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THE OPENUNIVERSITY OF SRI LANKA
BACHELOR OF TECHNOLOGY (CIVIL) – LEVEL 06
Final Examination 2014/2015

CEX6230 – GEOTECHNICS

Time allowed: Three Hours

Date: Monday, 21st September, 2015 | Time: 0930-1230

Answer five questions. All questions carry equal marks.

1. Fig. 1 is an extract from the Design Manual DM7.01 of the US Navy.

   A. List the dependent and independent variables shown in Fig. 1 (4 points)

   B. Explain how Dry Unit Weight is determined for a borehole specimen. (4 points)

   C. Explain how Relative Density is determined for a borehole specimen. (4 points)

   D. Explain how you would use Fig. 1 when computing the force due to active earth pressure on a gravity retaining wall. (4 points)

   E. For a course grained soils, when computing active earth pressures, strength parameter ϕ' is used instead of ϕ. Discuss the validity of this statement. (4 points)

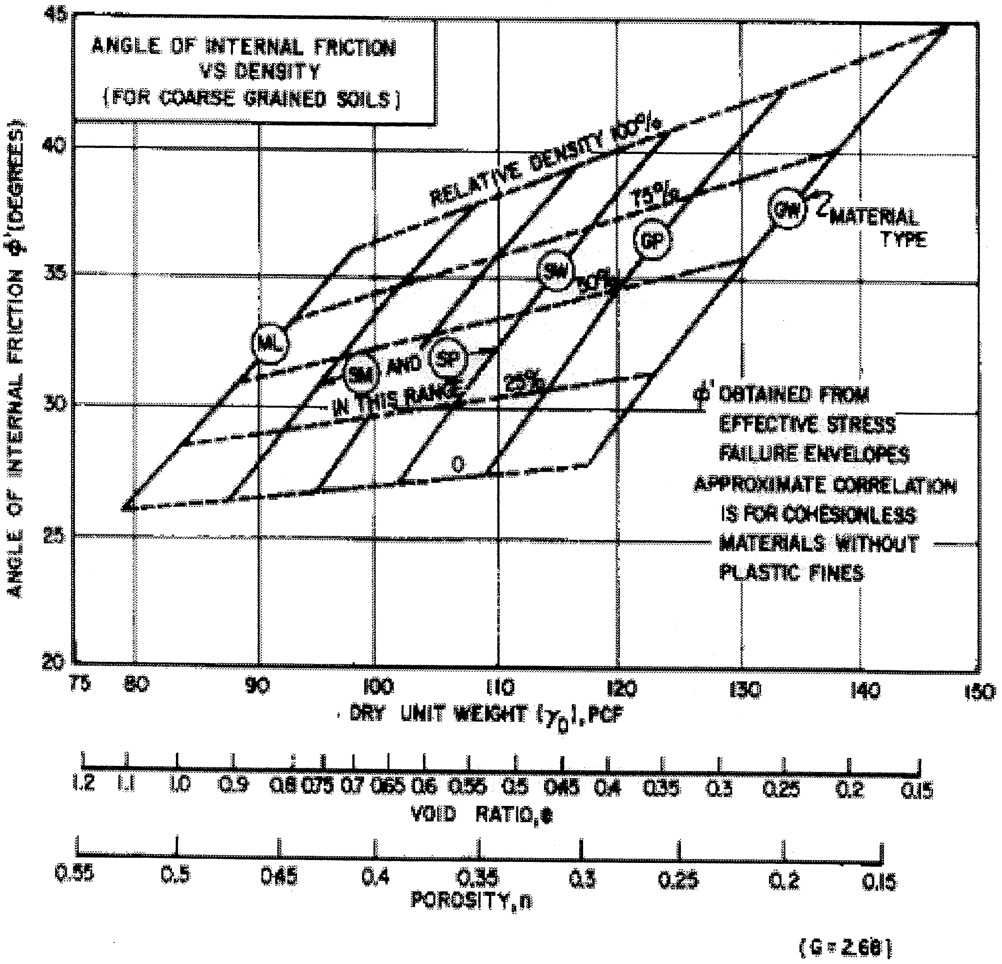


Fig. 1: Correlations of strength characteristics of granular soils (Figure 7, US Navy DM7.01)

2. Failure of natural slopes occurs in central hill country of Sri Lanka, triggered by high-intensity rains, over extended periods. During rainy reasons significant slope movements are observed.

