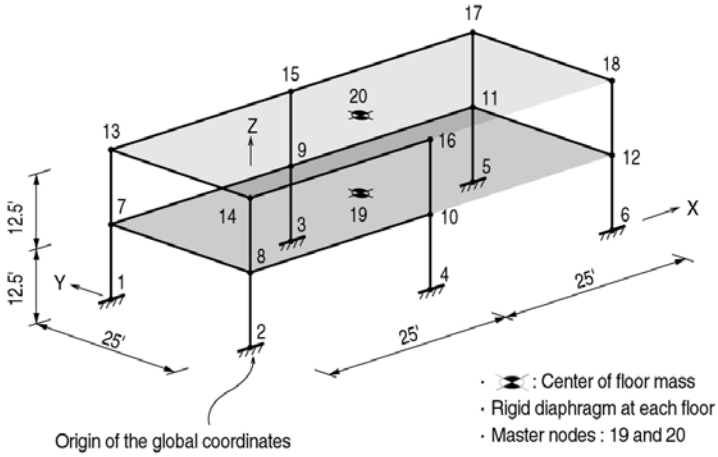
RS-3

Title

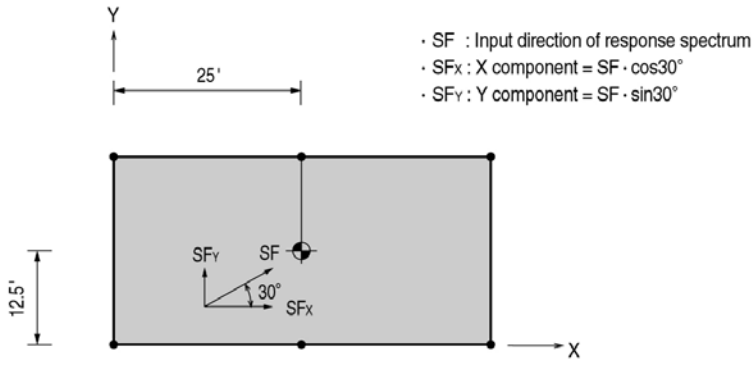
3-D, 2-story unsymmetrical structure

Description

Assume that each floor acts as a rigid diaphragm.
Calculate the natural frequencies.
Perform a response spectrum analysis.



(a) Structural analysis model



(b) Floor plan (Input direction of response spectrum)

Structural geometry and structural analysis model

Model

Analysis Type

3-D response spectrum analysis

Unit System

ft, kip

Dimension

Length 50 ft Width 25 ft Height 25 ft

Floor mass $M_x = M_y = 3.88$ kips $\cdot$ sec^2/ft

Rotational mass moment of inertia $M_{zz} = 1011$ kips $\cdot$ sec^2$\cdot$ft

Damping ratio $\xi = 0.05$ (5 %)

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

Response spectrum data (Accelerations with respect to periods)

Unit : ft/sec^2

Period(sec)	0.0	0.1	0.125	0.167	0.182	0.200	0.250	0.333
Acceleration	0.400	0.581	0.628	0.787	0.9439	1.0056	0.7980	0.8806
Period (sec)	0.431	0.500	0.667	1.000	1.273	2.000	10.00	100.0
Acceleration	0.9212	1.0466	0.6418	0.4822	0.2586	0.1602	0.0102	0.0

Element

Beam element

Material

Modulus of elasticity $E = 432000$ ksf

Section Property

Columns	Area	$A = 2.25$ ft^2
	Moment of inertia	$I_{yy} = 0.4219$ ft^4 $(= I_{zz})$
Beams	Moment of inertia	$I_{yy} = 0.6667$ ft^4

Boundary Condition

Nodes 1 ~ 6 ; Constrain all DOFs.

Nodes 19 and 20 ; 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. Mass moment of inertia about Z-axis is assigned to each master nodes. The response spectrum data act in the direction 30 degrees counterclockwise from the X-axis.

Number of natural frequencies to be computed = 6

Results

Eigenvalue Analysis Results

EIGENVALUE ANALYSIS

Mode No	Frequency (rad/sec)	Frequency (cycle/sec)	Period (sec)	Tolerance
1	15,154782	2,411959	0,414601	6,1876e-016
2	16,741843	2,664547	0,375298	0,0000e+000
3	25,795993	4,105560	0,243572	3,4169e-016
4	54,729236	8,710428	0,114805	1,4878e-014
5	56,964908	9,066247	0,110299	4,0640e-015
6	86,225648	13,723238	0,072869	8,8688e-014

