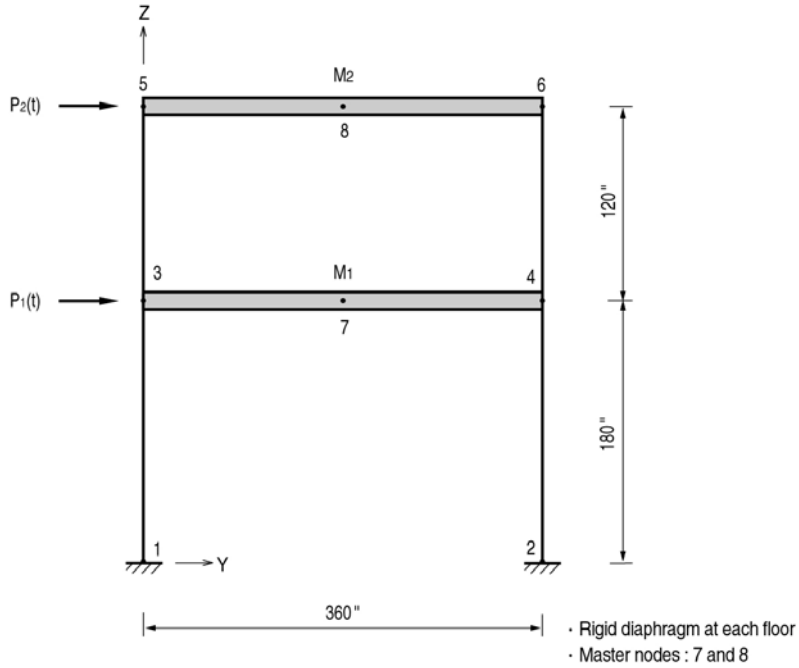
TH-4

Title

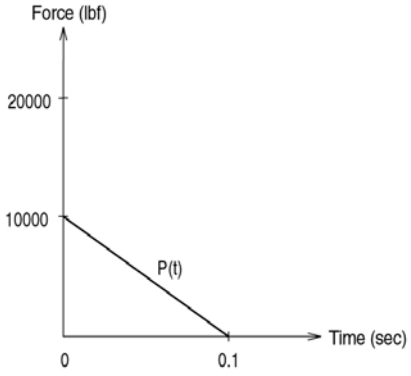
Dynamic modal response for 2-D rigid frame

Description

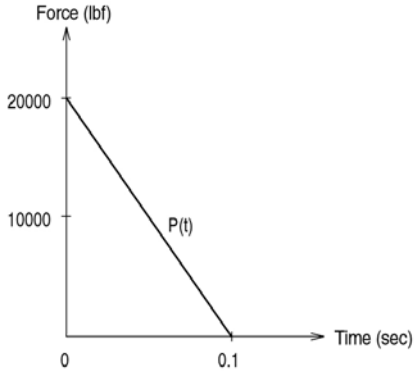
Perform a time history analysis of a structure under lateral dynamic loads.
Calculate the natural frequencies, the maximum displacement and the corresponding time.



(a) 2-D rigid frame under lateral loads



(b) Impulse at the 1st floor



(c) Impulse at the 2nd floor

Structural geometry and analysis model

Model

Analysis Type

2-D time history analysis

Unit System

in, lbf

Dimension

Length	L	= 360 in
Level height	H_1 (1^{st})	= 180 in
	H_2 (2^{nd})	= 120 in
Mass	M_1 (1^{st})	= 136 lbf · sec^2/in (in the Y direction)
	M_2 (2^{nd})	= 66 lbf · sec^2/in (in the Y direction)
Analysis time	t	= 0.2 sec
Time step	Δt	= 0.001 sec

Element

Beam Element

Material

Modulus of elasticity $E = 30 \times 10^6$ psi

Section Property

Columns (1^{st} floor)	Moment of inertia	$I_{yy} = 248.6$ in^4
Columns (2^{nd} floor)	Moment of inertia	$I_{yy} = 106.3$ in^4
Beams	Moment of inertia	$I_{yy} = 1.0 \times 10^{15}$ in^4 (Rigid)

Boundary Condition

Nodes 1 and 2	; Constrain all DOFs.
Nodes 3 ~ 6	; Constrain Dz and Rx. (Only Dy allowed)
Nodes 7 and 8	; Constrain Dy of all nodes at each floor to these nodes. (Master nodes)

Analysis Case

Impulse loads are applied in the Y direction.

