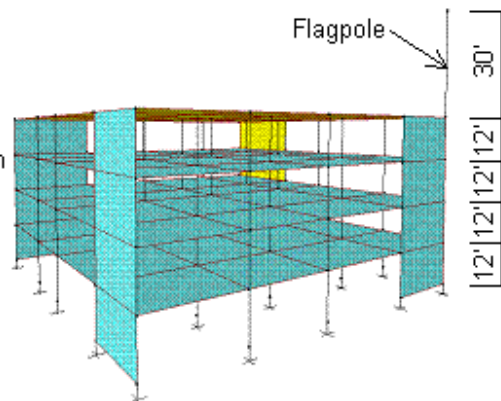
Typical Floor and Roof Plan

Assumptions

- Diaphragms are rigid in plane.
- Columns are fixed base.
- Consider the mass of the 250 pound man which is 0.00065 kip-sec²/in.

To Do

Determine maximum X-direction (U1) displacement at top and bottom of the flagpole for the specified response spectrum loading.



Three Dimensional Perspective View

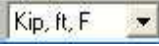
CSI Solution Demonstrates Use of These Features

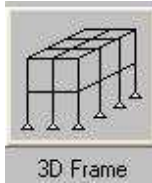
- Diaphragm Constraint
- Dynamic Analysis
- Grid Lines
- Mesh Areas
- Mode Shapes

- New Model From Template
- Linear Replication
- Response Spectrum Analysis

Problem Z Solution

1. Click the **File menu > New Model** command to display the **New Model** form.

2. Click the drop-down box in the status bar to change the units to .




3. Click on the **3D Frames** button to display the **3D Frames** form. In that form:



- Select *Open Frame Building* from the *3D Frame Type* drop-down list.
- Type **4** in the *Number of Stories* edit box.
- Type **4** in the *Number of Bays, X* edit box.
- Type **4** in the *Number of Bays, Y* edit box.
- Accept the default *Story Height*, 12.
- Type **30** in the *Bay width, X* edit box.
- Type **30** in the *Bay width, Y* edit box.
- Verify that the *Restraints* check box is checked.
- Click the **OK** button.

4. Click the **Define menu > Coordinate Systems/Grids** command to display the **Coordinate/Grid Systems** form. In that form:

- Click the **Modify/Show System** button to display the **Define Grid** form. In that form:
 - Verify that the *Ordinates* option is selected in the *Display Grids as* area in the middle right of the form.
 - Check the *Glue to Grid Lines* check box.
 - In the *X Grid Data* portion of the spreadsheet, click the -30 in the row 2 *Ordinate* cell and type **-35** in that cell. Click on the 30 in the row 4 *Ordinate* cell and type **40** in that cell.
 - In the *Y Grid Data* portion of the spreadsheet, click on the -30 in the row 2 *Ordinate* cell and type **-40** in that cell.
 - Click the **OK** buttons on the **Define Grid** and **Coordinate/Grid Systems** forms to exit all forms.

5. Verify that the 3-D View window is active. The window is active when its title is highlighted.

6. Click the **Set Display Options** button  to display the **Display Options for Active Window** form. In that form:

- Check the *Fill Objects* check box.
 - Click the **OK** button.
7. Click in the window labeled X-Y Plane @ Z=48 to activate it.
8. Click the **Set Display Options** button  to display the **Display Options for Active Window** form. In that form:
- Check the *Fill Objects* check box.
 - Click the **OK** button.
9. Click the **XZ View** button . The view switches to the X-Z plane @ Y=60 and appears as shown in Figure Z-1.

