THE OPEN UNIVERSITY OF SRI LANKA
BACHELOR OF TECHNOLOGY (CIVIL) – LEVEL 06
Final Examination 2012/2013

CEX6230 – GEOTECHNICS

Time allowed: Three Hours

Date: Monday, 19th August, 2013 — Time: 0930-1230

Answer five questions. All questions carry equal marks.

1. When designing a shallow footing, the estimated total settlement is checked against the permissible settlement, in order to limit total and differential settlements. Total settlement comprises of immediate settlement, primary consolidation settlement and the settlement due to secondary compression.

   A. Explain how you would estimate the immediate settlement beneath a shallow footing. State all design parameters you would use in the computation. (4 points)

   Figure 1 plots the results of a one-dimensional consolidation test specimen, representative of a 7m thick clay stratum. The in-situ effective overburden stress and void-ratio is determined to be 100kPa and 0.99, respectively.

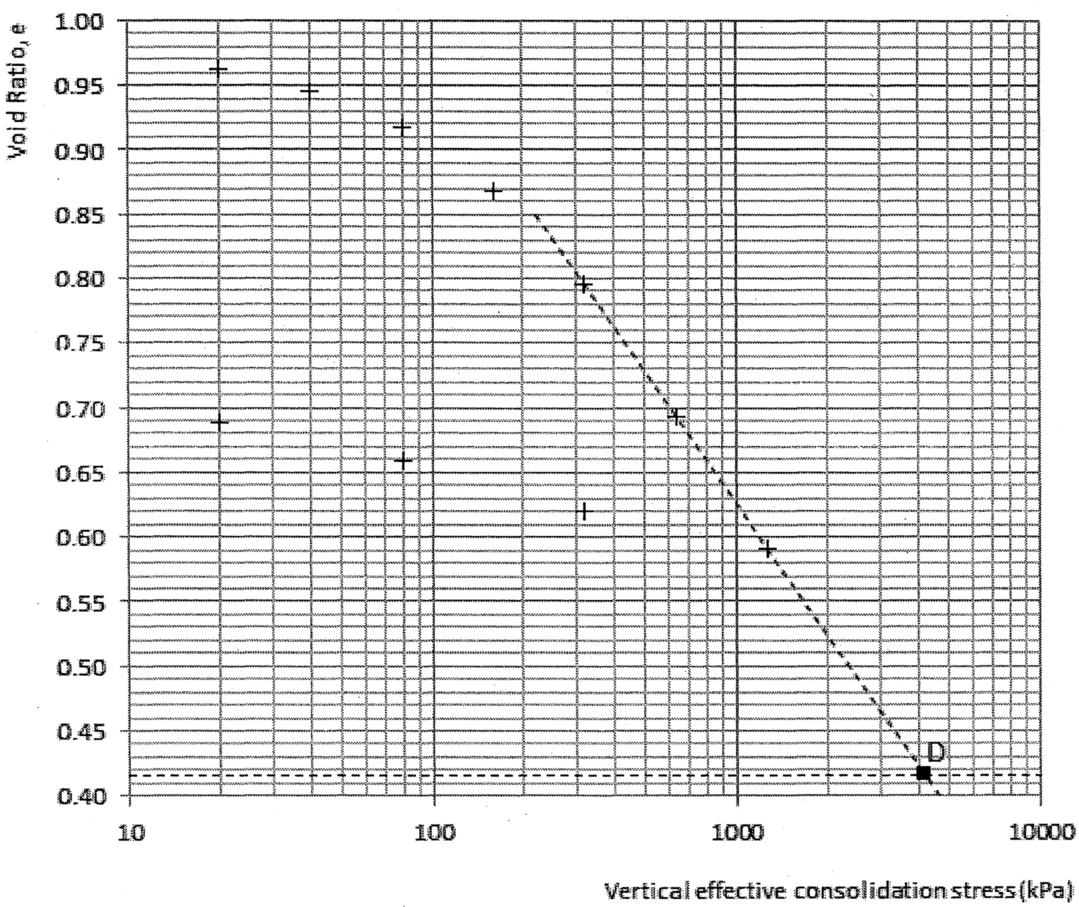


Figure 1: Variation of e versus p′

   B. Estimate the pre-consolidation stress. Show you construction on Figure 1 (refer annexure). Compute the over-consolidation ratio. (4 points)