   A. Discuss why soil mass looses its shear strength during slope movement. (4 points)

   B. During extended dry weather periods, matric suction in soils provides additional stability to slopes. Discuss the validity of this statement. (4 points)

C. Discuss how reducing infiltration and enhancing sub-surface drainage improve stability of a natural slope. (4 points)

D. Fig. 2 shows a proposed highway cut.

i. Using Taylor's Stability Chart, compute the factor of safety, F. $N_s = \frac{c_u}{F\gamma H}$. (3 points)

ii. Sketch the probable failure surface. (2 points)

iii. Show on a clear sketch what additional measures you would take to make the slope more stable. (3 points)

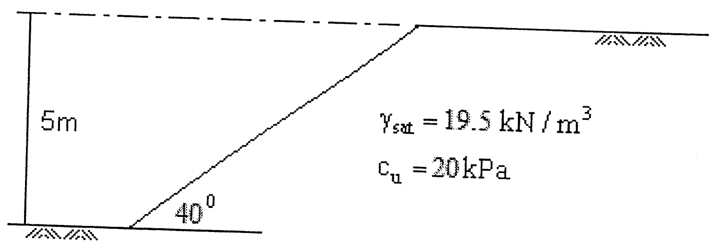


Fig. 2

3. Fig. 3 shows a soil profile where a sand layer is in an artesian situation.

A. Discuss how this artesian condition may have been formed. (3 points)

B. Compute total vertical stress, pore water pressure and effective vertical stress at points A, B, C and D. (6 points)

C. Compute the total head difference across the clay layer. State the direction of flow. (4 points)

D. Suppose that the artesian pressure drops to 1m below ground level, compute the resulting average effective stress at point D. (3 points)