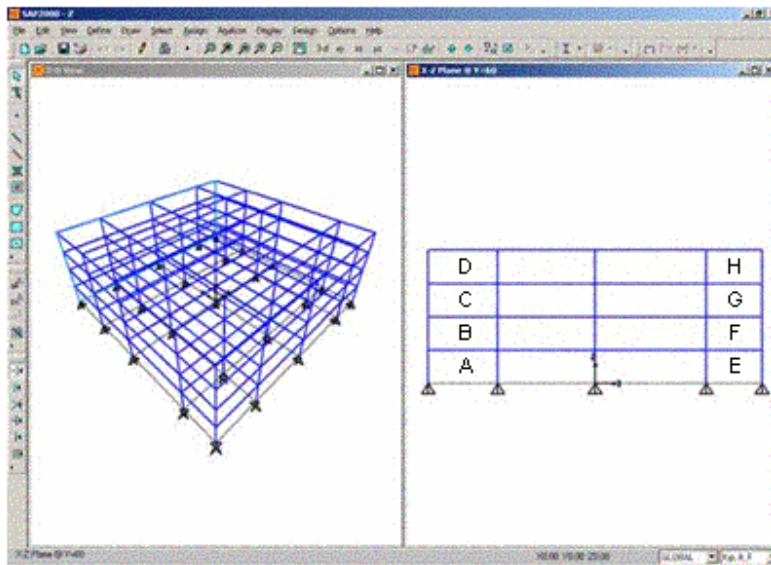



Figure Z-1: Screen After Step 9

10. Click the **Quick Draw Area** button  on the side toolbar to display the **Properties of Object** form.
11. Click once in each of the regions labeled “A,” “B,” “C” and “D” in Figure Z-1 to enter four area objects.
12. Click the **View menu > Set 2D View** command to display the **Set 2D View** form. In that form:
- Select the *X-Z Plane* option.
 - Type **-60** in the Y= edit box.
 - Click the **OK** button. The screen appears similar to that shown in Figure Z-1 (except that the location is now at Y=-60).
13. Click once in each of the regions labeled “E,” “F,” “G” and “H” in Figure Z-1 to enter four area objects.

14. Click the **View menu > Set 2D View** command to display the **Set 2D View** form. In that form:
 - Select the *Y-Z Plane* option.
 - Type **60** in the *X=* edit box.
 - Click the **OK** button. The screen appears as shown in Figure Z-

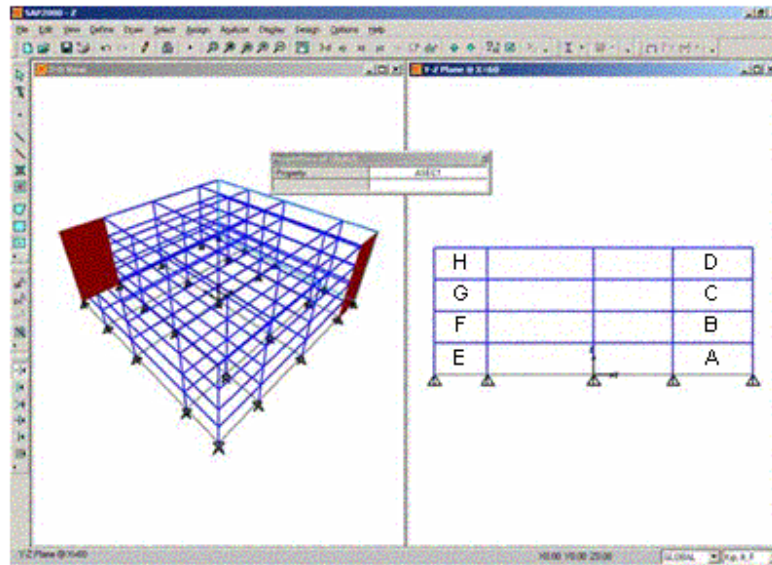

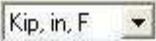
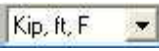









Figure Z-2: Screen After Step 14

15. Click once in each of the regions labeled “A,” “B,” “C” and “D” in Figure Z-2 to enter four area objects.
16. Click the **View menu > Set 2D View** command to display the **Set 2D View** form.
17. In that form:
 - Select the *Y-Z Plane* option.
 - Type **-60** in the *X=* edit box.
 - Click the **OK** button. The screen appears similar to that shown in Figure Z-2 (except that the location is now at *X=-60*).
18. Click once in each of the regions labeled “E,” “F,” “G” and “H” in Figure Z-2 to enter four area objects. This completes the drawing of the shear walls.
19. Click the **Set Select Mode** button  to exit draw mode and enter select mode.
20. Click the **Define menu > Materials** command to display the **Define Materials** form. In that form:
 - Highlight the **CONC** material and click the **Modify/Show Material** button to display the **Material Property Data** form. In that form:
 - Verify that the *Mass per unit Volume* is 4.662E-03.
 - Verify that the *Weight per unit Volume* is 0.15.