   C. Construct the idealized (i.e. in-situ) compression curve. Point D lies on the idealized compression curve. (6 points)

   D. Compute in-situ Compression Index and the Re-compression Index (2 points)

   E. Estimate the consolidation settlement of the clay layer, for a stress increment $\Delta\sigma_v$ = 250kPa (4 points)

2. Figure 2 shows a trapezoidal footing. The respective column loads at points P and Q are 475kN and 275kN. Both columns are 300mmx300mm square columns. L_1, the distance between point P and the edge RS is 1.0m. L_2, the distance between column centres is 3.0m.

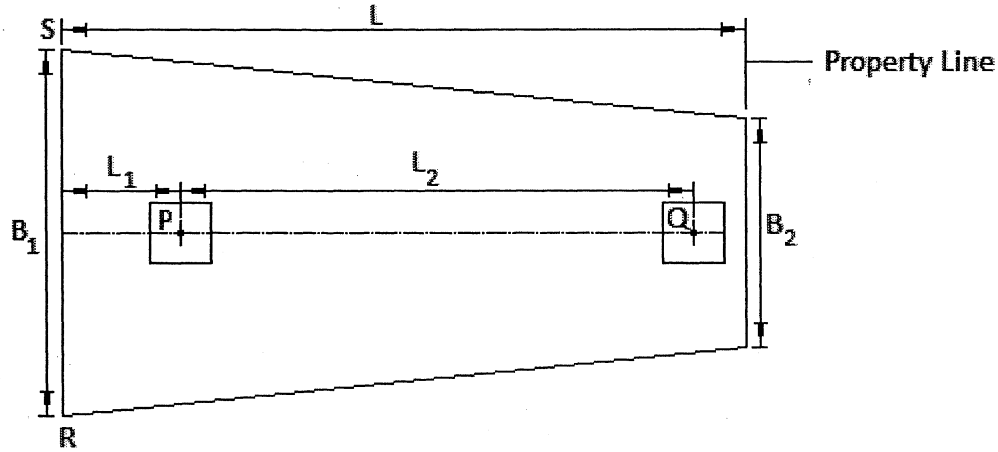


Figure 2

A. Express footing area A in terms of the dimensions L, B_1 and B_2. (2 points)

B. The design requires limiting the uniform net-allowable bearing pressure, σ, beneath the footing to 80kPa. Derive and expression that satisfy the said condition. (4 points)

C. Compute X, which is the distance from point P to the resultant load due to both column loads, measured along the centreline passing through P and Q. This gives the distance to the resultant force as $(L_1 + X)$, measured from edge RS. (4 points)

D. The resultant force due to a uniform net-bearing pressure, σ, acting on the footing area, A is equal to σA. The moment of this force taken about edge RS is equal to $\sigma A(L_1 + X)$. This moment is equal to sum of moments of the rectangle and the two triangles making the trapezoid, taken about edge RS. Derive the expression that relates $\sigma A(L_1 + X)$ to the sum of moments as described above. (4 points)

The distance $(L_1 + X)$ determined in questions 2B and 2D above, should be the same to ensure a uniform net-allowable bearing stress of not more than 80kPa.

E. Explain why $(L_1 + X) < L/2$ and $L/3 < (L_1 + X)$ (2 points)

F. Determine B_1 and B_2 which satisfies the all requirements. (4 points)

3. When answering this question, candidates are expected to provide short, precise and direct answers. The use of sketches and diagrams may reduce lengthy explanations. Please do not reproduce the question or any part of the question as your answer.

