Seismic load calculation

According BNBC 2020

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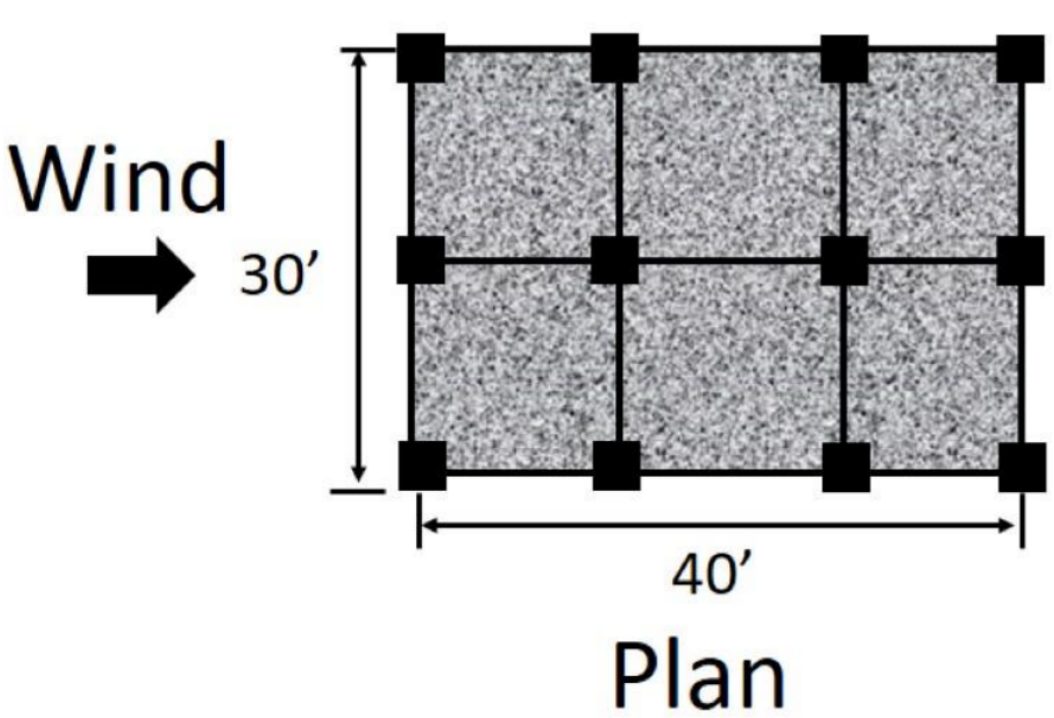
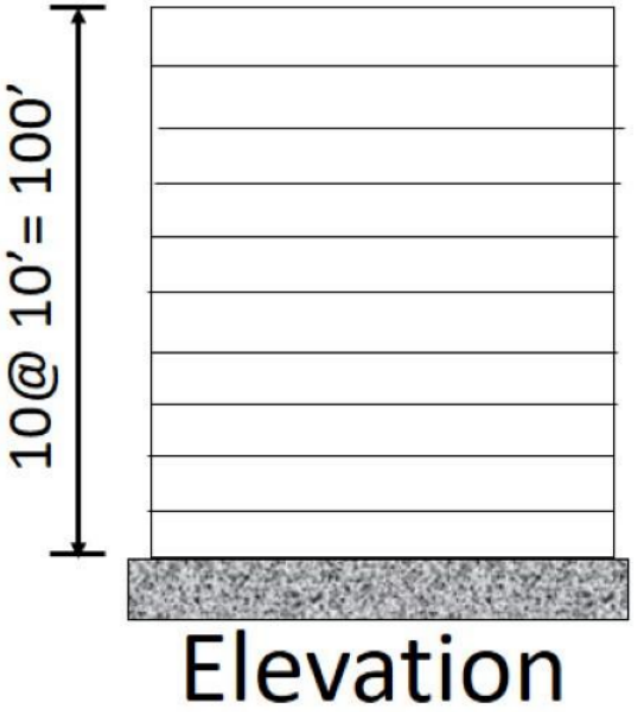
Problem 02

Calculate the design wind forces and earthquake loads at each floor level for the following six storied residential building as shown in figure bellow which will be constructed within Rajshahi City. Assume, seismic weight = 10 kN/m2 [According BNBC 2020]



Plan



Elevation

Solution: Problem 02 (Seismic)

We Know,

$$S_a = \frac{2}{3}\frac{ZI}{R}C_s$$

According Code,

Z=0.12

I=1

R=5

T= 0.0466x(10x10/3.28)0.9

T=1.009 s

$$C_s = S\left(1 + \frac{T}{T_B}(2.5\,\eta - 1)\right) \quad \text{for} \quad 0 \le T \le T_B \qquad (6.2.35a)$$

$$C_s = 2.5\,S\eta \quad \text{for} \quad T_B \le T \le T_C \qquad (6.2.35b)$$

$$C_s = 2.5\,S\eta\left(\frac{T_C}{T}\right) \quad \text{for} \quad T_C \le T \le T_D \qquad (6.2.35c)$$

$$C_s = 2.5\,S\eta\left(\frac{T_C\,T_D}{T^2}\right) \quad \text{for} \quad T_D \le T \le 4\ sec \qquad (6.2.35d)$$

