CVE40011

ENGINEERING DATA ANALYTICS AND APPLICATIONS

GROUP PROJECT

Due: 01/11/2024 Before **11:59PM**

Marks: 30

Note: 2 marks will be deducted for each day of late submission.

Project Summary

You need to create a program to analyse the lateral capacity of steel pole section including the soil parameter uncertainties. The pole 9.0 m height and embedded 2.0 m below ground level. The pole is subjected to 1.0 kN permanent lateral force at the tip of the pole. The pole has a constant diameter and wall thickness of 180 mm and 5.0 mm respectively. The pole is subjected to corrosion which causes reduction of the wall thickness over time.

The uncertainty parameters to be considered in the program are as follows:

Table 1. Uncertainty parameters

Parameters	**Unit**	**Mean**	**Coefficient of Variation**
Soil density	kN/m^3	19.5	0.1
Soil friction angle	^{o}	25	0.1
Steel yield strength	MPa	250	0.05
Corrosion factor (k')	oz/ft^2	3.3	0.07
Corrosion factor (u)	-	0.5	0.14

Note: Adopt normal distribution for all the parameters

Your Tasks

You need to form a group of 2 members and create a Python program to perform the following:

1. Section property analysis for circular hollow section. (3 marks)
2. Uncertainty parameter sampling following normal distribution with mean and coefficient variation as shown in Table 1.
   Set the total number of samples as 1,000 for each parameter.
   Create histogram plot for each uncertainty parameter in a single figure (use subplot, one axes per parameter). (7 marks)
3. Calculate the bending capacity of the section with no corrosion and create a figure with histogram plot. Note the mean and standard deviation of the section bending capacity in the figure title. (5 marks)
4. Calculate the remaining thickness and bending capacity of the section over time including the mean, upper and lower bound value and create a figure showing the sampling value in **grey with no line**, the mean value in **solid red**, and the upper/lower bound in **black dashed line**. (5 marks)
5. Calculate the lateral capacity of the embedded section over time including the mean, upper and lower bound value and create a figure showing the sampling value in **grey with no line**, the mean value in **solid red**, and the upper/lower bound in **black dashed line**. (5 marks)
6. Calculate the number of sample where the bending capacity is less than the required bending capacity over time. Create a figure and plot the results. (5 marks)

Combine all the figures into word document. Please submit the word document summarising all the figures asked in the tasks and the Python code/s into Canvas.

No marks will be given if Python file/s are not submitted.

Additional Information

Corrosion model (Romanoff, 1957)

$$W = k'T^u$$

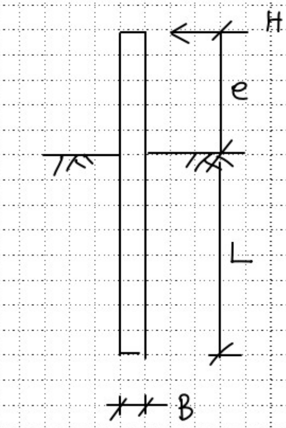
Earth pressure coefficient - Rankine

$$K_a = \tan^2\left(45 - \frac{\phi'}{2}\right) = \frac{1 - \sin(\phi')}{1 + \sin(\phi')}$$

$$K_p = \tan^2\left(45 + \frac{\phi'}{2}\right) = \frac{1 + \sin(\phi')}{1 - \sin(\phi')}$$

Lateral capacity of pile (Fleming et al., 2008)

PILE FOOTING ANALYSIS



INPUT:

H = HORIZONTAL FORCE

e = eccentricity of HORIZONTAL FORCE

L = Footing embedment depth

B = width of footing

ϕ = FRICTION ANGLE OF FOUNDATION MATERIAL

$\phi M_{u,pile}$ = ULTIMATE moment capacity OF PILE

S = PILE SPACING

γ = FOUNDATION SOIL DENSITY

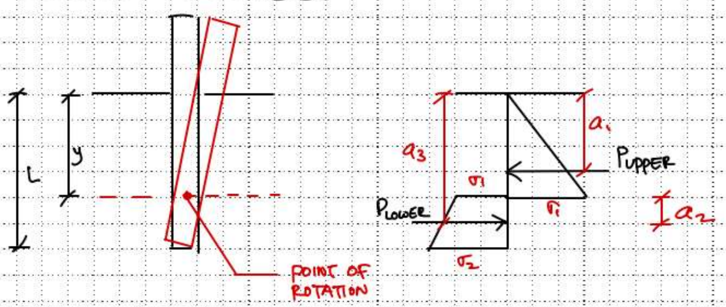
1. CALCULATE EARTH PRESSURE COEFFICIENT BASED ON REDUCED FRICTION ANGLE

$$\phi' = x \cdot \phi$$

x = REDUCTION FACTOR BASED ON AS 4678 DEPENDING ON SOIL CONDITIONS

- CLASS I
- CLASS II
- UNCONTROLLED FILL
- IN SITU MATERIAL

2. CHECK AS SHORT PILE



- $B' = \min(B, \text{SPACING}/3)$
- $\sigma_1 = 3\,k_p \cdot \gamma \cdot B' \cdot y$
- $\sigma_2 = 3\,k_p \cdot \gamma \cdot B' \cdot L$
- $P_{UPPER} = \sigma_1 \cdot (y/2)$

$$= 1.5\,k_p \cdot \gamma \cdot B' \cdot y^2$$

- $P_{LOWER} = \dfrac{(\sigma_1 + \sigma_2) \cdot (L - y)}{2}$

$$= \frac{(3k_p \cdot \gamma B' y + 3k_p \gamma B' L)(L-y)}{2}$$

$$= \frac{3k_p \gamma B' (L+y)(L-y)}{2}$$

$$= 1.5\,k_p \gamma B' (L^2 - y^2)$$

- $a_1 = (2/3)\,y$
- $a_2 = (L-y) - \dfrac{(L-y)}{3} \dfrac{(2\sigma_1 + \sigma_2)}{(\sigma_1 + \sigma_2)}$

$$= (L-y) - \frac{(L-y)}{3} \frac{(2 \cdot 1.5\,k_p \gamma B' y + 1.5 \cdot k_p \cdot \gamma B' L)}{(1.5\,k_p \cdot \gamma B' y + 1.5\,k_p \gamma B' L)}$$

$$= (L-y) - \frac{(L-y)}{3} \frac{(2y + L)}{(y + L)}$$

- $a_3 = y + a_2$

- HORIZONTAL FORCE EQUILIBRIUM

$$H_{f_1} = P_{UPPER} - P_{LOWER}$$

- MOMENT EQUILIBRIUM

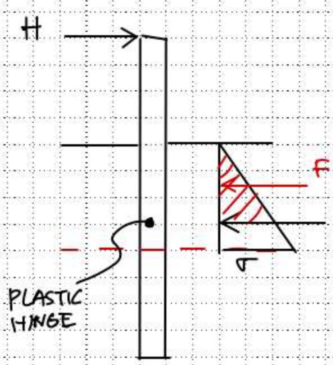
$$H_{f_2}(e+y) = P_{UPPER}(y-a_1) + P_{LOWER}(a_2)$$

$$H_{f_2} = \frac{P_{UPPER}(y-a_1) + P_{LOWER}(a_2)}{(e+y)}$$

- USE ITERATION TO FIND VALUE OF Y WHICH SATISFIES

— $H_{f_1} = H_{f_2}$

- MOMENT IN PILE



$$\left(\frac{2}{3}y\right)\left(\frac{1}{3}\right) = \frac{2}{9}y$$

$$H = n \cdot k_p \cdot \gamma \cdot y^2/2$$

$$n = \frac{H}{k_p \cdot \gamma \cdot y^2/2}$$

$$F = \frac{n \cdot k_p \cdot \gamma \cdot (2/3\,y)^2}{2}$$

$$M_p^* = H(e + 2/3\,y) - F\left(\frac{2}{9}y\right)$$

CHECK:

$$M_p^* < \phi M_{u,pile}$$

3. CHECK AS LONG PILE

SOIL PRESSURE BELOW POINT OF ROTATION IS IGNORED

- LIMITING PRESSURE = $3\,k_p\,\gamma \cdot y$
- $H_f(e + 2/3\,y) = \phi M_{u,pile}$
- $H_f = 3\,k_p\,\gamma\,B'\,y^2/2$

$$= 1.5\,k_p\,\gamma\,B'\,y^2$$

- SOLVE FOR Y

References

1. M. Romanoff, “Underground Corrosion,” Gaithersburg, MD, 1957. doi: 10.6028/NBS.CIRC.579.
2. K. Fleming, A. Weltman, M. Randolph, and K. Elson, *Piling engineering.* CRC press., 2008.