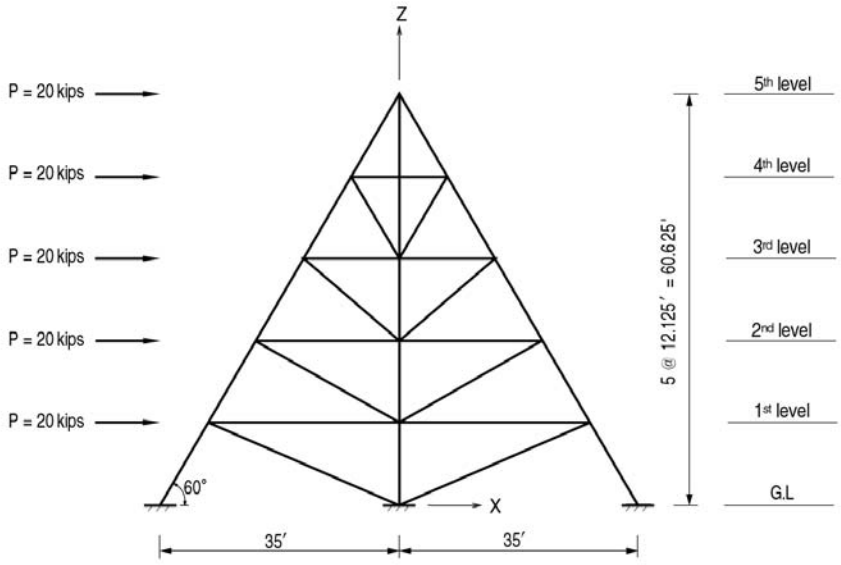
Eigen-9

Title

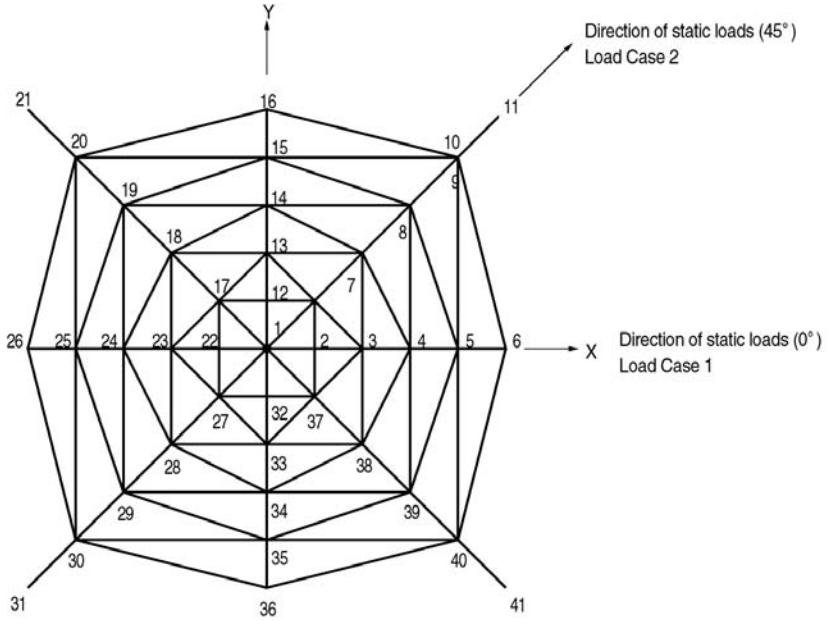
Eigenvalue and static analysis of a 5- level pyramid building under lateral loads.

Description

Perform the eigenvalue analysis of a pyramid building. Calculate the natural frequencies and the displacements of each floor due to static lateral loads.