1st floor ; $P_1(t) = 10000(1\text{-}t/td)$ lbf $(td = 0.1)$

2nd floor ; $P_2(t) = 20000(1\text{-}t/td)$ lbf $(td = 0.1)$

Number of natural frequencies to be computed = 2

Results

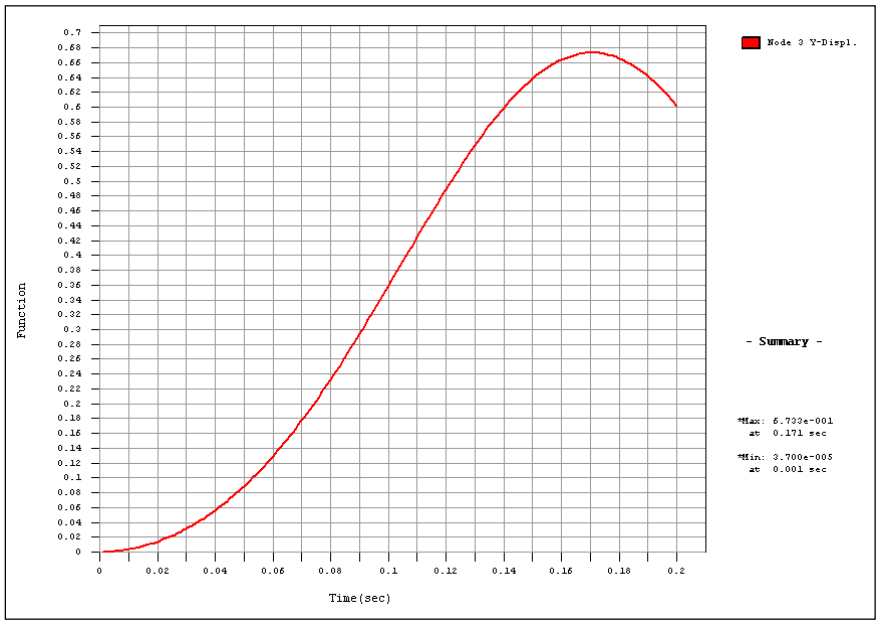
Eigenvalue Analysis Results

EIGENVALUE ANALYSIS													
	Mode No	Frequency (rad/sec)	Frequency (cycle/sec)	Period (sec)	Tolerance								
	1	11.827886	1.882466	0.531218	2.0316e-016								
	2	32.901865	5.236495	0.190967	2.6255e-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	98.72	98.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00	0.00	1.28	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