E. Compute the resulting settlement. (4 points)

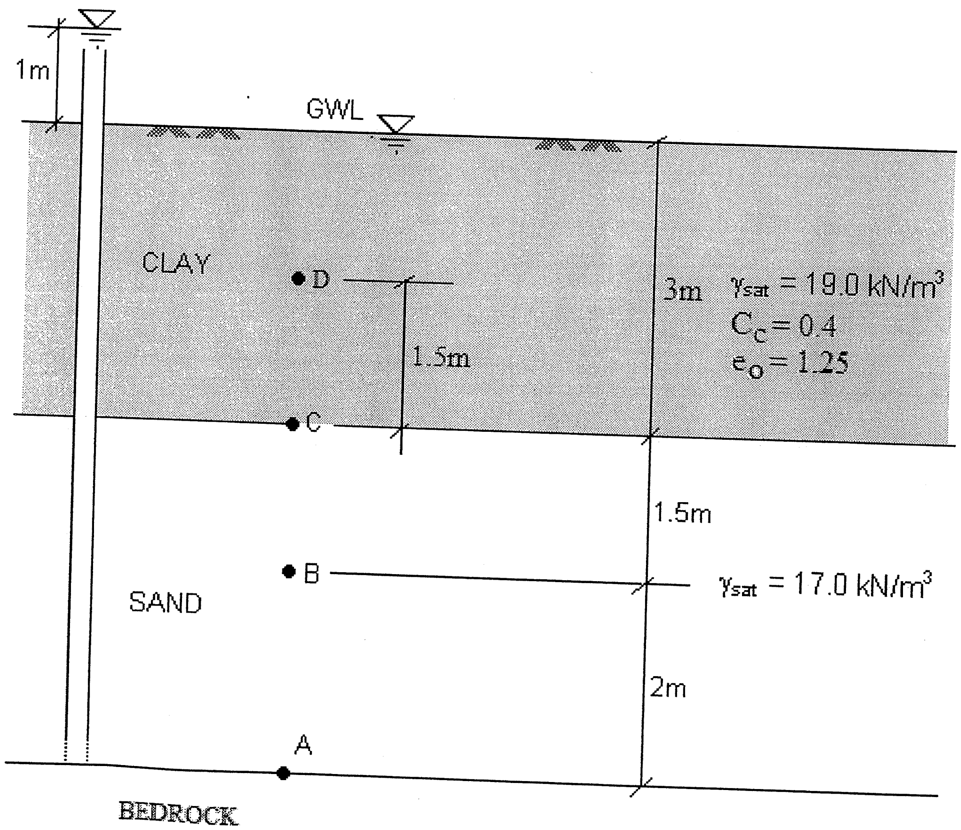


Fig. 3

4. Fig. 4 shows the soil profile of a low-lying land, and its proposed compacted fill. The Geotechnical Engineer wishes to assess strength and hence stability of the organic clay, during placement of the fill. She has obtained an undisturbed borehole specimen from a depth of 3m (i.e. refer Element A). The Oedometer test results show that element A is normally-consolidated.

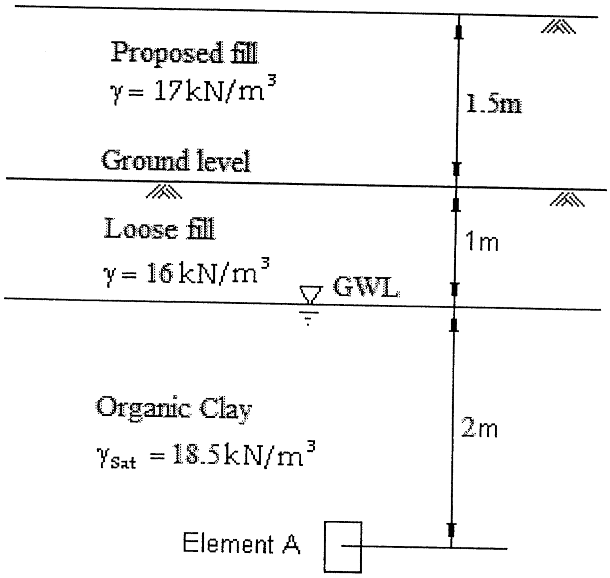


Fig. 4

A. <u>Discuss</u> whether she should assess short-term stability or long-term stability. <u>State</u> your reasons. (2 points)

B. <u>Discuss</u> whether she should perform a total stress analysis or an effective stress analysis. <u>State</u> your reasons. (2 points)

C. <u>List</u> in-situ measurements required for the analysis you have recommended in 4B. (2 points)

D. <u>Compute</u> p, p′, and q for element A, before placing the fill. (3 points)

E. Assuming that the lateral total stress remains constant during placement of fill, <u>compute</u> total stress path point (i.e. p and q), at end of placement of fill. (3 points)

The laboratory reports that element A has $c_u = 25kPa$, and $\phi' = 30^\circ$.

F. Using a graph sheet, <u>sketch</u> the following:

   i. Shear strength envelopes representing $c_u = 25kPa$, and $\phi' = 30^\circ$ (2 points)

   ii. Total Stress Path for element A, during loading. (2 points)

   iii. The Effective Stress Path for element A, during loading. (2 points)

