EXAMPLE 2

Three-Story Plane Frame - Dynamic Response Spectrum Analysis

Problem Description

This is a three-story plane frame subjected to the El Centro 1940 seismic response spectra, N-S component, 5 percent damping.

Assuming the beams to be rigid and a rigid offset at the column top ends of 24 inches (i.e., equal to the depth of the beams), and neglecting both shear deformations and axial deformations, the story lateral stiffness for this example can be calculated (Przemieniecki 1968).

The example then reduces to a three-spring, three-mass system with equal stiffnesses and masses. This can be analyzed using any exact method (Paz 1985) to obtain the three natural periods and mass normalized mode shapes of the system.

The spectral accelerations at the three natural periods can then be linearly interpolated from the response spectrum used.

The spectral accelerations can in turn be used with the mode shapes and story mass information to obtain the modal responses (Paz 1985). The modal responses for story displacements and column moments can then be combined using the complete quadratic combination procedure (Wilson, et al. 1981).

Geometry, Properties and Loading

The frame is modeled as a two-column line, single bay system. Kip-inch-second units are used. Other parameters associated with the structure are as follows:

All columns are W14X90

All beams are infinitely rigid and 24" deep

Modulus of elasticity = 29500 ksi

Typical story mass = 0.4 kip-sec^2/in

The column is modeled to have infinite axial area, so that axial deformation is neglected. Also, zero column shear area is input to trigger the ETABS option of neglecting shear deformations. These deformations are neglected to be consistent with the hand-calculated model with which the results are compared.

The frame geometry is shown in Figure 2-1.

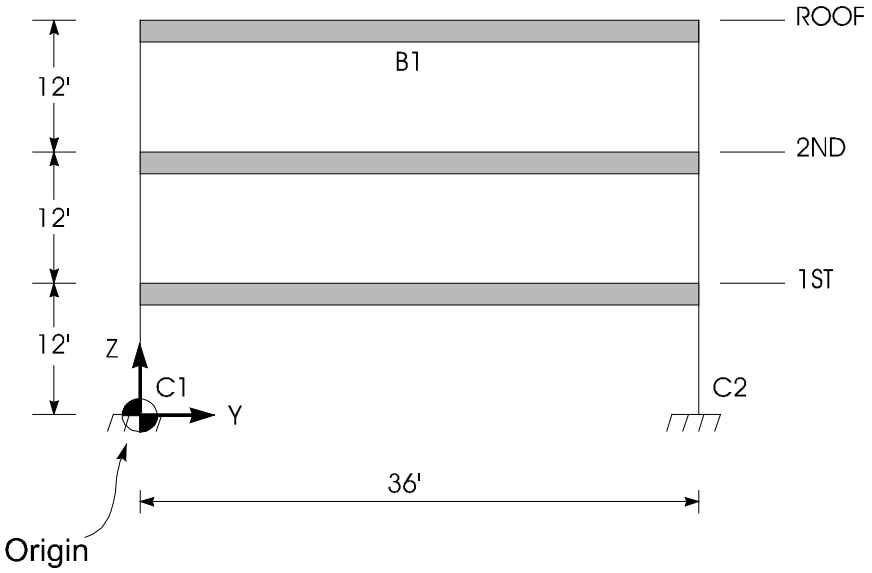

Figure 2-1 Three-Story Plane Frame

Technical Features in ETABS Tested

- Two-dimensional frame analysis
- Rigid joint offsets on beams and columns automatically calculated
- Dynamic response spectrum analysis

Results Comparison

The three theoretical natural periods and mass normalized mode shapes are compared in Table 2-1 with ETABS results.

Table 2-1 Comparison of Results for Periods and Mode Shapes

Mode	Period, secs.	Mode Shape	ETABS	Theoretical
1	0.4414	Roof Level	1.165	1.165
		2nd Level	0.934	0.934
		1st Level	0.519	0.519
2	0.1575	Roof Level	0.934	0.934
		2nd Level	-0.519	-0.519
		1st Level	-1.165	-1.165
3	0.1090	Roof Level	0.519	0.519

Table 2-1 Comparison of Results for Periods and Mode Shapes

Mode	Period, secs.	Mode Shape	ETABS	Theoretical
		2nd Level	-1.165	-1.165
		1st Level	0.934	0.934

The story displacements and column moments thus obtained are compared in Table 2-2 with ETABS results. The results are identical.

Table 2-2 Comparison of Displacements and Column Moments

Quantity	ETABS	Theoretical
Displacement at		
Roof	2.139	2.139
2nd	1.716	1.716
1st	0.955	0.955
Moment, Column C1, at Base	11,730	11,730

Computer Files

The input data file for this example is Example 02.EDB. The response spectrum file is ELCN-RS1. These files are provided as part of the ETABS installation.

Conclusion

The result comparison shows an exact match between the ETABS results and the theoretical data.