- Click the **OK** button on the **Material Property Data** form to return to the **Define Materials** form.
 - Highlight the STEEL material and click the **Modify/Show Material** button to display the **Material Property Data** form. In that form:
 - Verify that the *Mass per unit Volume* is 0.0152.
 - Verify that the *Weight per unit Volume* is 0.49.
 - Click the **OK** buttons on the **Material Property Data** and **Define Materials** forms to exit all forms.
21. Click the drop-down box in the status bar to change the units to .
22. Click the **Define menu > Materials** command to display the **Define Materials** form. In that form:
 - Highlight the CONC material and click the **Modify/Show Material** button to display the **Material Property Data** form. In that form:
 - Verify that the *Modulus of Elasticity* is 3600.
 - Verify that *Poisson's ratio* is 0.2.
 - Click the **OK** button to return to the **Define Materials** form.
 - Highlight the STEEL material and click the **Modify/Show Material** button to display the **Material Property Data** form. In that form:
 - Verify that the *Modulus of Elasticity* is 29000.
 - Verify that *Poisson's ratio* is 0.3.
 - Click the **OK** buttons on the **Material Property Data** and **Define Materials** forms to exit all forms.
23. Click the **Define menu > Frame Sections** command to display the **Frame Properties** form. In that form:
 - In the *Choose Property Type to Add* area, click the drop-down box that reads *Import I/Wide Flange* and then click on the *Import Pipe* item.
 - Click the **Add New Property** button to display the **Section Property File** form. In that form:
 - Locate the Sections.pro file, which should be located in the same directory as the SAP2000 program files. Highlight Sections.pro and click the **Open** button.
 - A form appears with a list of all pipe sections in the database. In that form:
 - Scroll down and click on the P3 (3" diameter standard pipe section) item.
 - Click the **OK** buttons on the **database** and **Pipe Section** forms to return to the **Frame Properties** form.
 - In the *Choose Property Type to Add* area, click the drop-down box that reads *Add I/Wide Flange* and then click on the *Add Rectangular* item.
 - Click the **Add New Property** button to display the **Rectangular Section** form. In that form:

- Type **BMCOL** in the *Section Name* edit box.
 - Select **CONC** from the *Material* drop-down box.
 - Type **20** in the *Depth (t3)* edit box.
 - Type **20** in the *Width (t2)* edit box.
 - Click the **OK** buttons on the **Rectangular Section** and **Frame Properties** forms to exit all forms.
24. Click the **Define menu > Area Sections** command to display the **Area Sections** form. In that form:
- Click the **Modify/Show Section** button to display the **Area Section Data** form. In that form:
 - Type **WALL** in the *Section Name* edit box.
 - Accept the default **CONC** material
 - In the *Area Type* area, verify that the *Shell* option is selected.
 - In the *Thickness* area, verify that both the *Membrane* and the *Bending thicknesses* are 12.
 - In the *Type* area, verify that the *Shell* option is selected.
 - Click the **OK** button to return to the **Area Sections** form.
 - Click the **Add New Section** button to display the **Area Section Data** form. In that form:
 - Type **FLOOR** in the *Section Name* edit box.
 - Accept the default **CONC** material.
 - Type **10** in the *Membrane* edit box.
 - Type **10** in the *Bending* edit box.
 - Click the **OK** buttons on the **Area Section Data** and **Area Sections** forms to exit all forms.
25. Click the drop-down box in the status bar to change the units to .
26. Click in the window labeled **Y-Z Plane @ X=-60** to verify it is active.
27. Click the **View menu > Set 2D View** command to display the **Set 2D View** form. In that form:
- Select the *X-Y Plane* option.
 - Type **48** in the *Z=* edit box.
 - Click the **OK** button.
28. Click the **Set Display Options** button  (or the **View menu > Set Display Options** command) to display the **Display Options for Active Window** form. In that form:
- Check the *Labels* box in the *Joints* area.
 - Click the **OK** button.

29. Click the **Draw Rectangular Area** button  on the side toolbar or the **Draw menu > Draw Rectangular Area** command to display the **Properties of Object** form. In that form:
- Verify that *FLOOR* is shown in the *Property* drop-down box.
31. Click on joint 25 and then joint 105 to enter a single area object for the entire floor.
32. Click the **Set Select Mode** button  to exit Draw mode and enter Select mode.
33. Select all objects in the X-Y Plane @ Z=48 by “windowing.”
34. Click the **Edit menu > Mesh Areas** command to display the **Mesh Selected Shells** form. In that form:
- Select the *Mesh using selected Joints on edges* option.
- Note:** The Mesh at intersections with grids option would work equally well.
- Click the **OK** button.
34. Select all objects in the X-Y Plane @ Z=48 by “windowing.”
35. Click the **Edit menu > Replicate** command to display the **Replicate** form. In that form:
- Verify the *Linear Tab* is selected.
 - In the *Distance* area type **-12** in the *dz* edit box.
 - Verify that 0 is entered in the *dx* and *dy* edit boxes.
 - Type **3** in the *Number* edit box.
 - Click the **OK** button to proceed with the replication and create the other floor diaphragms.
36. Click the **Select All** button  on the side toolbar.
37. Click the **Assign menu > Joint > Constraints** command to display the **Assign/Define Constraints** form. In that form:
- In the *Choose Constraint Type for Add* area click the drop-down box and select *Diaphragm*.
 - Click the **Add New Constraint** button to display the **Diaphragm Constraint** form. In that form:
 - Type **DIAPH** in the *Constraint Name* edit box.
 - Select the *Z Axis* option in the *Constraint Axis* area.
 - Check the *Assign a different diaphragm constraint to each different selected Z level* box. This will assign a diaphragm constraint at each floor level with the different diaphragms identified by their respective elevations.
 - Click the **OK** buttons on the **Diaphragm Constraint** and **Assign/Define Constraints** forms to exit all forms.
38. Click the **View menu > Set 2D View** command to display the **Set 2D View** form. In that form:
- Select the *X-Y Plane* option.