G. <u>State</u> your conclusions with regard to short-term stability of Element A. (2 points)

5. Fig. 5 shows a retaining structure made of reinforced earth.

A. <u>Discuss</u> situations where reinforced retaining structures are preferred over other forms. (2 points)

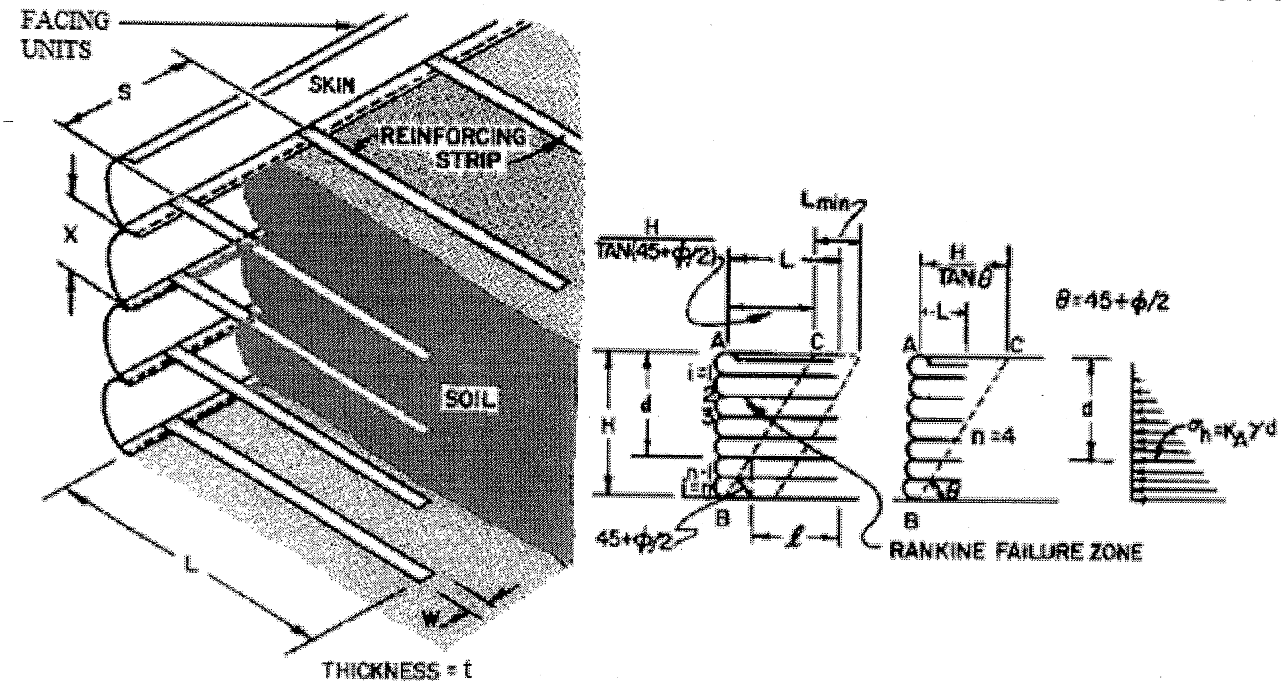
B. <u>Discuss</u> briefly, how elements of this structure contribute towards enhancing its stability, beyond its natural stable configuration. (4 points)

C. <u>List</u> the stability checks you would perform. <u>Discuss</u> the derivations of equations used in the design computations. (4 points)

D. An elevation difference of 3m is to be supported using a reinforced earth retaining structure. <u>Perform</u> the necessary geotechnical design checks. Reinforcement strips have a yield strength of 250 N/mm^2, and a cross section of 75mmx5mm. Candidates are required to state clearly the assumptions made. (6 points)

E. <u>Provide</u> a clear sketch indicating all details relevant to construction. (2 points)

F. <u>Show</u> on a sketch how drainage is provided. (2 points)



Safety against breaking of reinforced strips.

$$F_S = \frac{f_s\, W t}{K_A\, \gamma\, H\, S\, X}$$

S = Horizontal spacing between strips   X = Vertical Spacing between strips

f_s = allowable stress of reinforced strips.

Typically W = 3". A high factor of safety, F_S = 3.2, is used even though allowable metal stress is utilized in computing strip thickness. This is done to account for unknowns such as durability and corrosion.

SAFETY AGAINST PULLOUT $F_s = \frac{2\, L_{min} W \tan\delta}{K_A \cdot S \cdot X}$

L_{min} is measured beyond zone of Rankine failure. The upper strips may not have enough length to fulfill this requirement, but as long as the average length of all the strips satisfies this conditon the wall is considered satisfactory.

d = depth beneath top of wall

t = thickness of strip

γ = unit weight of backfill

B = width of wall

K_A = coefficient of each active pressure (higher than active value may be used depending on compaction conditions and limitations on deformations).

δ = angle of friction between reinforcing strip and the backfill material

ℓ = effective length of tie beyond potential sliding surface

Fig. 5 Reinforced Earth (Reference – Figure 35, DM 7.2, US Navy)

6.

