9.3 Seismic Loads Using Uniform Building Code '91

Description

A major portion of the United States is believed to be subject to seismic activity sufficient to cause significant structural damage, although many of these areas do not have any seismic design code requirements. The Uniform Building Code has comprehensive requirements for seismic design applicable throughout the United States, and is used in states which have experienced some of the most serious seismic activity. This application computes the seismic loads at each level of a building, following the static force procedure of the Uniform Building Code, 1991 Edition.

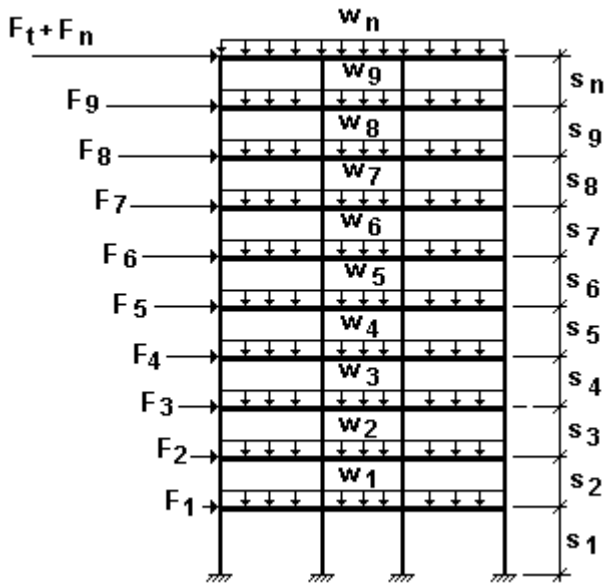
The required input includes the seismic zone factor, the importance factor, the site coefficient for soil characteristics, numerical and system coefficients (defined below), story heights, and the seismic dead loads of each story.

A summary of input and computed variables is shown on pages 5 and 6.

Reference: Uniform Building Code, 1991 Edition.

Input

Notation



Input Variables

Seismic zone factor
(Figure No. 23-2, and Table 23-I UBC '91): $Z := 0.15$

Site coefficient for soil characteristics
(Table 23-J, UBC '91): $S := 1.0$

Response modification factor, numerical
coefficient from Tables 23-O and 23-Q, UBC '91: $R_w := 12$

Importance factor (Table 23-L, UBC '91): $I := 1.0$

Numerical coefficient (Sec. 2334 (b) 2, UBC '91): $C_t := 0.035 \cdot \frac{s}{ft^{0.75}}$

Story heights: $s := ([16 \ \ 12 \ \ 12 \ \ 12 \ \ 12 \ \ 12 \ \ 12 \ \ 12 \ \ 12 \ \ 13.5])^{T} \cdot ft$

Seismic dead load at each story: $w := [960 \ \ 960 \ \ 960 \ \ 960 \ \ 960 \ \ 960 \ \ 960 \ \ 960 \ \ 960 \ \ 960]^{T} \cdot kip$

Computed Variables

h	height of each level above ground level
n	numerical subscript designating the top level
i	range variable subscript designating levels 1 through n
w_i	seismic dead load at each story
F_i	lateral seismic force applied at each level
T	fundamental period of vibration of the structure in the direction under consideration
W	total seismic dead load
V	total design lateral force at the base
F_t	that portion of the base shear V applied to top level in addition to F_n

Set ORIGIN to 1 to agree with code usage: $ORIGIN := 1$

Calculations

Number of stories: $n := \text{length}(s)$ $n = 10$

Height of each story above ground:

$i := 1..n$ $k := 1..n$ $h_i := \sum_k \left((k \le i) \cdot s_k \right)$

$h^{T} = [16 \;\; 28 \;\; 40 \;\; 52 \;\; 64 \;\; 76 \;\; 88 \;\; 100 \;\; 112 \;\; 125.5]\ ft$

Total seismic dead load: $W := \sum w = \left(9.6 \cdot 10^3\right)\ kip$

Total building height: $h_n = 125.5\ ft$

Building period T (Sec. 2334 (b), (34-3), UBC '91):

$T := C_t \cdot \left(h_n\right)^{0.75} = 1.312\ s$

Site coefficient C (Sec. 2334 (b), (34-2), UBC '91):

$$C := \text{if}\left[\frac{1.25 \cdot S}{\left(\frac{T}{sec}\right)^{\frac{2}{3}}} > 2.75,\ 2.75,\ \frac{1.25 \cdot S}{\left(\frac{T}{sec}\right)^{\frac{2}{3}}}\right] = 1.043$$

Total design lateral force or shear V, at the base (Sec. 2334 (b), (34-1), UBC '91):

$$V := \text{if}\left(\frac{C}{R_w} > 0.075,\ Z \cdot I \cdot C \cdot \frac{W}{R_w},\ Z \cdot I \cdot 0.075\ W\right) = 125.138\ kip$$

Force Ft, applied at top story (Sec. 2334 (b), (34-7), UBC '91):

$$F_t := \text{if}\left[T \le 0.7\ s,\ 0\ kip,\ \text{if}\left[0.07 \cdot \frac{T}{s} \cdot V \le 0.25 \cdot V,\ 0.07 \cdot \frac{T}{s} \cdot V,\ 0.25\ V\right]\right] = 11.496\ kip$$

Lateral seismic forces Fi at levels 1 through n (Sec. 2334 (b), (34-8), UBC '91):
(code formula modified to give the forces at all levels)

$$F_i := \frac{\left(V - F_t\right) \cdot w_i \cdot h_i}{\sum_{i=1}^{n} \left(w_i \cdot h_i\right)}$$

$F^{T} = [2.6 \;\; 4.5 \;\; 6.5 \;\; 8.4 \;\; 10.4 \;\; 12.3 \;\; 14.3 \;\; 16.2 \;\; 18.1 \;\; 20.3]\ kip$

Summary

Enter structural system description:
"Special moment resisting steel frame" (UBC '91, Section 2333 (f))

Seismic zone factor:
(Figure No. 23-2, and Table 23 -I UBC '91): $Z = 0.15$

Site coefficient for soil characteristics:
(Table 23-J, UBC '91): $S = 1$

Response modification factor, numerical
coefficient from Tables 23-O and 23-Q, UBC '91: $R_w = 12$

Importance factor:
(Table 23-L, UBC '91): $I = 1$

Numerical coefficient:
(Sec. 2334 (b) 2, UBC '91) $C_t = 0.035 \ \frac{s}{ft^{\frac{3}{4}}}$

Level numbers above ground, story heights s, seismic dead load per story, force F at each level, and height h of each level above ground:

$$s = \begin{bmatrix} 16 \\ 12 \\ 12 \\ 12 \\ 12 \\ 12 \\ 12 \\ 12 \\ 12 \\ 13.5 \end{bmatrix} ft \qquad w = \begin{bmatrix} 960 \\ 960 \\ 960 \\ 960 \\ 960 \\ 960 \\ 960 \\ 960 \\ 960 \\ 960 \end{bmatrix} kip \qquad F = \begin{bmatrix} 2.592 \\ 4.536 \\ 6.48 \\ 8.424 \\ 10.368 \\ 12.312 \\ 14.256 \\ 16.2 \\ 18.144 \\ 20.331 \end{bmatrix} kip \qquad h = \begin{bmatrix} 16 \\ 28 \\ 40 \\ 52 \\ 64 \\ 76 \\ 88 \\ 100 \\ 112 \\ 125.5 \end{bmatrix} ft$$

Force Ft applied at top level: $F_t = 11.496 \ kip$

Total Base Shear: $V = 125.138 \ kip$