A. Figure 3A shows a shallow rigid footing subjected to an axial force and a bending moment. Compute the resulting stress distribution beneath the footing. (5 points)

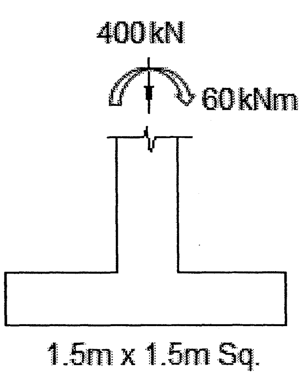


Figure 3A

B. Figure 3B gives the result obtained during a Unconfined Compression (UC) test. Sketch the Total Stress Path (TSP) for this test. Name the axis. Sketch Mohr-Coulomb failure line. Explain why you aren't able to sketch the Effective Stress Path (ESP) for this test. (5 points)

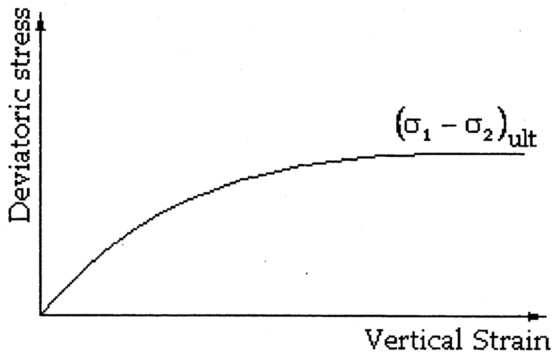


Figure 3B

C. Discuss why properties of high-plasticity clays differ from low-plasticity clays. (5 points)

D. Sketch the variation of Deviatoric Stress vs. Axial Strain and Volumetric Strain vs. Axial Strain for an over-consolidated clay soil. Name the axis. (5 points)

4. Figure 4 shows a homogeneous earth embankment dam through which uniform water seepage occurs. It is founded on impervious bedrock. The phreatic surface at full supply level of 10m is indicated by line BC. It intercepts the toe filter at point C. Point C is located 1.7m above datum AF.

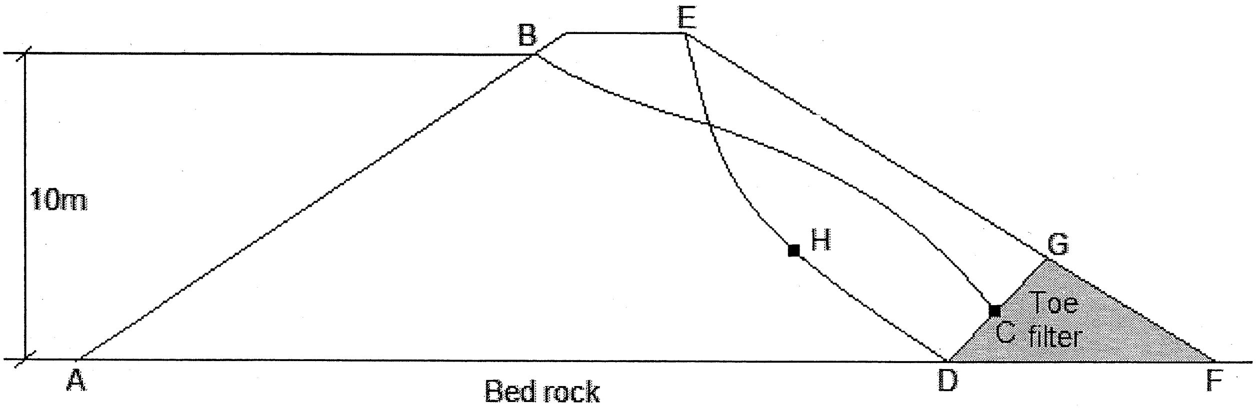


Figure 4

A. Determine the pressure head, elevation head and the total head at points A, B, C and D. (4 points)

B. Demarcate the constant head boundaries and the no-flow boundaries. (2 points)

C. Draw the flow-net that represents seepage through the dam (refer annexure). (6 points)

D. Compute pore water pressure due to seepage acting at point H. Point H is 3.6m above datum AF (4 points)

E. Explain how you would assess the stability of the dam section EGFDE, considering the potential failure surface represented by arc ED. (4 points)