A. Discuss nature of swelling clays, with reference to building construction. Recommend measures you would consider during construction, in order to prevent damage to single-story structures due to alternate wetting and drying of such soils. (5 points)

B. Explain the Critical Void Ratio concept in relation to stress-strain behaviour of sandy soils. (5 points)

C. Explain Normal Consolidation Line and Critical State Line. Fig. 6C plots two stress paths, OAB and OAC. Explain stress-path segments OA, AB and AC. (5 points)

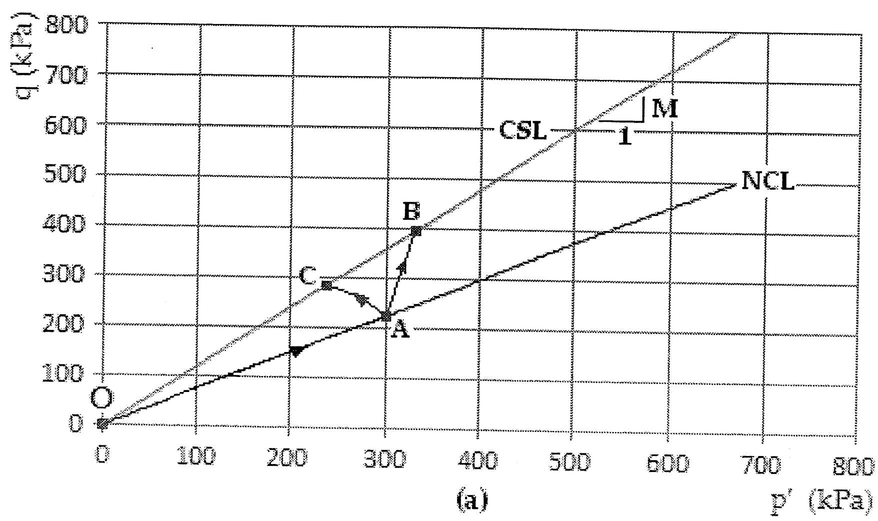


Fig. 6C

D. Fig. 6D shows an analogy, which is used to explain primary consolidation of a clay soil when subjected to a vertical load. Explain how primary consolidation is explained using the process described in Fig. 6D.

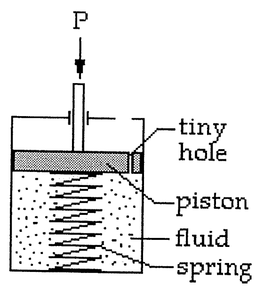


Fig. 6D

7.

A. Sketch bearing stress distributions that occur across the width of a i) rigid and ii) flexible strip footing. A strip footing has a 150mm thick reinforced footing pad. Discuss whether you would consider it to be a flexible footing or a rigid footing. (5 points)

B. Fig. 7B shows the idealised in-situ compression curve obtained during a 1-Dimensional Consolidation Test. Explain how you would determine parameters e_o and σ'_{vo}. (5 points

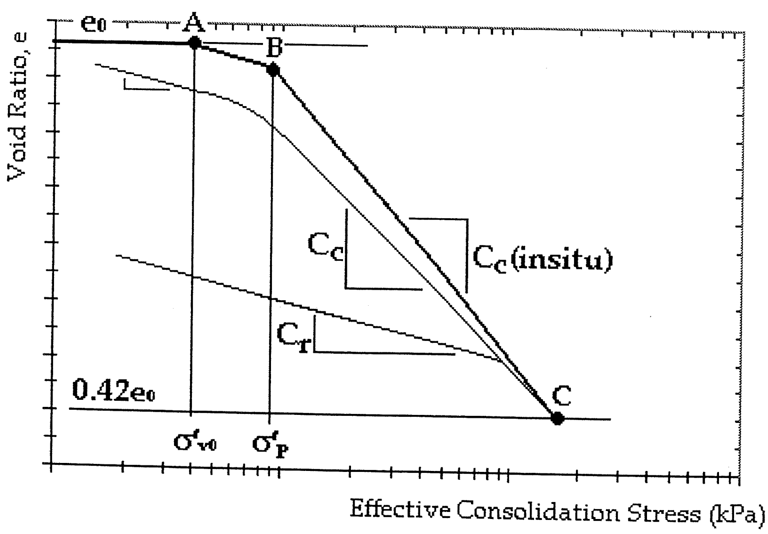


Fig. 7B

C. Define all parameters listed in equation $\frac{\partial \bar{u}}{\partial t} = c_v \frac{\partial^2 \bar{u}}{\partial z^2} + c_h \left(\frac{\partial^2 \bar{u}}{\partial r^2} + \frac{1}{r} \frac{\partial \bar{u}}{\partial r} \right)$. (5 points)