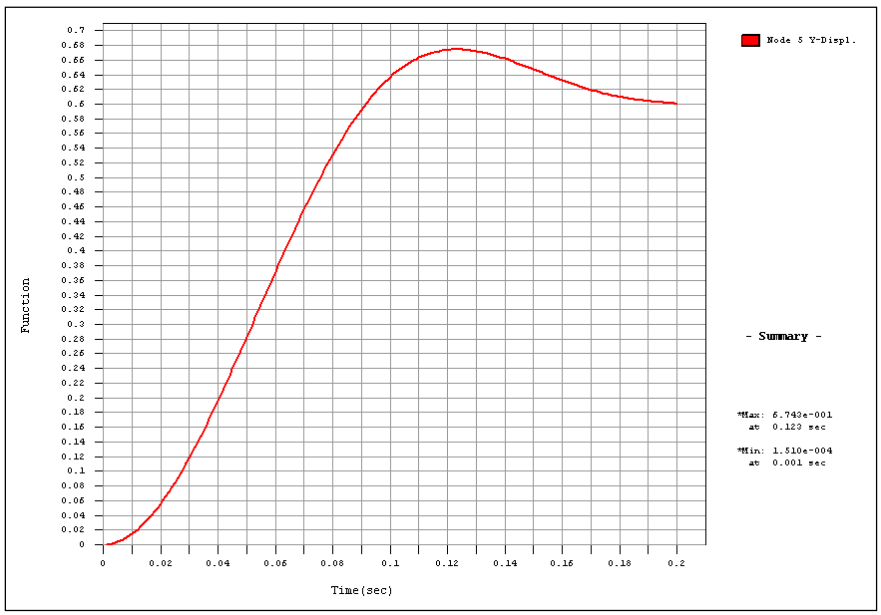
Displacements

	Node	Load	DX (in)	DY (in)	DZ (in)	RX ([rad])	RY ([rad])	RZ ([rad])
▶	1	LCOMB1(max)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	2	LCOMB1(max)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	3	LCOMB1(max)	0.000000	0.673300	0.000000	0.000000	0.000000	0.000000
	4	LCOMB1(max)	0.000000	0.673300	0.000000	0.000000	0.000000	0.000000
	5	LCOMB1(max)	0.000000	0.674290	0.000000	0.000000	0.000000	0.000000
	6	LCOMB1(max)	0.000000	0.674290	0.000000	0.000000	0.000000	0.000000
	7	LCOMB1(max)	0.000000	0.673300	0.000000	0.000000	0.000000	0.000000
	8	LCOMB1(max)	0.000000	0.674290	0.000000	0.000000	0.000000	0.000000
	1	LCOMB1(min)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	2	LCOMB1(min)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	3	LCOMB1(min)	0.000000	0.000037	0.000000	0.000000	0.000000	0.000000
	4	LCOMB1(min)	0.000000	0.000037	0.000000	0.000000	0.000000	0.000000
	5	LCOMB1(min)	0.000000	0.000151	0.000000	0.000000	0.000000	0.000000
	6	LCOMB1(min)	0.000000	0.000151	0.000000	0.000000	0.000000	0.000000
	7	LCOMB1(min)	0.000000	0.000037	0.000000	0.000000	0.000000	0.000000
	8	LCOMB1(min)	0.000000	0.000151	0.000000	0.000000	0.000000	0.000000
	1	LCOMB1(all)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	2	LCOMB1(all)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	3	LCOMB1(all)	0.000000	0.673300	0.000000	0.000000	0.000000	0.000000
	4	LCOMB1(all)	0.000000	0.673300	0.000000	0.000000	0.000000	0.000000
	5	LCOMB1(all)	0.000000	0.674290	0.000000	0.000000	0.000000	0.000000
	6	LCOMB1(all)	0.000000	0.674290	0.000000	0.000000	0.000000	0.000000
	7	LCOMB1(all)	0.000000	0.673300	0.000000	0.000000	0.000000	0.000000
	8	LCOMB1(all)	0.000000	0.674290	0.000000	0.000000	0.000000	0.000000

Displacements



Y-displacements at the node 3



Y-displacements at the node 5

Comparison of Results

Natural Frequencies

Unit : Hz

Result		Ref. 1	SAP2000	MIDAS/Civil
Natural frequency	1st mode	11.8	11.8	11.8
	2nd mode	32.9	32.9	32.9

