Earthquake Load Calculation (base shear method)
The 3-story standard office building is located in Los Angeles situated on stiff soil. The structure of the building is steel special moment frame. All moment-resisting frames are located at the perimeter of the building. Determine the earthquake force on each story in North-South direction.

Part A: Mass calculation
Building envelope =184’x124’
Floor slab envelope (for dead load calculation) =182’x122’
Floor slab envelope (for live load calculation) =180’x120’ (not used in seismic calculation)
Penthouse envelope (height=12’) =62’x32’
Parapet Wall (height = 42”)

1. Dead Load
   - Floor Slab (including steel deck) = 53 psf
   - Ceiling / Flooring = 3 psf
   - Mechanical/Electrical = 7 psf
   - Partitions = 10 psf
   - Steel Framing (assumption) = 13 psf
   - Roofing = 7 psf
   - Penthouse (additional to roof load) = 40 psf

   For typical floor (floor weight calculations) = 53+3+7+10+13 = 86 psf
   For roof (excluding penthouse) = 53+3+7+7+13 = 83 psf
   For penthouse = 53+3+7+40+13 = 116 psf

2. Dead load due to Exterior Wall
   Unit weight: = 0.025 kip/ft
   Perimeter: = 2*(184+124) = 616 ft
   Weight of the exterior wall between two stories is divided into two. Half goes to upper story and half goes to lower story.
   - Roof = 0.025*(13/2)*616 = 100 kips
   - Floor 3 = 0.025*(13/2+13/2)*616 = 200 kips
   - Floor 2 = 0.025*(13/2+13/2)*616 = 200 kips
   - Penthouse exterior wall = 0.025*12*2(62+32) = 56 kips

3. Dead load due to Parapet on Roof
   Total Load: = 0.025*(42/12)*616 = 54 kips

Floor Seismic Dead Weights
   - Roof = (0.083*182*122)+(0.116*32*62)+54+100+56 = 2283 kips
   - Floor 3 = (0.086*182*122)+200 = 2110 kips
   - Floor 2 = (0.086*182*122)+200 = 2110 kips

Part B: Seismic force analysis (ASCE 7-02)

Two steel frames on the perimeter are moment-resistance frame. So the weights on each floor will be divided into two to calculate the lateral forces on each moment-resisting frames.

Seismic mass of each moment-resisting frame:
   - Roof = 2283/2/32.2 = 35.45 kips-sec^2/ft
   - Floor 3 = 2110/2/32.2 = 32.76 kips-sec^2/ft
   - Floor 2 = 2110/2/32.2 = 32.76 kips-sec^2/ft

The mass of each story of one moment-resisting frame is:

<table>
<thead>
<tr>
<th>Story</th>
<th>2 -3 (kips-sec^2/ft)</th>
<th>Roof (kips-sec^2/ft)</th>
<th>Total (kips-sec^2/ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>32.76</td>
<td>35.45</td>
<td>100.97</td>
</tr>
</tbody>
</table>
1. Maximum considered earthquake ground motion (LA), from Figure 9.4.1.1:
\[ S_s = 2.05g \]
\[ S_1 = 0.81g \]

2. Site class is D (stiff soil, Table 9.4.1.2), and from Table 9.4.1.2.4a and 9.4.1.2.4b:
\[ F_a = 1.0 \]
\[ F_v = 1.5 \]

3. Adjusted maximum considered earthquake response acceleration:
\[ S_{MS} = F_a S_s = 2.05g \]
\[ S_{M1} = F_v S_1 = 1.215g \]

4. Design spectral response acceleration:
\[ S_{DS} = \frac{2}{3} S_{MS} = 1.367g \]
\[ S_{D1} = \frac{2}{3} S_{M1} = 0.81g \]

5. Calculation of seismic response coefficient:
From table 9.5.2.2, the response modification factor \( R = 8 \).
From table 9.1.4, the occupancy importance factor \( I = 1 \).
\[ C_s = \frac{S_{DS}}{R/I} = \frac{1.367g}{8} = 0.171g \]

Maximum seismic response coefficient (Eq. 9.5.5.2.1-2)
From table 9.5.5.3.2, we get: \( C_t = 0.028 \), \( x = 0.8 \), then:
Approximate fundamental period: \( T_a = C_t h_n x = 0.028 \times (39)^{0.8} = 0.525 \)
\[ T = C_a T_a = 1.4 \times 0.525 = 0.735 \text{ sec (section 9.5.5.3)} \]
\[ C_{s,\text{max}} = \frac{S_{D1}}{T(R/I)} = \frac{0.81g}{0.735(8/1)} = 0.138g \]

For category E (Table 9.4.2.1a), minimum seismic response coefficient (Eq. 9.5.5.2.1-4):
\[ C_s = \frac{0.5 S_1}{R/I} = \frac{0.5 \times 0.81g}{8} = 0.051g \]
Use \( C_s = 0.138g \)

6. Total base shear force (Eq. 9.5.5.2.1):
\[ V = C_s W = 0.138 \times 32.2 \times 100.97 = 449 \text{ kips} \]

7. Distribute the base shear force to each story (Section 9.5.5.4)
\[ T = 0.735 \text{ sec, so: } k = 1 + (2-1) \times (0.735 - 0.5)/(2-1) = 1.235 \text{ sec} \]
\[ C_{v\times} = \frac{w_i h_i^k}{\sum w_i h_i^k} \]
\[ F_x = C_{v\times} V \]
<table>
<thead>
<tr>
<th>LEVEL</th>
<th>Story height</th>
<th>Height</th>
<th>Weight (kips)</th>
<th>$W_iH_i^k$</th>
<th>$C_{rx}$</th>
<th>Force (kips)</th>
<th>Story Shear (kips)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>13</td>
<td>39</td>
<td>35.45</td>
<td>3270</td>
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<td>0</td>
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<td>3</td>
<td>13</td>
<td>26</td>
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<td>390</td>
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<td>Total</td>
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<td>100.97</td>
<td>5880</td>
<td>1.0</td>
<td>449</td>
<td>449</td>
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