- Verify that 0 is entered in the $Z=$ edit box.
 - Click the **OK** button.
39. Select all objects at this level by “windowing.”
40. Click the **Assign menu > Joint > Restraints** command to display the **Joint Restraints** form. In that form:
- Click the **Fixed Support** button  in the *Fast Restraints* area.
 - Click the **OK** button.
41. Click the **Select All** button  on the side toolbar to select all objects.
42. Click the **Assign menu > Frame/Cable/Tendon > Frame Sections** command to display the **Frame Properties** form. In that form:
- Click on BMCOL in the *Properties* area to highlight it.
 - Click the **OK** button.
43. Click the **Show Undeformed Shape** button  to remove the displayed frame section assignments.
44. Click the **View menu > Set 2D View** command to display the **Set 2D View** form. In that form:
- Select the *X-Z Plane* option.
 - Type **-60** in the $Y=$ edit box.
 - Click the **OK** button.
45. Click the **Define menu > Coordinate Systems/Grids** command to display the **Coordinate/Grid Systems** form. In that form:
- Click the **Modify/Show System** button to display the **Define Grid** form. In that form:
 - Verify that the *Ordinates* option is selected in the *Display Grids as* area in the middle right of the form.
 - In the Z Grid Data portion of the spreadsheet, type **z6** in the *Grid ID* cell of row 6. In that same row, type **78** in the *Ordinate* cell and click in the *Line Type* cell to display *Primary*, the *Visibility* cell to display *Show*, and *Bubble Loc.* cell to display *Right*.
 - Click the **OK** buttons on the **Define Grid** and **Coordinate/Grid Systems** forms to exit all forms.
46. Click the **View menu > Set 2D View** command to display the **Set 2D View** form. In that form:
- Select the *X-Z Plane* option.
 - Type **-60** in the $Y=$ edit box.
 - Click the **OK** button. The screen appears as shown in Figure Z-3.

