Experimental Soil Mechanics

Geo-centrifuge Project: Assignment 1

<u>Task 1 of 3</u>

In many introductory geotechnical courses, the concept of stress distribution under a foundation load is often presented using a figure similar to that depicted in Figure 1 where the shapes of the principal stresses under a square load are shown for a normalized case. The stresses diminish in an expanding bulb-like pattern. The formation of this bulb under a foundation is considered fundamental and creates a segue for more rigorous soil mechanics.

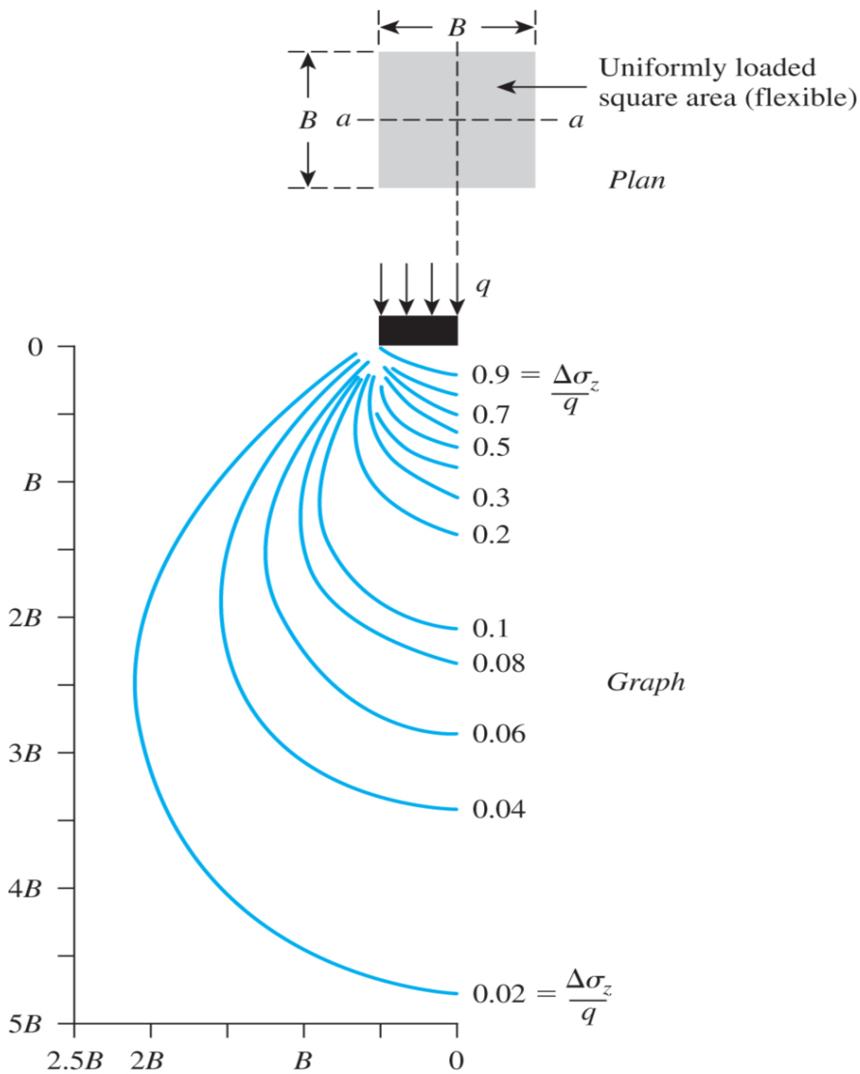


Figure 1: Vertical stresses under a square footing (Bowles, 1982)[1]

Design a field loading test to evaluate the actual shape and distribution of the vertical stresses in soil under a square foundation and measure the foundation vertical load capacity. The footing is resting on a

[1] Bowles, J., (1982), Foundation Analysis and Design, McGraw-Hill.

deep layer of Nevada sand with relative density of 50% (Fig. 2). The footing has a width (*B*) and is subjected to a column load (*P*). Tactile pressure sensors will be used to measure the stresses in the soil (Fig. 3). These are thin, flexible sheets that contain a matrix of force sensors (almost 2000 per unit). They are used in conjunction with data acquisition and analysis software to display the stresses along the face of the sensor (Fig. 4). The length of a side of the matrix is 6 meters (labeled as Matrix Width and Height in Fig. 3). The following items are required as part of the design at this stage:

a. Find the optimal depth location and lateral extension of the pressure sensors below the footing. (use only four pressure sensors). There are 4 proposed layouts for the depth of the sensors and you are asked to choose one of them, give full detailed explanation for the reason behind your choice, all the depth options are formatted as (distance from soil surface to 1st sensor, distance between 1st and 2nd sensors, distance between 2nd and 3rd sensors, distance between 3rd and 4th sensors) all distances are a function of footing width (B).
   i- (0.5B, 0.5B, 0.5B, 0.5B).
   ii- (0.5B, 0.5B, 1.0B, 1.0B).
   iii- (0.2B, 0.3B, 0.4B, 0.6B).
   iv- (0.2B, 0.2B, 0.2B, 0.2B).
b. What are the soil parameters needed to evaluate soil strength? What are the lab experiments that should be conducted to obtain them? What are the soil parameters needed to evaluate soil strength? What are the lab experiments that should be conducted to obtain them?

