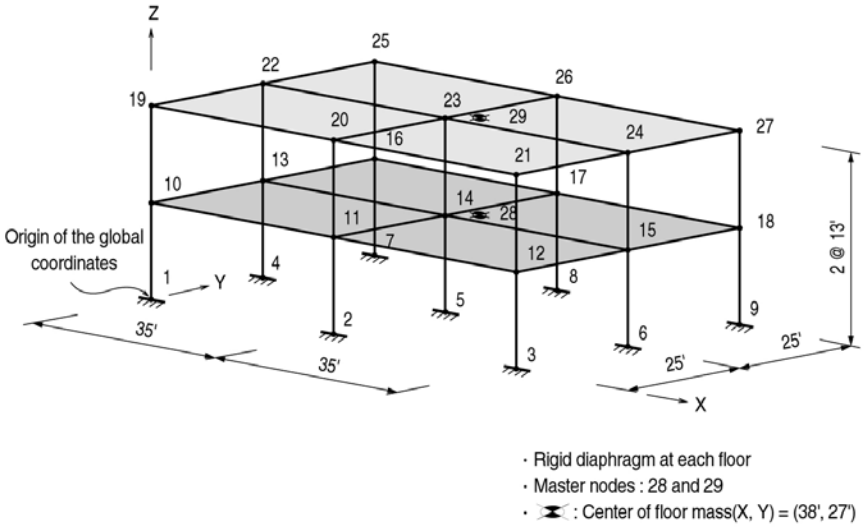
RS-4

Title

3-D, 2-story frame structure

Description

Given is a 3-D, 2-story frame structure with rigid diaphragm floors.
Calculate the natural periods of the structure.
Determine the displacements at each floor.
The structure is symmetrical in both directions in plan. The center of gravity at each floor is eccentric from the geometric center.



Structural geometry and analysis model

Model

Analysis Type

3-D response spectrum analysis

Unit System

ft, kip

Dimension

Length 70 ft Width 50 ft Height 26 ft

Floor mass $M_x = M_y = 6.21118$ kips · sec^2/ft

Damping ratio $\xi = 0.04$ (4 %)

Gravitational acceleration $g = 32.2$ ft/sec^2

Response spectrum data (Accelerations with respect to periods)

Unit : ft/sec^2

Period(sec)	0.0	100.0
X acceleration	0.4	0.4

Element

Beam element

Material

Modulus of elasticity $E_{column} = 3.5 \times 10^5$ ksf

$E_{beam} = 5.0 \times 10^5$ ksf

Section Property

Columns	Area	$A = 4.00$ ft^2
	Moment of inertia	$I_{yy} = 1.25$ ft^4 $(=I_{zz})$
Beams	Moment of inertia	$I_{yy} = 2.61$ ft^4 (Strong axis)

Boundary Condition

Nodes 1 ~ 9 ; Constrain all DOFs.

Nodes 28, 29 ; Constrain Dx, Dy and Rz of all nodes at each floor to these nodes. (Master nodes)

Analysis Case

Floor masses are assigned to the master nodes at each floor in the directions of X and Y-axes.

The response spectrum data are applied in the X direction.

Number of natural frequencies to be computed = 4

Method of Mode Combination

SRSS (Square Root of the Sum of the Squares)

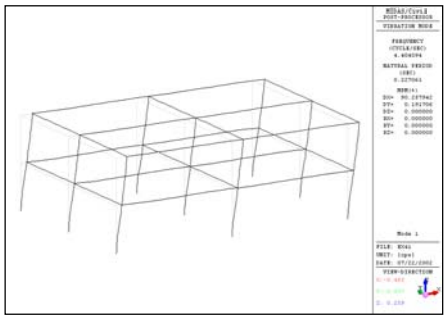
Results

Eigenvalue analysis results

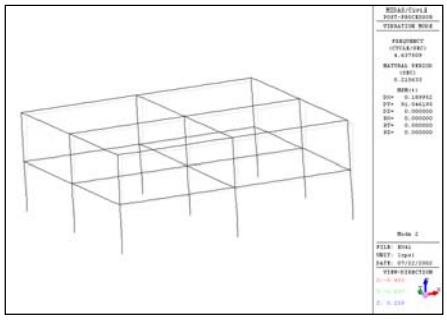
	Node	Mode	UX	UY	UZ	RX	RY	RZ
	EIGENVALUE ANALYSIS							
		Mode No	Frequency (rad/sec)	(cycle/sec)	Period (sec)	Tolerance		
		1	27,671740	4,404094	0,227061	0,0000e+000		
		2	29,138329	4,637509	0,215633	9,3730e-016		
		3	85,666069	13,634178	0,073345	7,4359e-016		
		4	87,260445	13,887931	0,072005	1,5647e-014		

Displacement results

	Node	Load	DX (ft)	DY (ft)	DZ (ft)	RX ([rad])	RY ([rad])	RZ ([rad])
▶	29	RX	0.020119	0.001236	0.000000	0.000000	0.000000	0.000032

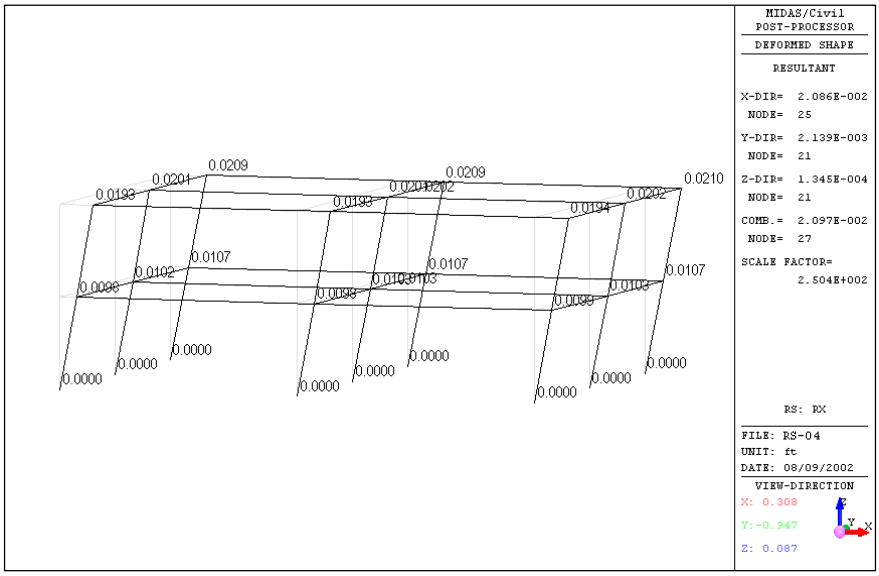


(a) 1st vibration mode



(b) 2nd vibration mode

Vibration modes of the structure



Displacements for the structure

Comparison of Results

Natural Periods

Unit : sec

Mode of vibration	Ref. 1	SAP2000	MIDAS/Civil
1 *st*	0.2271	0.2271	0.2271
2 *nd*	0.2156	0.2156	0.2156
3 *rd*	0.0733	0.0733	0.0733
4 *th*	0.0720	0.0720	0.0720

Global X-displacement at the Master Node 29

Unit : ft

Node	Ref. 1	SAP2000	MIDAS/Civil
29	0.0201	0.0201	0.0201

References

Peterson, F. E., "*EASE2, Elastic Analysis for Structural Engineering, Example Problem Manual*", Engineering Analysis Corporation, Berkeley, California, 1981.

"*SAP90, A Series of Computer Programs for the Finite Element Analysis of Structures, Structural Analysis Verification Manual*", Computer and Structures, Inc., 1992, Example 3.