D. Fig. 7D shows pore water pressure profiles (a) equilibrium with water table and (b) during excessive evaporation /evapo-transpiration. Explain how curve (b) affects effective stress. (5 points)

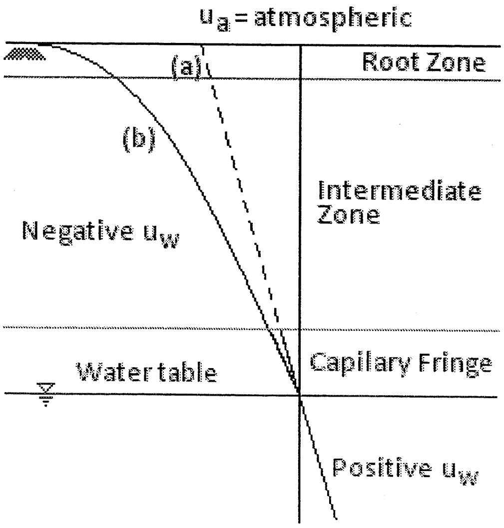


Fig. 7D

8.

A. The elastic settlement of soil along the pile shaft is expressed as: $\delta_{e(3)} = \frac{1}{pL} \cdot \frac{Q_S D}{E_S}\left(1-\mu_s^2\right) I_S$, where Q_s – load carried by pile-shaft; D – width or diameter of the pile; E_s and ν_s being the modulus of elasticity and Poisson's Ratio of the soil, p – perimeter of pile; L – embedded length of pile; I_S – an influence factor representing soil along pile-shaft expressed as: $I_S = 2 + 0.35\sqrt{\frac{L}{D}}$. Sketch a soil element next to the vertical surface of the pile, at a particular depth; show all stresses acting on this soil element, when the pile is loaded. Also show how this soil element deforms when loaded. (5 points)

B. Discuss using a sketch, how you would estimate the consolidation settlement of a pile group, located in a clayey soil stratum. (5 points)

C. Determine pile length, L required to support the load shown in Fig. 8. The pile diameter is 450mm. A factor of safety of 3.0 is to be maintained. (10 points)