5. Figure 5 shows a raft foundation exerting a bearing stress of 170kPa.

A. Sketch the stress bulb that represents the vertical stress at bedrock depth. Determine the stress level at bedrock depth. (2 points)

B. Discuss how you would consider the stress dispersion when determining the total elastic settlement. (5 points)

C. Compute the elastic settlement due to Layer 1. (5 points)

D. Compute the elastic settlement due to Layer 2. (4 points)

E. Discuss whether the total elastic settlement falls within the permissible total settlement. If the estimated settlement is not satisfactory, explain what changes you wish to propose to make the check satisfactory. (4 points)

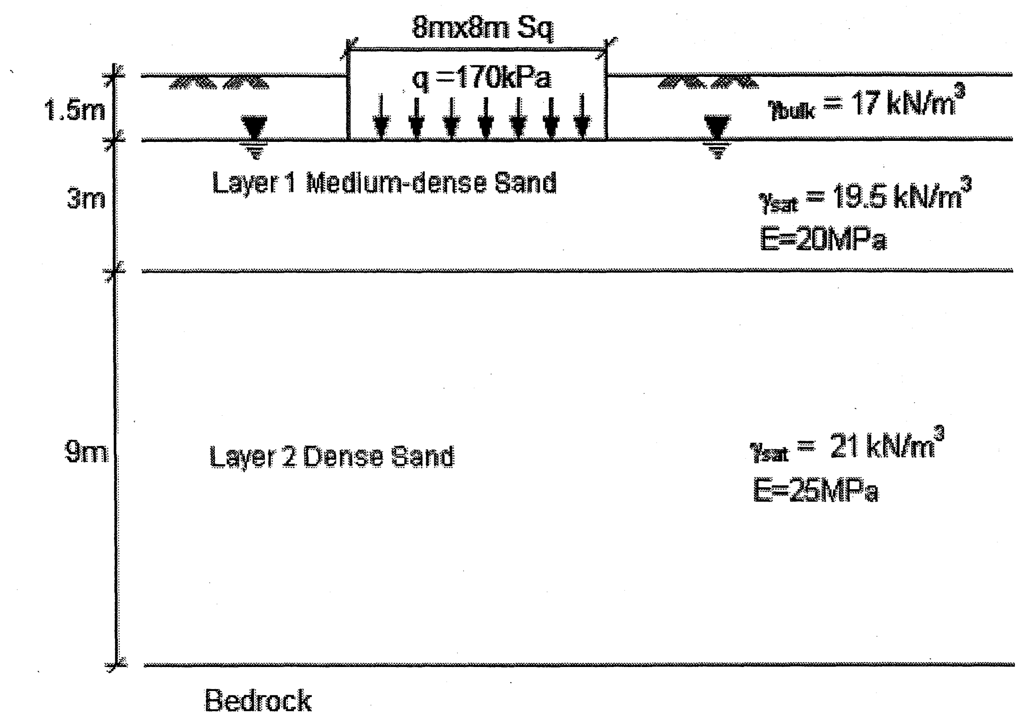


Figure 5

6. Figure 6a shows a braced excavation in a sandy soil, where struts are placed at centre to centre distance of 1.2m along the excavated trace. The natural water table is well below the excavated depth. Soil properties: $\gamma_{bulk} = 17 kN/m^3; \phi' = 32^0; \ c' = 0$. Figure 6b gives an extract from BS8002: 1994.

   A. Sketch the distribution of horizontal stress (in kPa) with depth, per meter length of sheet-pile wall, as per BS 8002:1994. Show principal values. (4 points)

   B. State the assumptions you would make when determining the force acting on each strut. (2 points)

   C. Compute the force acting on each strut, spaced at 1.2m apart. (4 points)

   D. Compute the maximum bending moment per 1.2m length of sheet-pile wall, and the distance to the point of maximum bending moment from ground level. (6 points)

   E. Compute the section modulus (in mm^3) required if the design yield strength of the sheet-pile wall material is 200MPa. (4 points)

