

# TH-5

## Title

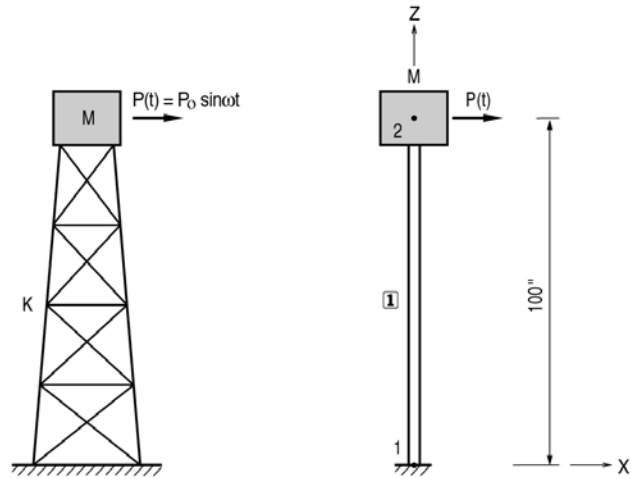
Tower structure under a harmonic excitation force

## Description

Perform a time history analysis for a steel tower structure subjected to a lateral harmonic excitation force.

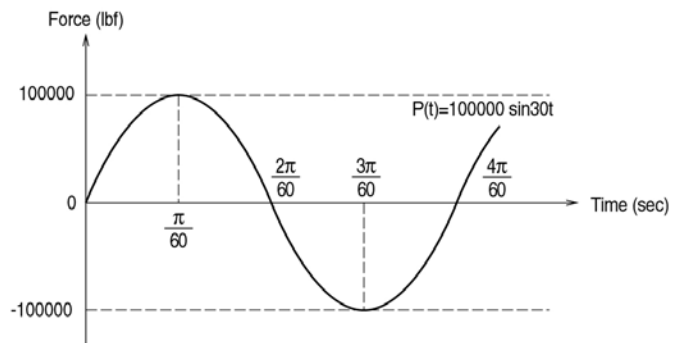
Determine the lateral displacements, velocities and accelerations with respect to time variables.

The steel tower structure is modeled as a beam element with equivalent flexural stiffness. A lumped mass is located at the top of the structure.



(a) Tower structure subjected to a harmonic load

(b) Structural analysis model



(c) Harmonic load

*Structural geometry and analysis model*

## Model

### *Analysis Type*

2-D time history analysis (X-Z plane)

### *Unit System*

in, lbf

### *Dimension*

|               |            |   |
|---------------|------------|---|
| Height        | H          | = 100 in  |
| Mass          | M          | = 100 lbf · sec <sup>2</sup> /in (in the X direction) |
| Damping ratio | $\xi$      | = 0.0   |
| Analysis time | t          | = 0.3 sec   |
| Time step     | $\Delta t$ | = 0.001 sec   |

### *Element*

Beam Element

### *Material*

Modulus of elasticity  $E = 2.0 \times 10^7$  psi

### *Section Property*

Moment of inertia  $I_{yy} = 1666.667 \text{ in}^4$

### *Boundary Condition*

Node 1 ; Constrain all DOFs

Node 2 ; Constrain Dz. (Dx and Ry allowed)

### *Analysis Case*

A harmonic excitation force is applied at the node 2 in the X direction.

$$P(t) = P_o \sin \omega t \text{ lbf}$$

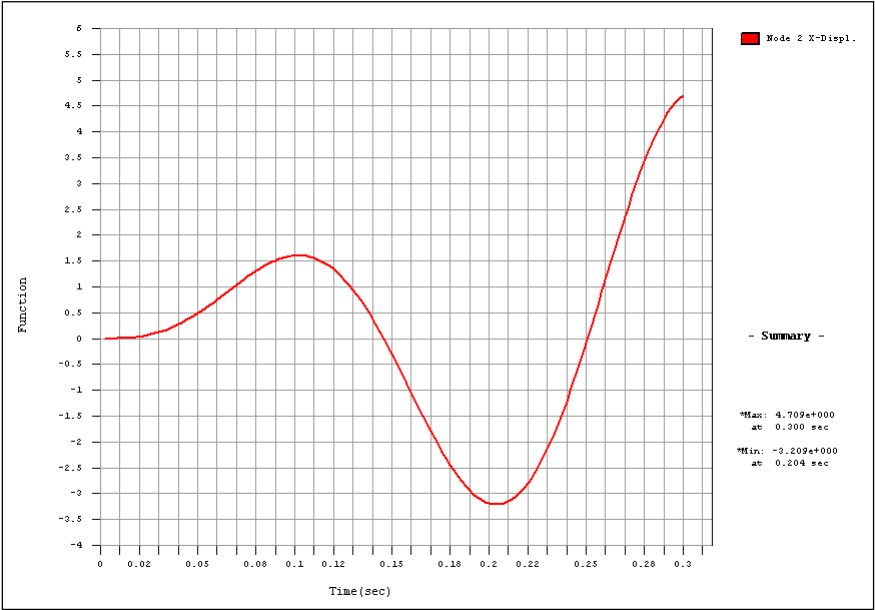
Where,  $P_o = 1.0 \times 10^5$  lbf,  $\omega = 30$  rad/sec