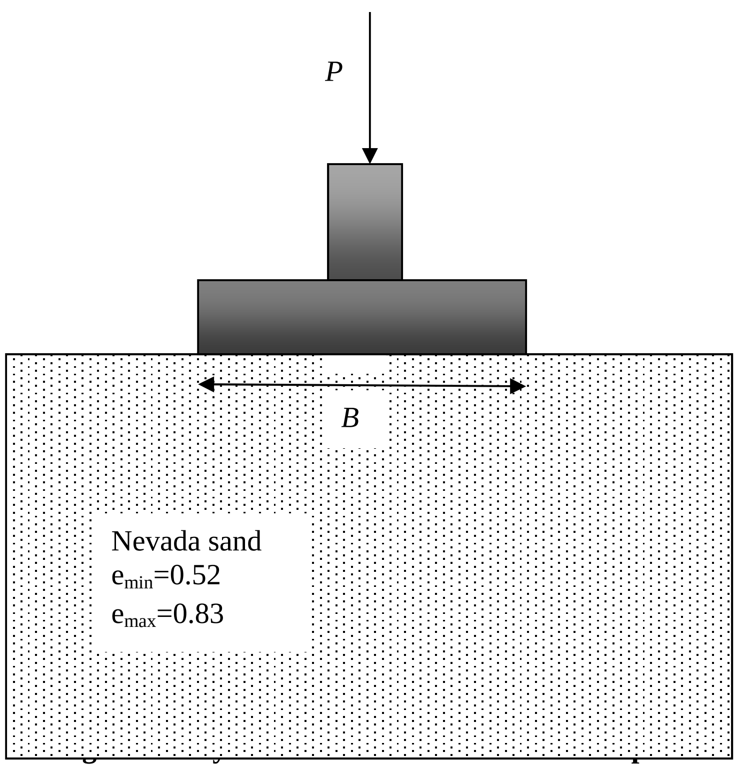
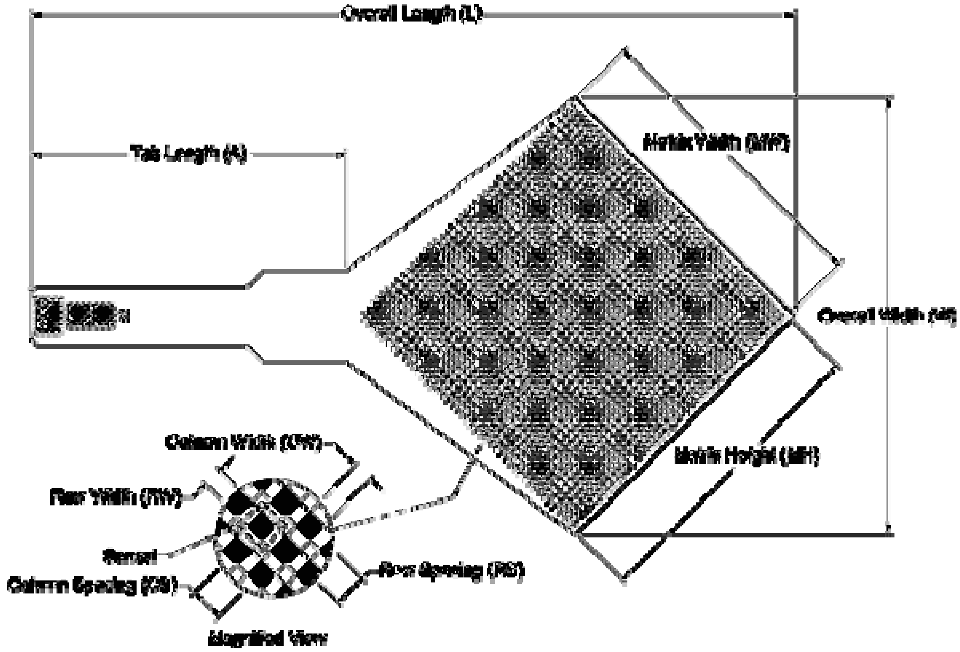


Figure 2: Layout of the foundation and soil deposit



c.