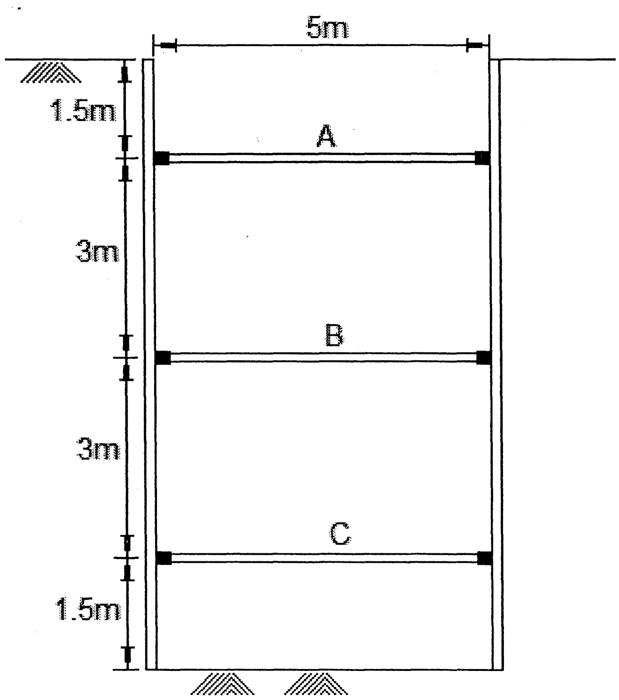


Figure 6a. Excavation supported by sheet-pile wall.

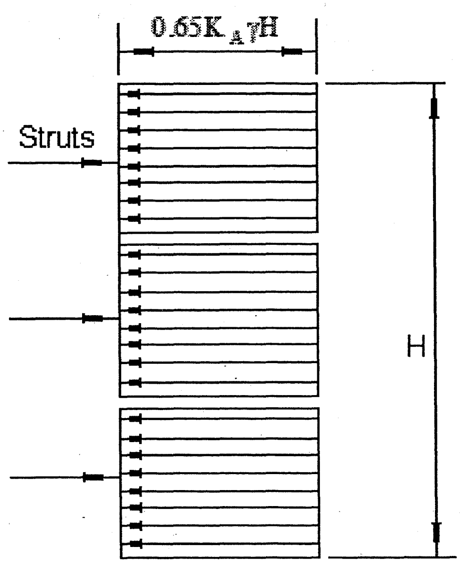


Figure 6b: Active pressure diagrams for maximum strut load for braced earth pressure retaining structures in Sand (Figure 37, BS 8002: 1994 – Code of Practice for Earth Retaining Structures).

7. When answering this question, candidates are expected to provide short, precise and direct answers. The use of sketches and diagrams may reduce lengthy explanations. Please do not reproduce the question or any part of the question as your answer.

   A. Figure 7A shows the variation of coefficient of lateral earth pressure due to inward and outward wall movements. Compare the three states of lateral stress described in the said figure. (5 points)

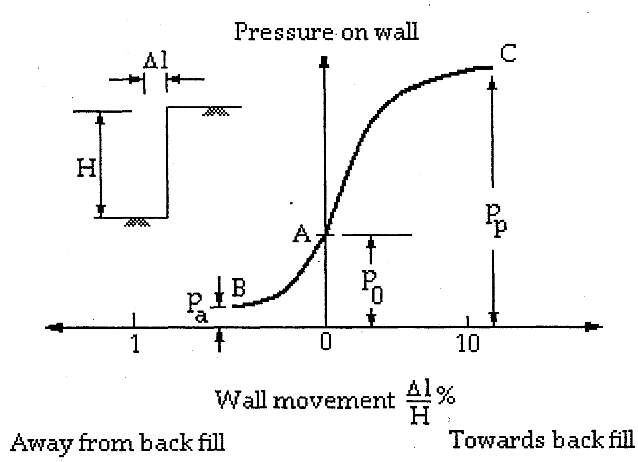


Figure 7A

   B. Figure 7B shows the regions that are stressed due to structural loads. Discuss the influence of soil surcharge, D on ultimate bearing capacity of the soil. (5 points)

