Example 3: Out of Plane confined Masonry Wall Capacity

Description

Calculate the out of plane capacity and demand stresses of a first-story confined Masonry wall of a two-story residency which has all the borders restrained. This wall is located in Managua (a = 0.367g), and a Soil Amplification factor of 1.7 (Assuming type of soil D), per Managua City Seismic Resistant Code (NSM, 2021). The wall has a thickness of 15 cm, the wall total length (including vertical confined elements) is 3.00 m, its height 3.50 m, the columns and beams, width and height, is 15 cm both, the intermediate beam is located at the half of the wall's height. After a Seismic and Gravity Analysis of the building, the wall results in having an axial load of 4000 kg (Assume an eccentricity of 10% of the thickness of the wall) and the shear load is 1000kg. Consider f'm = 55 kg/cm2 based on net area. Use the Guidelines on chapter 19 (E070,2019) to do the stress check.

Out[36]:

Click here to toggle on/off the raw code.

Solution:

Data:

1. Seismic Hazard

1.1. PGA

$$\text{ac} = 0.367 \quad (g)$$

1.2. Soil Amplification Factor

$$\text{Fs} = 1.700$$

1.3. Importance Factor

$$I = 1$$

2. Geometry Properties

2.1. Wall Length

$$L = 3.000 \quad (m)$$

2.2. Wall thickness

$$t = 0.150 \quad (m)$$

2.3. Wall Height

$$H = 3.500 \quad (m)$$

2.4. Confined Wall Elements width and height

$$w_c = 0.150 \quad (m)$$

2.5. Panel length

$$\text{Lw} = L - w_c \cdot 2 = 3.000 - 0.150 \cdot 2$$

2.6. Panel height

$$\text{Hw} = \frac{H - w_c - w_c}{2} = \frac{3.500 - 0.150 - 0.150}{2}$$

3. Material Properties

3.1. Masonry compressive strength based on Net area

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$$f_{mn} = 55 \quad (kg/cm^2)$$

3.2. Relationship ratio between Gross Area and Net Area.

$$\text{factor} = \frac{48.75}{93}$$

4. Loads

4.1. Wall Panel weight

$$Pe = 1800 \cdot t \cdot \text{factor} = 1800 \cdot 0.150 \cdot 0.524$$

4.2. Axial Load on Walls

$$P = 4000 \quad (kg)$$

4.3. Shear Load on Walls

$$V = 1000 \quad (kg)$$

5. Boundary Conditions

5.1. Wall with all borders restrained

Reference: Peruvian code, chapter 19, table 13 (E070, 2019)

$$\text{Case} = 1 \quad (\text{-})$$

Calculations

1. Geometric parameters and adimensional moment coefficient

Reference: Peruvian code, chapter 19, table 13 (E070, 2019)

$$a = \text{np. minimum}(Lw, \ Hw) = np.\,minimum(2.700, \ 1.600)$$

$$b = \text{np. maximum}(Lw, \ Hw) = np.\,maximum(2.700, \ 1.600)$$

$$m = 0.095 \quad (\text{-})$$

1.1. Axial Load Eccentricity (Assuming 10 \% of thickness)

$$e = 0.10 \cdot t = 0.10 \cdot 0.150$$

2. Hazard transformation from Nicaraguan Hazard to Peruvian Hazard

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$Z = 0.367$ (g)

$U = 1$ (-)

$S = 1.700$ (-)

3. Demands

3.1. Out of plane stress

Reference: Peruvian code, chapter 19, article 68 (E070, 2019)

$w = 0.4 \cdot Z \cdot U \cdot S \cdot \text{Pe} = 0.4 \cdot 0.367 \cdot 1 \cdot 1.700 \cdot 141.532$

3.2. Out of plane moment

Reference: Peruvian code, chapter 19, article 68 (E070, 2019)

$\text{Ms} = m \cdot w \cdot (a)^2 = 0.095 \cdot 35.292 \cdot (1.600)^2$

3.3. Moment due to gravity load eccentricity

Reference: Peruvian code, chapter 19, article 69.1 (E070, 2019)

$\text{Mg} = P \cdot e = 4000 \cdot 0.015$

3.4. Total Design Moment

Reference: Peruvian code, chapter 19, article 69.1 (E070, 2019)

$\text{Mt} = \text{Ms} + \text{Mg} = 8.565 + 60.000$

3.5. Maximum stress

3.5.1. Gravity load per unit length

Reference: Peruvian code, chapter 19, article 69.2 (E070, 2019)

$\text{fa} = \dfrac{P}{t} = \dfrac{4000}{0.150}$

3.5.2. Stress due to Mt

Reference: Peruvian code, chapter 19, article 69.2 (E070, 2019)

$\dfrac{\text{Mt}}{} \quad \dfrac{68.565}{}$

$$fm = 6 \cdot \frac{}{(t)^2} = 6 \cdot \frac{}{(0.150)^2}$$

3.5.3. Stress capacities

Reference: Peruvian code, chapter 19, article 69.3 (E070, 2019)

$$f_{mg} = \text{factor} \cdot f_{mn} \cdot 10000 = 0.524 \cdot 55 \cdot 10000$$

$$\text{Fa} = 0.20 \cdot f_{mg} \cdot \left(1 - \left(\frac{H}{35 \cdot t}\right)^2\right) = 0.20 \cdot 288306.452 \cdot \left(1 - \left(\frac{3.500}{35 \cdot 0.150}\right)^2\right)$$

$$\text{Fm} = 0.4 \cdot f_{mg} = 0.4 \cdot 288306.452$$

4. Stress check

Reference: Peruvian code, chapter 19, article 69.3 (E070, 2019)

$$\text{Since, } fa + fm < 0.25 \cdot f_{mg} \rightarrow (26666.667 + 18283.980 < 0.25 \cdot 288306.452):$$

$$\text{Check} = \text{Ok}, 44950.65 < 72076.6129032258$$

$$\text{Since, } \frac{fm}{Fm} + \frac{fa}{Fa} \leq 1.33 \rightarrow \left(\frac{18283.980}{115322.581} + \frac{26666.667}{32034.050} \leq 1.33\right): \quad (-)$$

$$\text{Check} = \text{Ok}, 0.99 < 1.33$$