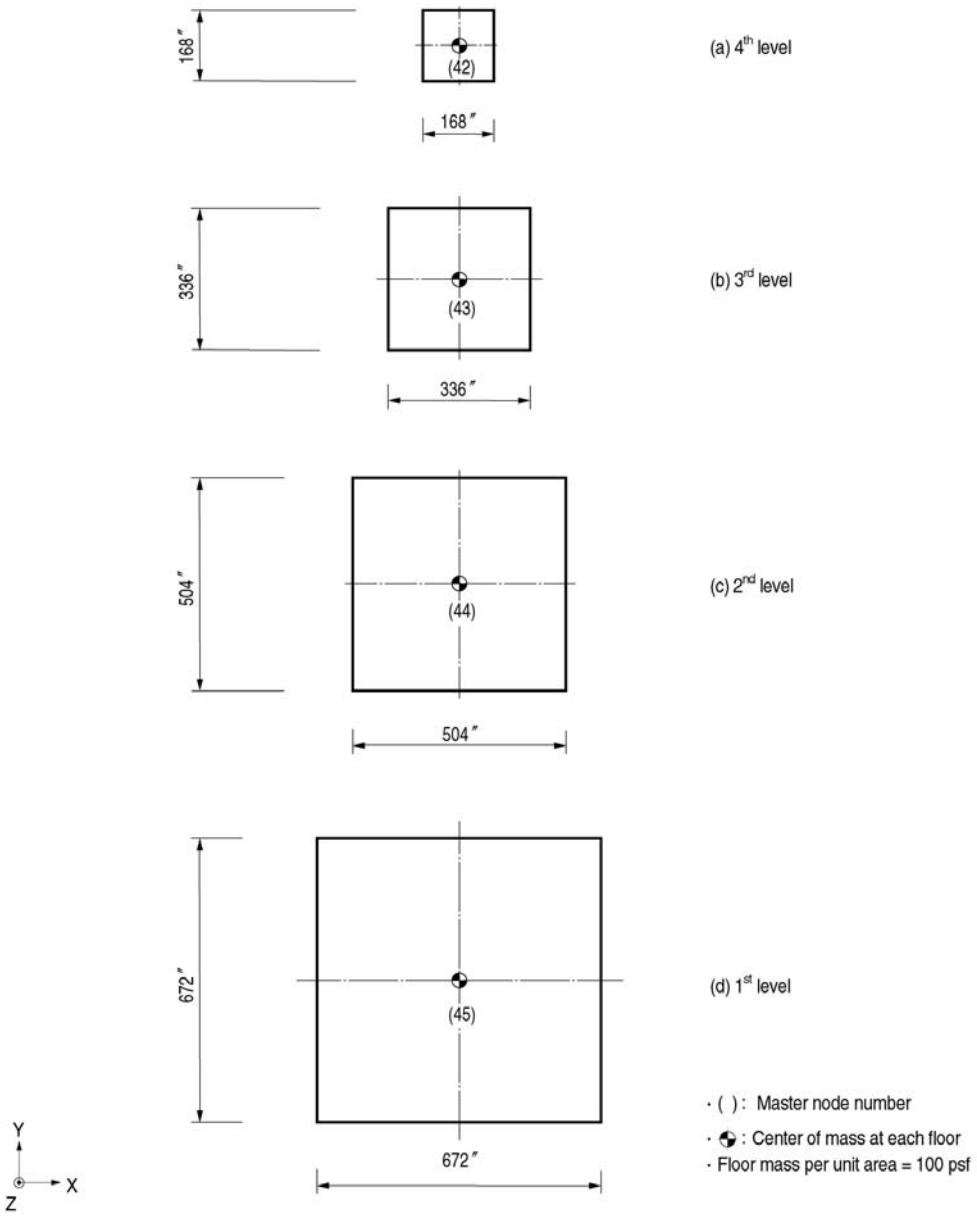


(a) Elevation of the structure



(b) Plan of the structure

Stuctural analysis model



Plan dimensions of each floor

Model

Analysis Type

3-D static and eigenvalue analysis

Unit System

in, kip

Dimension

Length 70 × 12 in Width 70 × 12 in Height 5 × 12.125 × 12 in

Floor load W = 100 psf

Floor mass $M = 1.7972 \times 10^{-6}$ kips·sec^2/in

Nodes 42 ~ 45 are the master nodes for the 4th ~ 1st levels in a decending order respectively.

Gravitational acceleration g = 386.4 in/ sec^2

Mass and rotational mass moment of inertia at each floor.

Floor	Master node	Mass, M_X=M_Y	Rotational mass moment of inertia, I_m
4	42	0.0507246	238.6087
3	43	0.2028986	3817.7391
2	44	0.4565217	19327.3044
1	45	0.8115942	61083.8261

Element

Beam element

Material

Modulus of elasticity E = 29500 ksi

Poisson's ratio ν = 0.3

Section Property

Horizontal beams	Area	A	= 13.5 in^2
	Effective Shear Area	A_{sy}	= 6.5016 in^2
		A_{sz}	= 6.1105 in^2
	Torsional stiffness	I_{xx}	= 1.22 in^4
	Moment of inertia	I_{yy}	= 712.0 in^4 (Strong axis)
		I_{zz}	= 22.5 in^4 (Weak axis)
Diagonals	Area	A	= 11.7 in^2
	Effective Shear Area	A_{sy}	= 2.97 in^2
		A_{sz}	= 7.532 in^2
	Torsional stiffness	I_{xx}	= 1.12 in^4
	Moment of inertia	I_{yy}	= 146.0 in^4 (Strong axis)
		I_{zz}	= 49.1 in^4 (Weak axis)

Boundary Condition

Nodes 6 ~ 41 (at an increment of 5) ; Constrain all DOFs.