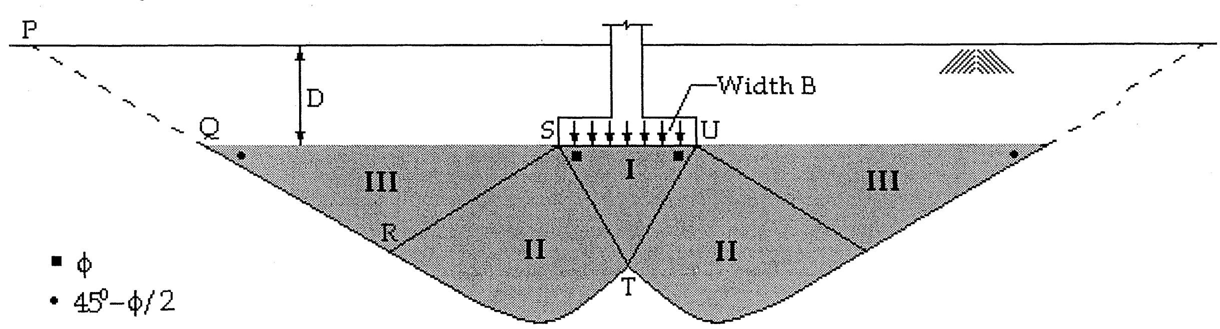


Figure 7B

   C. Discuss the three modes of instabilities associated with gravity retaining walls. (5 points)

D. During the analysis of the stability of slopes, the factor of safety against sliding is expressed as: $F = \dfrac{\sigma_n \tan\phi + c}{\sigma_n \tan\phi_d + c_d}$. Define the terms specified in the equation. (5 points)

8. Bishop's pore pressure parameters A and B is used to estimate the change in excess pore water pressure, Δu, due to changes in total principal stresses, $\Delta\sigma_1$ and $\Delta\sigma_3$. This is expressed as: $\Delta u = B[\Delta\sigma_3 + A(\Delta\sigma_1 - \Delta\sigma_3)]$.

A. Explain what parameter B represents. (4 points)

B. Explain what parameter A represents. (4 points)

Figure 8 shows a clay soil element A, located at a depth 8m below ground level.

C. Compute the principal stresses with respect to total and effective stress, acting on soil element A. State the assumptions made, in computing the said stresses. (4 points)

D. An Unconsolidated Undrained (UU) Triaxial loading test is to be performed on the normally consolidated clay specimen obtained from location A. Explain how you would create the in-situ conditions using the UU triaxial test setup, relating to stresses computed in question 8C above. Candidates should note that conventional triaxial loading test commences from an average cell pressure and a zero deviatoric stress. (4 points)

E. The UU triaxial test revealed that the specimen failed at a deviatoric stress of 150kPa. Its pore water pressure in excess of the applied back pressure at failure was observed to be 75kPa. Compute Bishop's pore-pressure parameter A_f, at failure. (4 points)