Figure 3: Tekscan Model 5250 Sensor

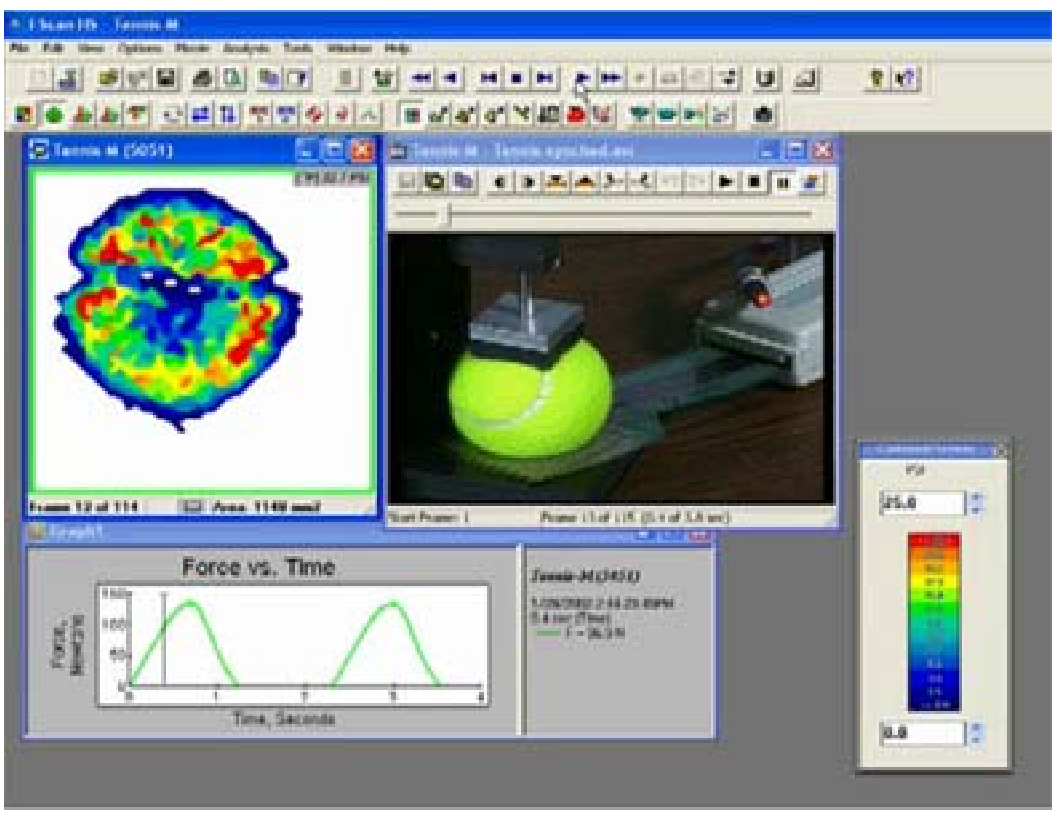


Figure 4: Tekscan software used to show stresses on a tennis ball

Task 2 of 3

Estimate the column load that would cause failure of the soil underneath the footing described in Task 1. Soil failure is a function of soil shear parameters, soil density, and footing width.

a) What is the recommended footing width (B) knowing that the loading jack maximum capacity is 18 kN and tactile pressure sensors dimensions are 6x6m? Provide a detailed reasoning for the proposed design.
b) Calculate the ultimate bearing capacity for the footing as a function of its width (*B*). What is the corresponding ultimate design load as a function of (*B*)?
c) Sketch the anticipated failure planes in the soil under the square footing.

Task 3 of 3

In this part of the problem, you are asked to design the centrifuge model of the footing and soil deposit presented in Task 1. The centrifugal acceleration that will be applied to the model is 25 g. Draw a sketch of your design illustrating the model dimensions. Show the exact location and type of sensors you recommend for use in this model and define their functionality.

Guidelines for Project Report Preparation

- Students should be aware that this project has new elements and presents a real-life challenge and therefore they are expected to make an effort to seek answers to the required questions beyond the traditional way of relying on a textbook.
- Students are expected to meet with the professor or TA to discuss the project before preparing their final report.
- The report should reflect the effort of each student not a group of students. Similar reports will receive **zero grade**.
- Each student must present a professionally-written report **(Typed)** which includes documentation of the project and a summary and discussion of the results.
- The report should be one single document either in MS WORD or PDF formats.
- The report should include appendices showing engineering calculations, and examples of spreadsheets developed for this project. A reference list using the ASCE citation format must also be included listing all textbooks and references used for the project.
- Figures produced in the report should be of high quality **(No Hand Drawings).** All figures should be numbered and captioned. Similarly, all tables should be numbered and captioned.
- Figures and Tables should be cited within the text of the report.
- Equations should be numbered.
- Source of any material (e.g., figure, equation, etc.) should be properly cited.
- No hand-written material or hand-drawn figures will be accepted.
- 20% of the assignment grade is on the quality of the submitted report.