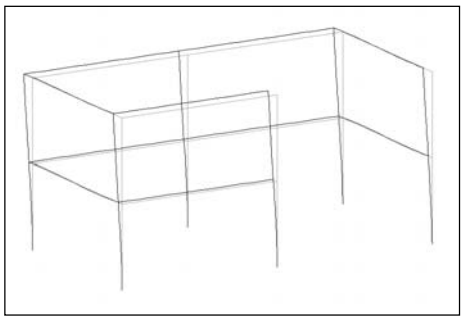
MODAL PARTICIPATION MASSES(%) PRINTOUT

Mode No	TRAN-X		TRAN-Y		TRAN-Z		ROTN-X		ROTN-Y		ROTN-Z	
	MASS	SUM	MASS	SUM	MASS	SUM	MASS	SUM	MASS	SUM	MASS	SUM
1	0,00	0,00	86,57	86,57	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
2	86,97	86,97	0,00	86,57	0,00	0,00	0,00	0,00	0,00	0,00	1,00	1,00
3	1,19	88,16	0,00	86,57	0,00	0,00	0,00	0,00	0,00	0,00	87,60	88,61
4	0,00	88,16	13,43	100,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	88,61
5	11,83	99,99	0,00	100,00	0,00	0,00	0,00	0,00	0,00	0,00	0,12	88,73
6	0,01	100,00	0,00	100,00	0,00	0,00	0,00	0,00	0,00	0,00	11,27	100,00

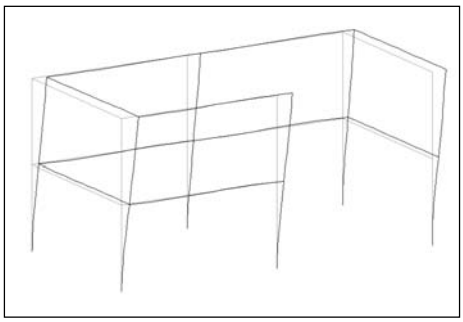
EIGENVECTOR

Displacements

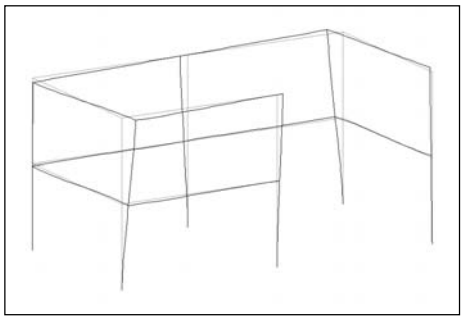
	Node	Load	DX (ft)	DY (ft)	DZ (ft)	RX ([rad])	RY ([rad])	RZ ([rad])
▶	19	RESP	0.048868	0.034028	0.000000	0.000000	0.000000	0.000323
	20	RESP	0.105880	0.078156	0.000000	0.000000	0.000000	0.000796



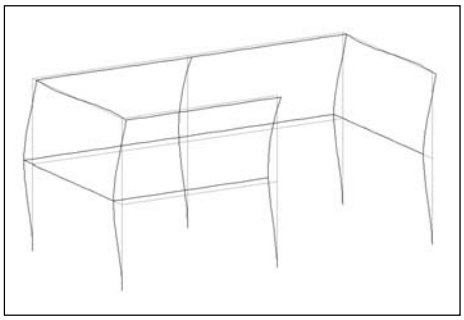
(a) 1st vibration mode



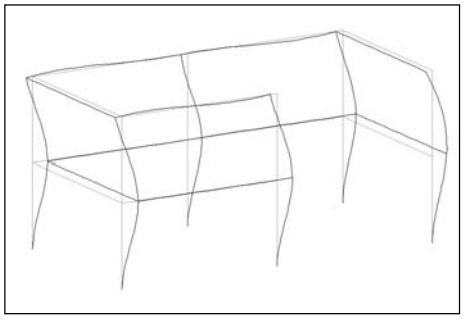
(b) 2nd vibration mode



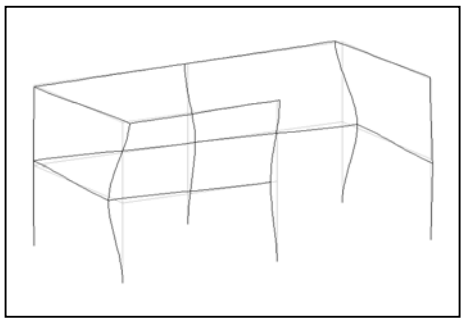
(c) 3rd vibration mode



(d) 4th vibration mode



(e) 5th vibration mode



(f) 6th vibration mode

Vibration modes of the structure

Comparison of Results

Unit : sec

Vibration mode	Natural period	
	SAP2000	MIDAS/Civil
1 *st*	0.4146	0.4146
2 *nd*	0.3753	0.3753
3 *rd*	0.2436	0.2436
4 *th*	0.1148	0.1148
5 *th*	0.1103	0.1103
6 *th*	0.0729	0.0729

Unit : ft

Node	Displacement component	Displacement at the master node	
		SAP2000	MIDAS/Civil
19	X displacement	0.0489	0.0489
	Y displacement	0.0341	0.0340
	Z rotational displacement	0.0003	0.0003
20	X displacement	0.1060	0.1059
	Y displacement	0.0782	0.0782
	Z-rotational displacement	0.0008	0.0008

Reference

"*SAP90, A Series of Computer Programs for the Finite Element Analysis of Structures, Structural Analysis Verification Manual*", Computer and Structures, Inc., 1992, Example 8.

Response Spectrum Data