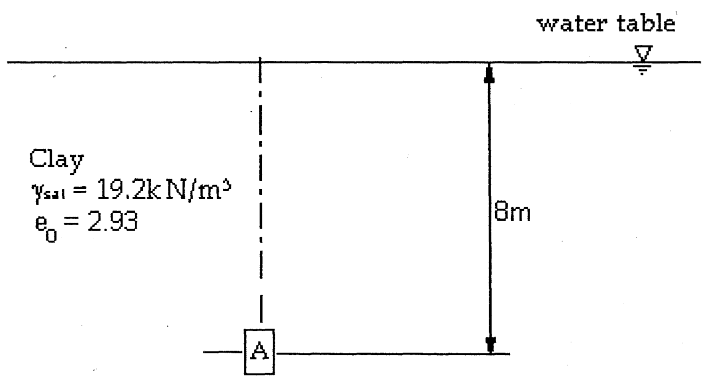
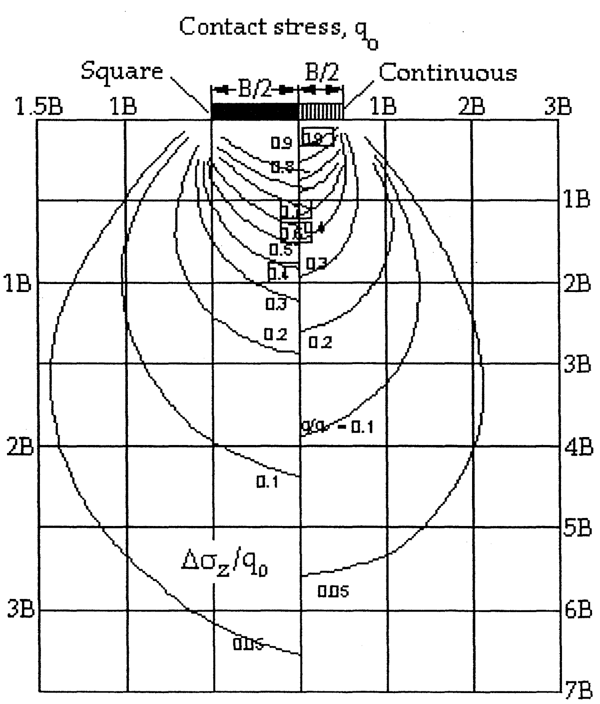
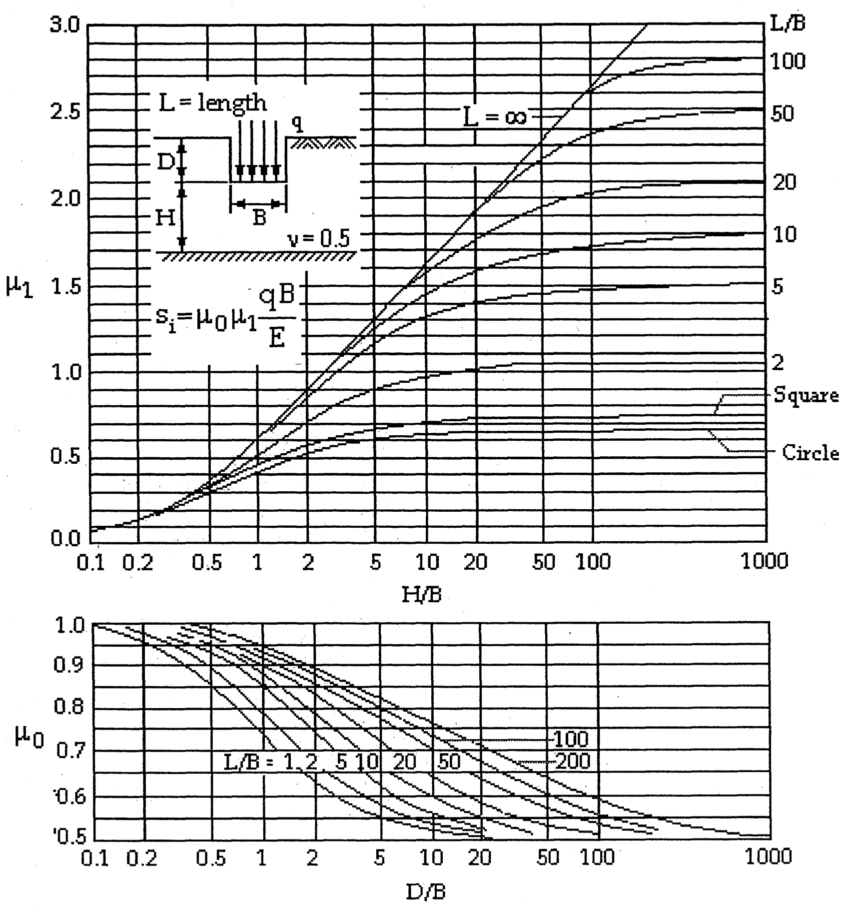


Figure 8




L = length
q
D
H
B
ν = 0.5
$s_i = \mu_0 \mu_1 \frac{qB}{E}$
L = ∞
L/B
100
50
20
10
5
2
Square
Circle
μ_1
H/B
μ_0
L/B = 1, 2, 5, 10, 20, 50
100
200
D/B

Attach this sheet to your answer script.