Solution: Problem 02 (Seismic)

From Soil report,

$$\bar{N} = \frac{5+5+5+5+10+10+10+10+10+10+10+10}{\frac{5}{2}+\frac{5}{9}+\frac{5}{13}+\frac{5}{6}+\frac{10}{13}+\frac{10}{8}+\frac{10}{9}+\frac{10}{11}+\frac{10}{29}+\frac{10}{30}+\frac{10}{50}+\frac{10}{50}}$$

$$\bar{N} = \mathbf{10.65}$$

$$\therefore Site\ Class = SD$$

S=1.35

T_B=0.20

T_C=0.80

T_D=2.0

$Here, T_C < T < T_D$

$\therefore$ *Eqn* 6.2.35 (c) will be used

Site Class	Description of soil profile up to 30 meters depth	Average Soil Properties in top 30 mete: Shear wave velocity, $\bar{V}_s$ (m/s)	SPT Value, $\bar{N}$ (blows/30cm)	Undrai strength
SC	Deep deposits of dense or medium dense sand, gravel or stiff clay with thickness from several tens to many hundreds of metres.	180 – 360	15 - 50	70
SD	Deposits of loose-to-medium cohesionless soil (with or without some soft cohesive layers), or of predominantly soft-to-firm cohesive soil.	< 180	< 15	<
SE	A soil profile consisting of a surface alluvium	--	--	

Table 6.2.16: Site Dependent Soil Factor and Other Parameters Defining Elasti Spectrum

Soil type	*S*	T_B(s)	T_C(s)
SA	1.0	0.15	0.40
SB	1.2	0.15	0.50
SC	1.15	0.20	0.60
SD	1.35	0.20	0.80
SE	1.4	0.15	0.50

Solution: Problem 02 (Seismic)

$$C_s = 2.5\,S\eta\left(\frac{T_C}{T}\right) \quad \text{for} \quad T_C \le T \le T_D \qquad (6.2.35c)$$

$Cs = 2.5 \times 1.35 \times 1\left(\frac{0.08}{1.009}\right)$

$Cs = 2.675$

$\therefore Sa = \frac{2}{3} \times \frac{0.12x1}{5} x\ 2.675$

$Sa = 0.0428$

$Sa = 0.67 \times .11 \times .12 \times 1 \times 1.35$

$Sa = 0.0119$

S_a =	Design spectral acceleration (in units of g) which shall not be less than $0.67\beta ZIS$
β =	Coefficient used to calculate lower bound for S_a. Recommended value for β is 0.11

$\therefore$ **Sa=0.0428**

Seismic weight of the building,

$$W = \frac{30}{3.28} x \frac{40}{3.28}\ x\ 10 \times 11 = 12{,}269.48\ \text{kN}$$

Solution: Problem 02 (Seismic)

Base shear,

$V = 0.0428x(\frac{30}{3.28} x \frac{40}{3.28} x 10x11) = \mathbf{525.13\ kN}$

Distribution of lateral load on each story level,

$$F_x = V \frac{w_x h_x{}^k}{\sum_{i=1}^{n} w_i h_i{}^k}$$

Here, building period, T=1.009s

From interpolation value of k=1.25

W_i and W_x(for a single story)$= 10x \frac{30}{3.28} x \frac{40}{3.28} = 1115$ kN

$W_i\ h_i = 1115(31.5+61.5+91.5+121.5+151.5+181.5+211.5+241.5+271.5+301$

$\mathbf{W_i\ h_i = 826601}$

Solution: Problem 02 (Seismic)

$$F3=525x\frac{1115x3^{1.25}}{826601}=2.79\ kN$$

$$F6=525x\frac{1115x6^{1.25}}{826601}=6.65\ kN$$

$$F9=525x\frac{1115x9^{1.25}}{826601}=11.04\ kN$$

$$F12=525x\frac{1115x12^{1.25}}{826601}=15.81kN$$

$$F15=525x\frac{1115x15^{1.25}}{826601}=20.91kN$$

$$F18=525x\frac{1115x18^{1.25}}{826601}=26.26\ kN$$

$$F21=525x\frac{1115x21^{1.25}}{826601}=31.84\ kN$$

$$F24=525x\frac{1115x24^{1.25}}{826601}=37.62\ kN$$

$$F27=525x\frac{1115x27^{1.25}}{826601}=43.58\ kN$$

$$F30=525x\frac{1115x30^{1.25}}{826601}=49.72\ kN$$