EXAMPLE 4

Single-Story, Three-Dimensional Frame - Dynamic Response Spectrum Analysis

Problem Description

This is a one-story, four-bay, three-dimensional frame. The frame is subjected to the El Centro 1940 N-S component seismic response spectrum, for 5 percent damping, in two orthogonal directions. The columns are modeled to neglect shear and axial deformations to be consistent with the assumptions of hand calculations with which the results are compared.

The example is a three-degree-of-freedom system. From the individual column lateral stiffnesses, assuming rigid beams and rigid offsets at column top ends equal to 36 inches (i.e., the depth of the beams) and neglecting both shear deformations and column axial deformations, the structural stiffness matrix can be assembled (Przemieniecki 1968).

Geometry, Properties and Loads

The frame geometry is shown in Figure 4-1.
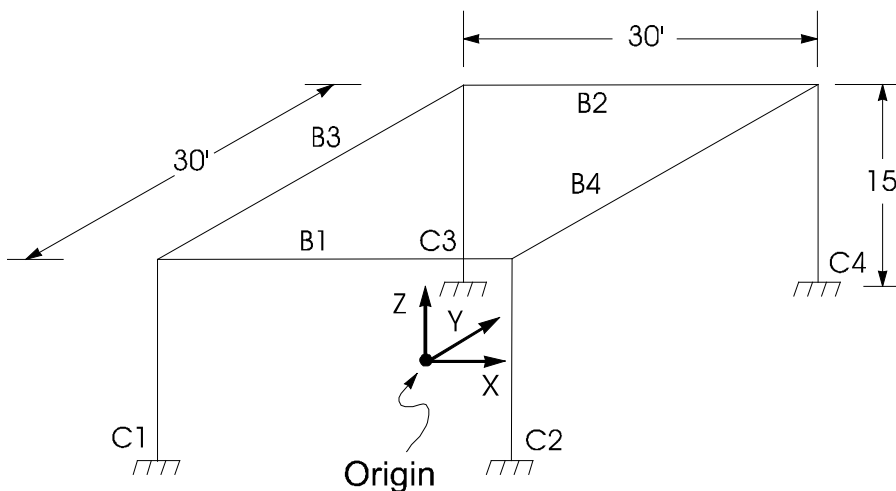
Figure 4-1 Single-Story Three-Dimensional Frame

The structure is modeled as a single frame with four column lines and four bays. Kip-inch-second units are used. Other parameters associated with the structure are as follows:

Columns on lines C1 and C2: 24" x 24"

Columns on lines C3 and C4: 18" x 18"
All beams infinitely rigid and 36" deep

Modulus of elasticity   = 3000 ksi
Story weight   =   150 psf

Technical Features of ETABS Tested

➢ Three-dimensional frame analysis

➢ Automatic story mass calculation

➢ Dynamic response spectrum analysis

Results Comparison

From the stiffness and mass matrices of the system, the three natural periods and mass normalized mode shapes of the system can be obtained (Paz 1985). These are compared in Table 4-1 with ETABS results.

Table 4-1 Comparison of Results for Periods and Mode Shapes

Mode	Quantity	ETABS	Theoretical
1	Period, sec.	0.1389	0.1389
	Mode Shape		
	X-translation	-1.6244	-1.6244
	Y-translation	0.0000	0.000
	Z-rotation	0.0032	0.0032
2	Period, sec.	0.1254	0.1254
	Mode Shape		
	X-translation	0.000	0.000
	Y-translation	1.6918	1.6918
	Z-rotation	0.000	0.000
3	Period,sec.	0.0702	0.070
	Mode Shape		
	X-translation	0.4728	0.4728
	Y-translation	0.000	0.000
	Z-rotation	0.0111	0.0111

Computer File

The input data file for this example is Example 04.EDB. This file is provided as part of the ETABS installation.

Conclusion

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