

Assignment 4: VBA Programming

Date Due: February 15, 2023

Instructor: Trani

Problem 1

Read the brief article about the Dynamic Cone Penetration Test (DCPT) to understand the content of the question below. A brief article on the subject is available at:

<https://pavementinteractive.org/reference-desk/pavement-management/pavement-evaluation/dynamic-cone-penetration-test/>

According to the article, the Dynamic Penetration Index is correlated with the California Bearing Ratio (CBR) according to the equation:

$$CBR = 292/DPI^{1.12}$$

Where:

CBR is the California Bearing Ratio (dimensionless), DPI is the Dynamic Penetration Index - a parameter used to assess the geotechnical properties of the soil. An engineer provides you with the following values of DPI collected at various test sites. The DPI values were derived using a Standard Penetration Test (ASTM D-1586-64).

Test Site Sample	DPI (dim)
1	9.2
2	20.5
3	11.5
5	17.8
6	8.5
7	16.2
8	19.1
9	15.9
10	9.6

- 1) Create a function in Excel/VBA to estimate the value of CBR given the value of DPI using the formula above.
- 2) Apply the Excel function created above in the list of items to produce corresponding values of CBR at each test site.
- 3) Create a second function to calculate the flexible pavement thickness (t) of an airport pavement using the values of CBR estimated above. Use the empirical pavement thickness formula provided in class. You are welcome to reuse the function that we created in class as well.

Problem 2

Table 1 provides the California Bearing Ratios of various types of Soils according to the Unified Soil Classification System (USCS).

Table 1. CRB Values for Typical Soils According to the Unified Soil Classification System (USCS).

USCS Soil Type	CBR (dim)	General Soil Type
GW	55	Coarse-grained soils
GP	45	Coarse-grained soils
GM	35	Coarse-grained soils
GC	30	Coarse-grained soils
SW	29	Coarse-grained soils
SM	28	Coarse-grained soils
SP	24	Coarse-grained soils
SC	13	Coarse-grained soils
ML	12	Fine-grained soils
CL LL < 50%	12	Fine-grained soils
OL	5	Fine-grained soils
MH	9	Fine-grained soils
CH LL > 50%	13	Fine-grained soils
OH	4	Fine-grained soils

- A) Create a new spreadsheet and associated VBA code to estimate the total pavement thickness (in inches) according to the empirical equation:

$$\text{Thickness_inches} = \sqrt{\text{Load} / (8.1 * \text{CBR}) + \text{Area} / \pi}$$

Where:

Thickness_inches is the total pavement thickness (in inches)

Load is the single-wheel equivalent load in pounds

Area is the contact area between the tire and the pavement (square inches)

CBR is the California Bearing Ratio (dim)

The new spreadsheet should allow the user (via a **data validation drop down menu list**) to select the soil type according to the USCS table above to estimate the value of CBR used in the calculation of pavement thickness. You must provide a **list of soil types** in the cell allowing the user to change the string value of the cell. The suggested interface of the Excel file should look like the one below. Note that the CBR cell with label GM is not hard coded, rather is part of the drop-down list.

Area	200	sq. inches
CBR	GM	dim
Load (lb)	Pavement Thickness (in)	
25000		
26000		
27000		
28000		
29000		
30000		
31000		
32000		

Your VBA code should read the values of “load, “soil type” as a string (via a drop-down list), and “area” from the spreadsheet. The calculation of pavement thickness should be done inside VBA code. The table with load values and pavement thicknesses should be generated in code.

B) Test the function created with the following specifications: wheel load values ranging from 25,000 to 40,000 lbs. in a table format. Area = 200 square inches. USCS soil type = GM (corse-grained soil). Make a plot next to the answers provided in your table. The plot should have load (in pounds) in the x-axis and pavement thickness (in inches) in the y-axis. Show the results in your homework solution via a screen capture. In your solution, include a screen capture of the formula used to invoke the Excel function.

C) Test the function created with the following specifications: wheel load values ranging from 25,000 to 40,000 lbs. in a table format. Area = 225 square inches. USCS soil type = MH (fine-grained soil). Make a plot next to the answers provided in your table. The plot should have load (in pounds) in the x-axis and pavement thickness (in inches) in the y-axis. Show the results in your homework solution via a screen capture. In your solution, include a screen capture of the formula used to invoke the Excel function.

Problem 3

This problem deals with deflection calculations for a cantilever beam (i.e., a beam supported at one end to a wall) with a total load W distributed along the beam (see Figure 1). More information about the equations of the beam can be found at: http://www.engineersedge.com/beam_bending/beam_bending8.htm.

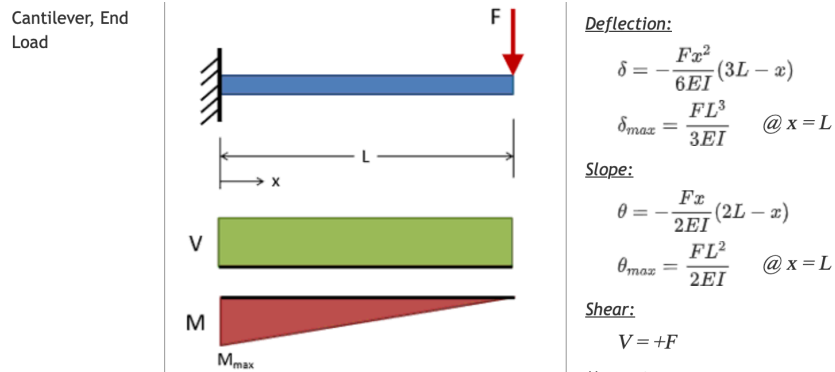


Figure 1. A cantilever beam supported at one end. Source: <https://mechanicalc.com/reference/beam-deflection-tables>.

Nomenclature for beam deflection and stress calculation equations.

- F = load (lb)
- E = Modulus of elasticity (lb/sq-in)
- I = Moment of inertia (in⁴)
- x = distance from the datum point (in)
- L = beam length (in)
- θ is the slope of the beam at station x (radians)
- δ is the beam deflection at station x (inches).

a) Create two **VBA subroutines** (not functions) to estimate: 1) the beam deflection (δ) at any station of the beam and 2) the slope (θ) of the beam at stations from $x=0$ to $x=L$ at intervals of one inch. Your code calculates (δ) and (θ) as a function of known quantities F, E, I, L, and x. Your VBA code should read values: F, E, I, L, and x from the spreadsheet. These values will be entered by the user in the worksheet in separate cells. The values of (δ) and (θ) should be calculated every one inch along the beam and written back to a table in the spreadsheet. Write code to calculate the deflection of the beam inside a FOR-Loop. The mechanics of the problem are similar to the loop with concatenation example discussed in class.

b) Test your VBA code using the following values for the beam model parameters. Assume a beam is 300 inches in length and that we need to calculate the deflection and the slope of the beam at various stations (say every one inch).

- F = 1000; % lbs
- I = 125; % inches to the fourth power
- L = 300; % inches
- E = 29e6; % psi

c) Plot the solution of the steel beam deflections obtained in part (b). Label your plot accordingly.

d) Try the analysis for a 300 inch beam made of concrete with a value of $E = 15e6$ psi.

Show all your screen captures of your code and the output produced by the VBA code.

e) Copy the beam deflections obtained for steel and concrete and compare the deflection profiles. Comment.
Show screen captures of the output produced and the VBA code.