Nodes 42 ~ 45 ; Constrain Dx, Dy and Rz of all nodes at each level to these nodes. (Master nodes)

Analysis Case

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

Rotational mass moment of inertia about Z- axis, $I_m = M \times (b^2+h^2)/12$ is assigned to each master node..

Load Case 1 ; A lateral load, 20 kips is applied to the master nodes at each floor in the X direction.

Load Case 2 ; A lateral load, 20 kips is applied to the master nodes at each floor in the direction 45 degrees counterclockwise from the X-axis.

Number of natural frequencies to be computed = 9

Results

Eigenvalue Analysis Results

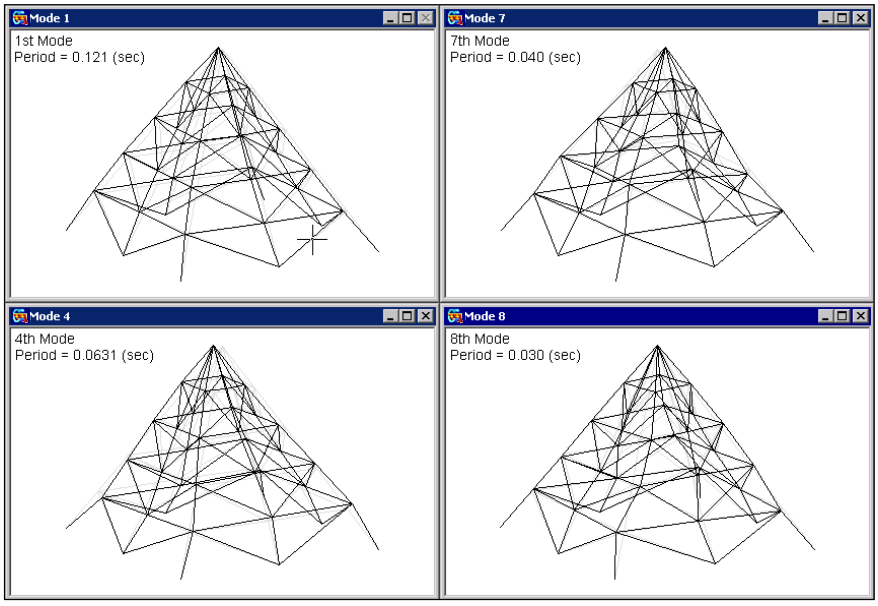
EIGENVALUE ANALYSIS					
Mode No	Frequency (rad/sec)	Frequency (cycle/sec)	Period (sec)	Tolerance	
1	51,936044	8,265878	0,120979	6,7436e-016	
2	51,936044	8,265878	0,120979	5,0577e-016	
3	99,591127	15,850420	0,063090	3,6679e-016	
4	99,591127	15,850420	0,063090	3,6679e-016	
5	103,027287	16,397302	0,060986	0,0000e+000	
6	158,020893	25,149806	0,039762	1,6026e-015	
7	158,020893	25,149806	0,039762	2,3310e-015	
8	212,034308	33,746308	0,029633	7,2341e-014	
9	263,121148	41,877031	0,023879	1,1560e-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	2,03	2,03	94,88	94,88	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
2	94,88	96,91	2,03	96,91	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
3	1,42	98,33	0,95	97,85	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
4	0,95	99,28	1,42	99,28	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
5	0,00	99,28	0,00	99,28	0,00	0,00	0,00	0,00	0,00	0,00	95,04	95,04
6	0,09	99,37	0,61	99,89	0,00	0,00	0,00	0,00	0,00	0,00	0,00	95,04
7	0,61	99,98	0,09	99,98	0,00	0,00	0,00	0,00	0,00	0,00	0,00	95,04
8	0,00	99,98	0,00	99,98	0,00	0,00	0,00	0,00	0,00	0,00	4,94	99,97
9	0,02	100,00	0,00	99,98	0,00	0,00	0,00	0,00	0,00	0,00	0,00	99,97