Results

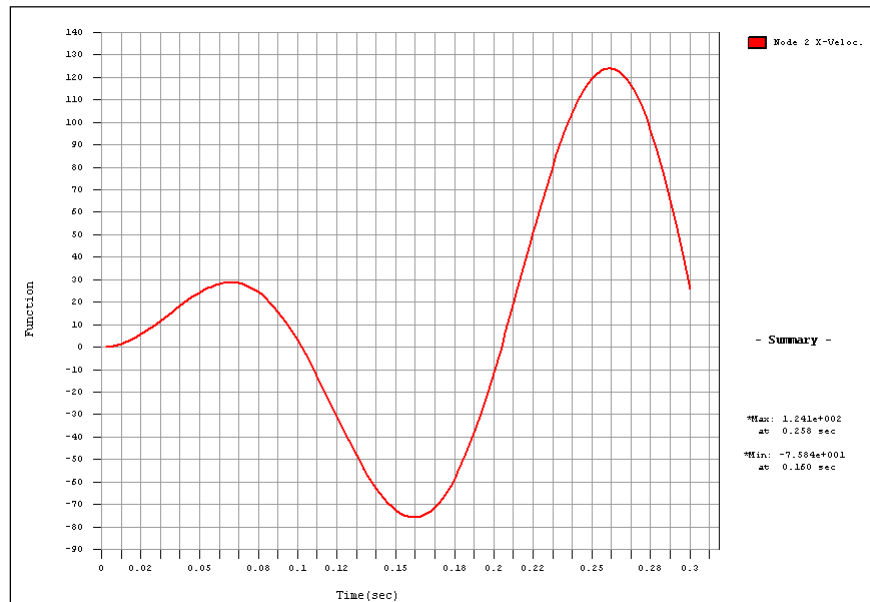
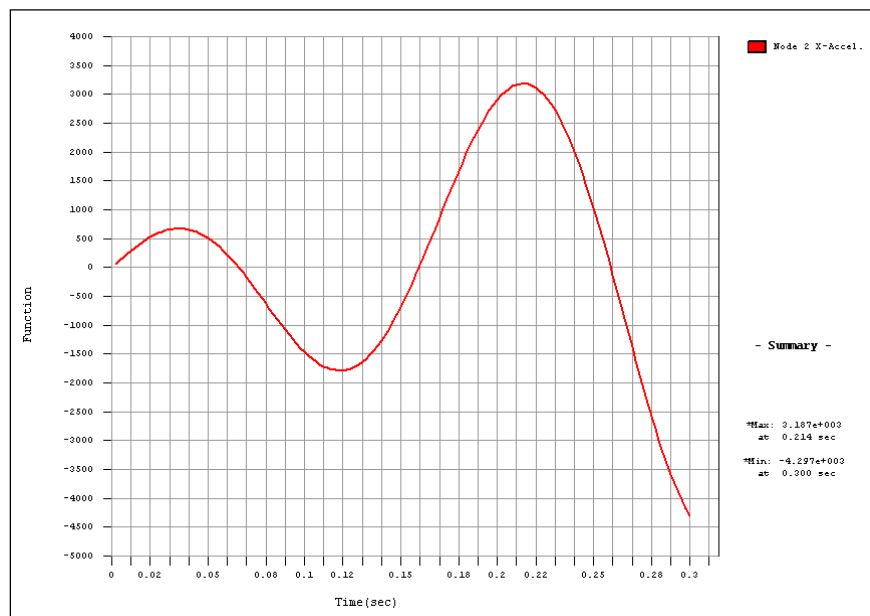
Eigenvalue Analysis Results

| EIGENVALUE ANALYSIS                    |           |             |          |          |             |      |        |      |        |      |        |      |
|--|-----------|-------------|----------|----------|-------------|------|--------|------|--------|------|--------|------|
| Mode No                                | Frequency |             | Period   |          | Tolerance   |      |        |      |        |      |        |      |
|  | (rad/sec) | (cycle/sec) | (sec)    | (sec)    |             |      |        |      |        |      |        |      |
| 1                                      | 31,622780 | 5,032922    | 0,198692 | 0,198692 | 0,0000e+000 |      |        |      |        |      |        |      |
| 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                                      | 100,00    | 100,00      | 0,00     | 0,00     | 0,00        | 0,00 | 0,00   | 0,00 | 0,00   | 0,00 | 0,00   | 0,00 |
| EIGENVECTOR                            |           |             |          |          |             |      |        |      |        |      |        |      |

Time History Analysis Results



X-displacements at the node 2

*X-velocities at the node 2**X-accelerations at the node 2*

## Comparison of Results

|                |         | Unit : sec, in |        |             |
|----------------|---------|----------------|--------|-------------|
| Result         |         | Theoretical    | Ref.1  | MIDAS/Civil |
| Natural period |         | 0.20           | 0.1926 | 0.199       |
| Lateral        | 0.1 sec | 1.608          | 1.595  | 1.607       |
| displacement   | 0.2 sec | -3.187         | -3.163 | -3.186      |
| ( $\delta_x$ ) | 0.3 sec | 4.742          | 4.674  | 4.709       |

## Reference

Paz, Mario, “*Structural Dynamics ; Theory and Computation*”, 3rd Edition, Van Nostrand Reinhold, New York, 1991, pp. 84 ~ 87, EX. 4-5, 4-6.