Maximum Displacements

Unit : sec, in

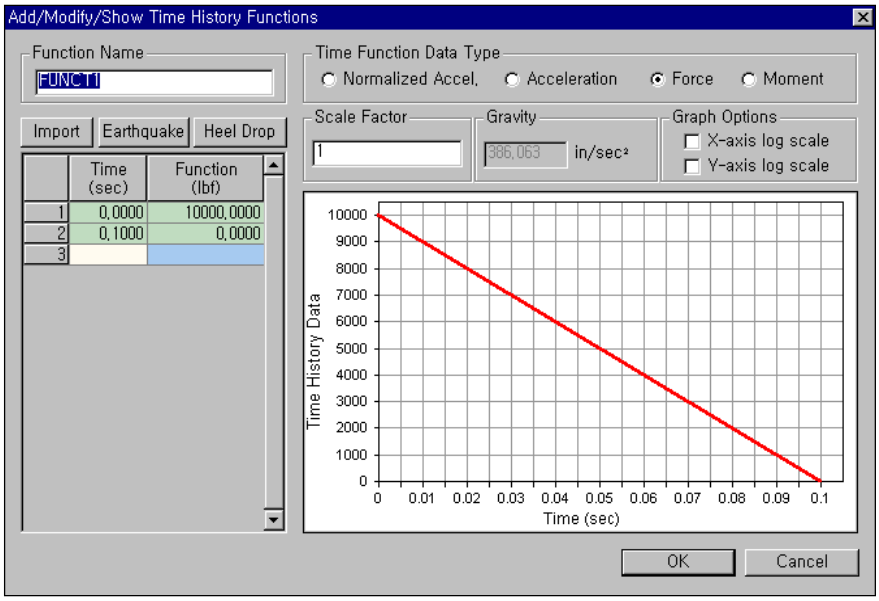
Node	Time at which the maximum displacement occurrs (t)		Maximum displacement ($\delta_{Y,max}$)	
	SAP2000	MIDAS/Civil	SAP2000	MIDAS/Civil
3	0.171	0.171	0.673	0.673
5	0.123	0.123	0.674	0.674

References

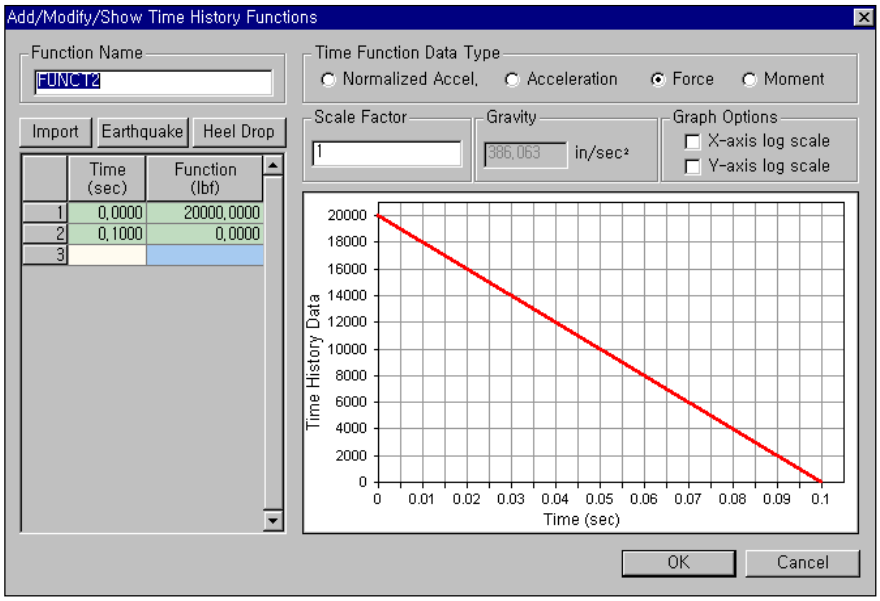
Paz, Mario, "*Structural Dynamics* ; *Theory and Computation*", 3rd Edition, Van Nostrand Reinhold, New York, 1991, Example 11-1.

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

Time History Loading Data



(a) Time history loads applied at the 1st floor



(b) Time history loads applied at the 2nd floor