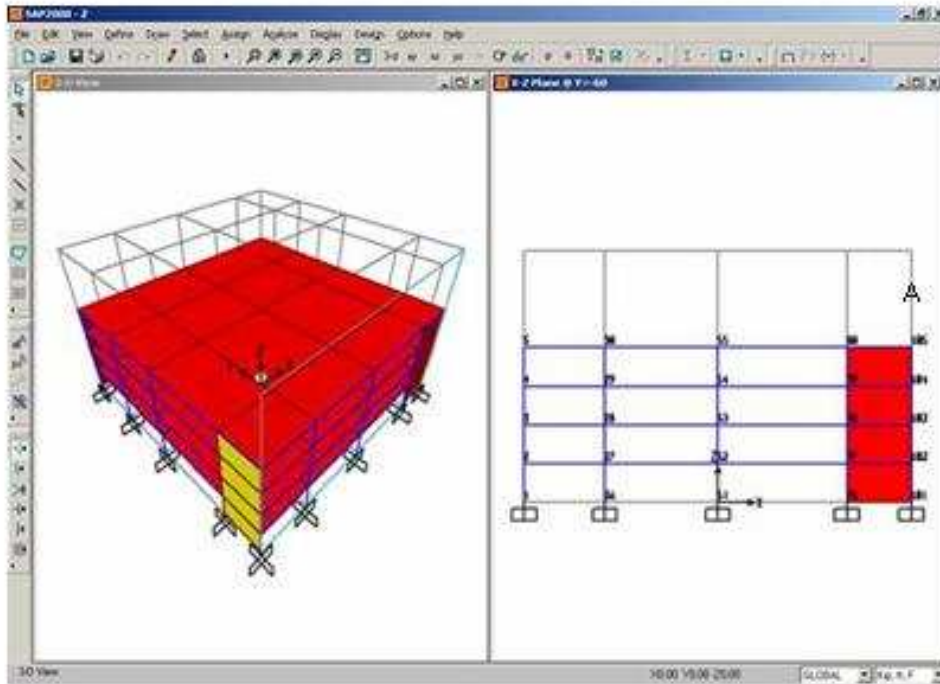




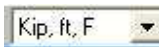




Figure Z-3: Screen After Step 46

47. Click the **Quick Draw Frame/CableTendon** button  on the side toolbar or the **Draw menu > Quick Draw Frame/Cable/Tendon** command to display the **Properties of Object** form. In that form:
 - Select *P3* from the *Property* drop-down box.
 - Verify that *Continuous* is shown in the *Moment Releases* drop-down box.
48. Click on the grid line at the point labeled “A” in Figure Z-3 to enter the flagpole frame object.
49. Click the **Set Select Mode** button  to exit Draw mode and enter Select mode.
50. Click the drop-down box in the status bar to change the units to .
51. Click on the joint at the top of the flagpole to select it.
52. Click the **Assign menu > Joint > Masses** command to display the **Joint Masses** form. In that form:
 - Type **.00065** in the *Direction 1*, *Direction 2* and *Direction 3* edit boxes.
 - Click the **OK** button.
53. Click the **Show Undeformed Shape** button  to remove the displayed joint mass assignments.
54. Click the drop-down box in the status bar to change the units to .

55. Click the **Define menu > Functions > Response Spectrum** command to display the **Define Response Spectrum Functions** form. In that form:
- In the *Choose Function Type to Add* area, click the drop-down box and select *UBC 94 Spectrum*.
 - Click the **Add New Function** button to display the **Response Spectrum UBC 94 Function Definition** form. In that form:
 - Type **SPEC1** in the *Function Name* edit box.
 - In the *Parameters* area, select 2 from the *Soil Type* drop-down list.
 - Click the **OK** buttons on the **Response Spectrum UBC 94 Function Definition** and **Define Response Spectrum Functions** forms to exit all forms.
56. Click the **Define menu > Analysis Cases** command to display the **Analysis Cases** form. In that form:
- Click the **Add New Case** button to display the **Analysis Case Data – Linear Static** form. In that form:
 - Type **RS1** in the *Analysis Case Name* edit box.
 - In the *Analysis Case Type* area, select *Response Spectrum* from the drop-down list.
 - Accept the default *Modal Combination* option, CQC.
 - Accept the default *Directional Combination* option, SRSS.
 - In the *Loads Applied* area:
 - Verify that *U1* is shown in the *Load Name* drop-down list.
 - Verify that *SPEC1* is shown in the *Function* drop-down list.
 - Type **32.2** in the *Scale Factor* edit box.
 - Click the **Add** button.
 - In the *Loads Applied* area:
 - Select *U2* in the *Load Name* drop-down list.
 - Verify that *SPEC1* is shown in the *Function* drop-down list.
 - Type **9.66** (.3*32.2=9.66) in the *Scale Factor* edit box.
 - Click the **Add** button.
 - Verify that *Modal Damping* is set to *Constant* at 0.05.
 - Click the **OK** button.
 - Click on MODAL in the *Case Name* list to highlight it.
 - Click the **Modify/Show Case** button to display the **Analysis Case Data - Modal** form. In that form:
 - Select the *Ritz Vectors* option in the *Type of Modes* area.
 - In the *Number of Modes* area, type **20** in the *Maximum Number of Modes* edit box.

- Select *Accel* from the *Load Type* drop-down box in the *Loads Applied* area.
 - Verify that *UX* is shown in the *Load Name* drop-down list.
 - Click on the **Add** button.
 - Select *UY* from the *Load Name* drop-down list.
 - Click on the **Add** button.
 - Click the **OK** buttons on the **Analysis Case Data – Modal** and **Analysis Cases** forms to exit all forms.
57. Click the **Run Analysis** button  to display the **Set Analysis Cases to Run** form. In that form:
- Click the **Run Now** button.
58. When the analysis is complete, check the messages in the **SAP Analysis Monitor** window (there should be no warnings or errors) and then click the **OK** button to close the window.
59. Click in the window with the elevation showing to make sure it is active.
60. Click the **View menu > Set 2D View** command to display the **Set 2D View** form. In that form:
- Select the *X-Z Plane* option.
 - Type **-60** in the *Y=* edit box.
 - Click the **OK** button.
61. Click the **Display menu > Show Deformed Shape** command to display the **Deformed Shape** form. In that form:
- Select *RS1* from the *Case/Combo Name* drop-down box.
 - Click the **OK** button.
62. Right click the joints at the top and bottom of the flagpole to see their displacements.

Note: If the top of the flagpole goes off of the screen when the deformed shape is displayed, click the **Zoom Out One Step** button  as many times as required to bring the joint back on to the screen.