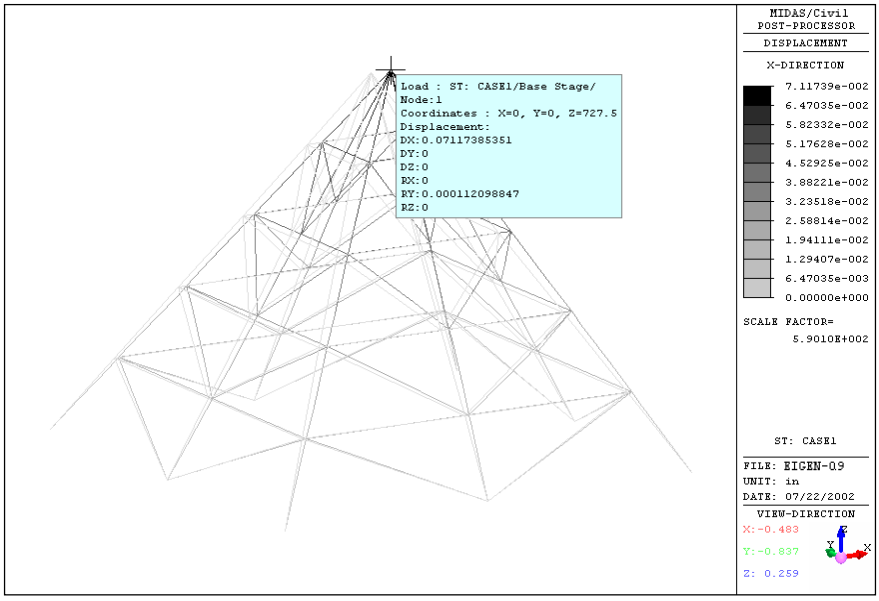
EIGEN VECTOR								

Displacements

	Node	Load	DX (in)	DY (in)	DZ (in)	RX ([rad])	RY ([rad])	RZ ([rad])
▶	1	CASE1	0.071174	0.000000	0.000000	0.000000	0.000112	0.000000
	42	CASE1	0.054813	0.000000	0.000000	0.000000	0.000000	0.000000
	43	CASE1	0.040476	0.000000	0.000000	0.000000	0.000000	0.000000
	44	CASE1	0.027948	0.000000	0.000000	0.000000	0.000000	0.000000
	45	CASE1	0.015033	0.000000	0.000000	0.000000	0.000000	0.000000
	1	CASE2	0.050327	0.050327	0.000000	-0.000079	0.000079	0.000000
	42	CASE2	0.038758	0.038758	0.000000	0.000000	0.000000	0.000000
	43	CASE2	0.028621	0.028621	0.000000	0.000000	0.000000	0.000000
	44	CASE2	0.019762	0.019762	0.000000	0.000000	0.000000	0.000000
	45	CASE2	0.010630	0.010630	0.000000	0.000000	0.000000	0.000000



Vibration modes of the structure



X-displacements of the structure (Node 1)

Comparison of Results

Natural Periods

Unit : sec

Mode	Natural period	
	ETABS	MIDAS/Civil
1st	0.12098	0.12098
2nd	0.12098	0.12098
3rd	0.06309	0.06309
4th	0.06309	0.06309
5th	0.06099	0.06099
6th	0.03976	0.03976
7th	0.03976	0.03976
8th	0.02963	0.02963
9th	0.02388	0.02388

Displacements at each level

Unit : in

Load Case	Level	Displacement			
		ETABS		MIDAS/ Civil	
		δ_X	δ_Y	δ_X	δ_Y
1	1st	0.01503		0.01503	
	2nd	0.02795		0.02795	
	3rd	0.04048		0.04048	
	4th	0.05481		0.05481	
	5th	0.07117		0.07117	
2	1st	0.01063	0.01063	0.01063	0.01063
	2nd	0.01976	0.01976	0.01976	0.01976
	3rd	0.02862	0.02862	0.02862	0.02862
	4th	0.03876	0.03876	0.03876	0.03876
	5th	0.05033	0.05033	0.05033	0.05033

Reference

"*ETABS, Examples Manual*", Version 6.0 Computers and Structures, Inc., Berkeley, California, 1994, Example 18.