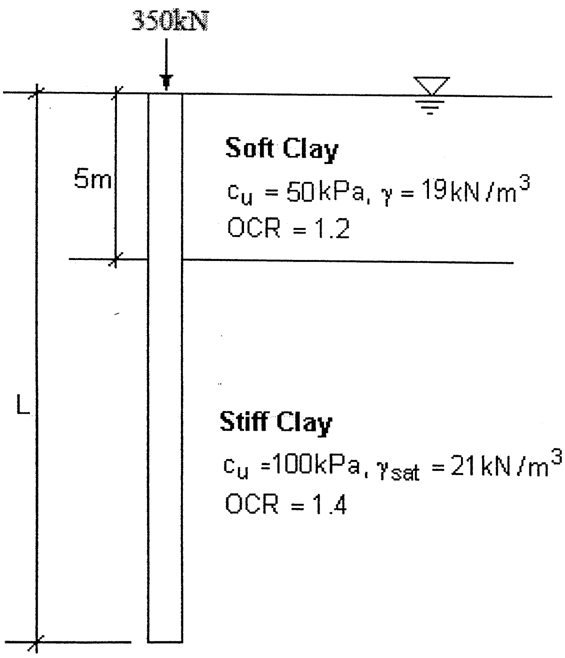
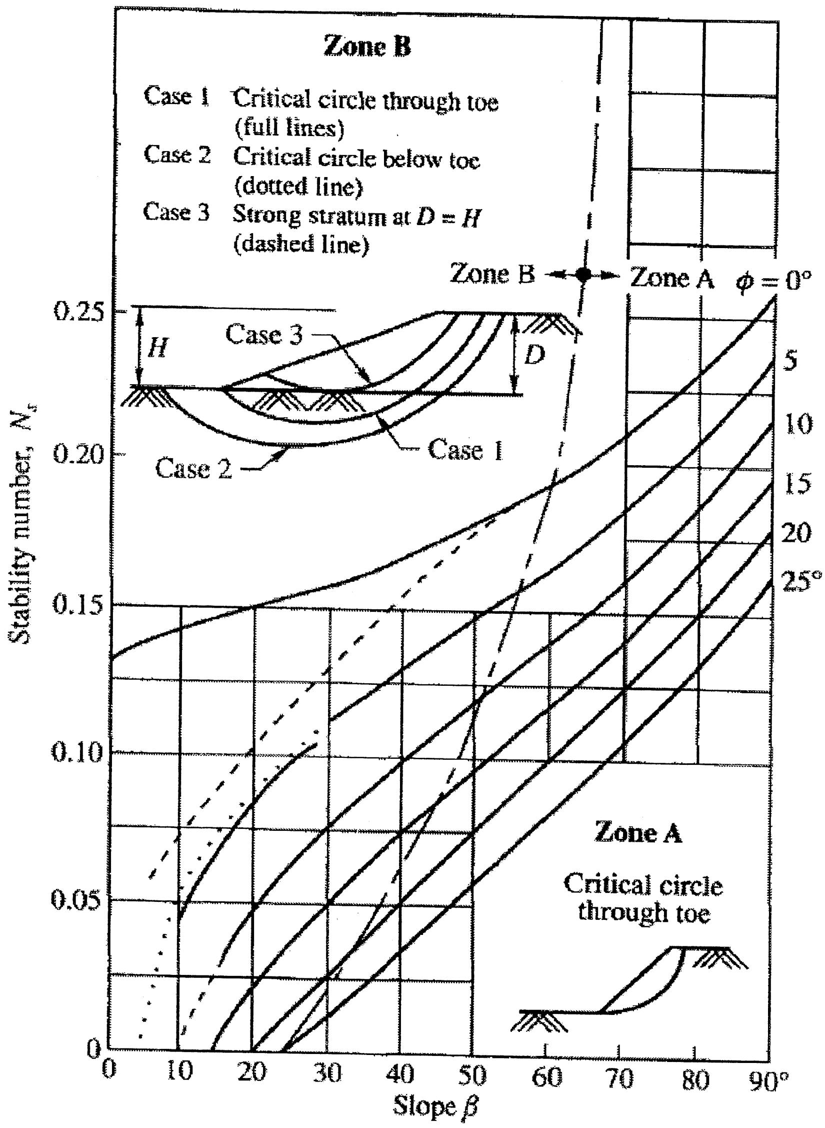
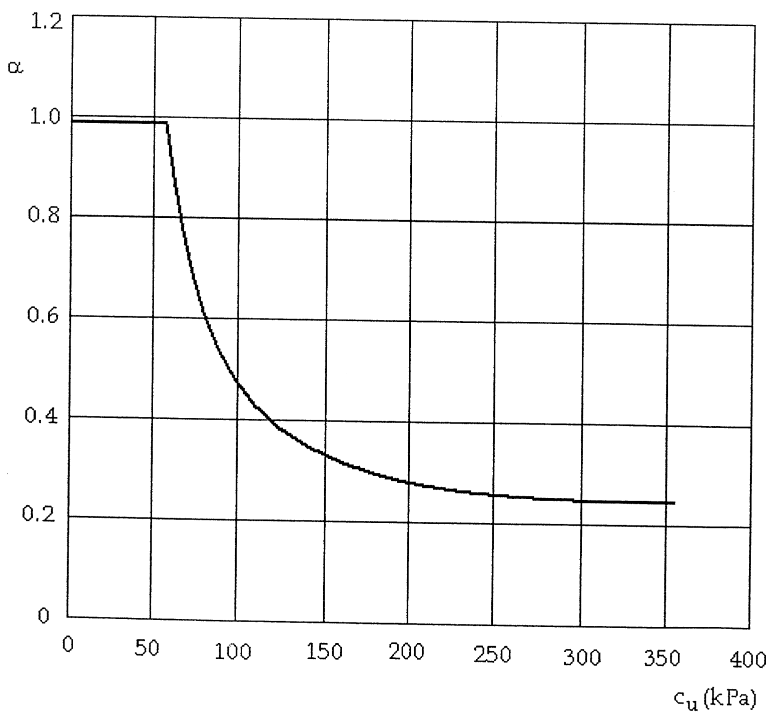
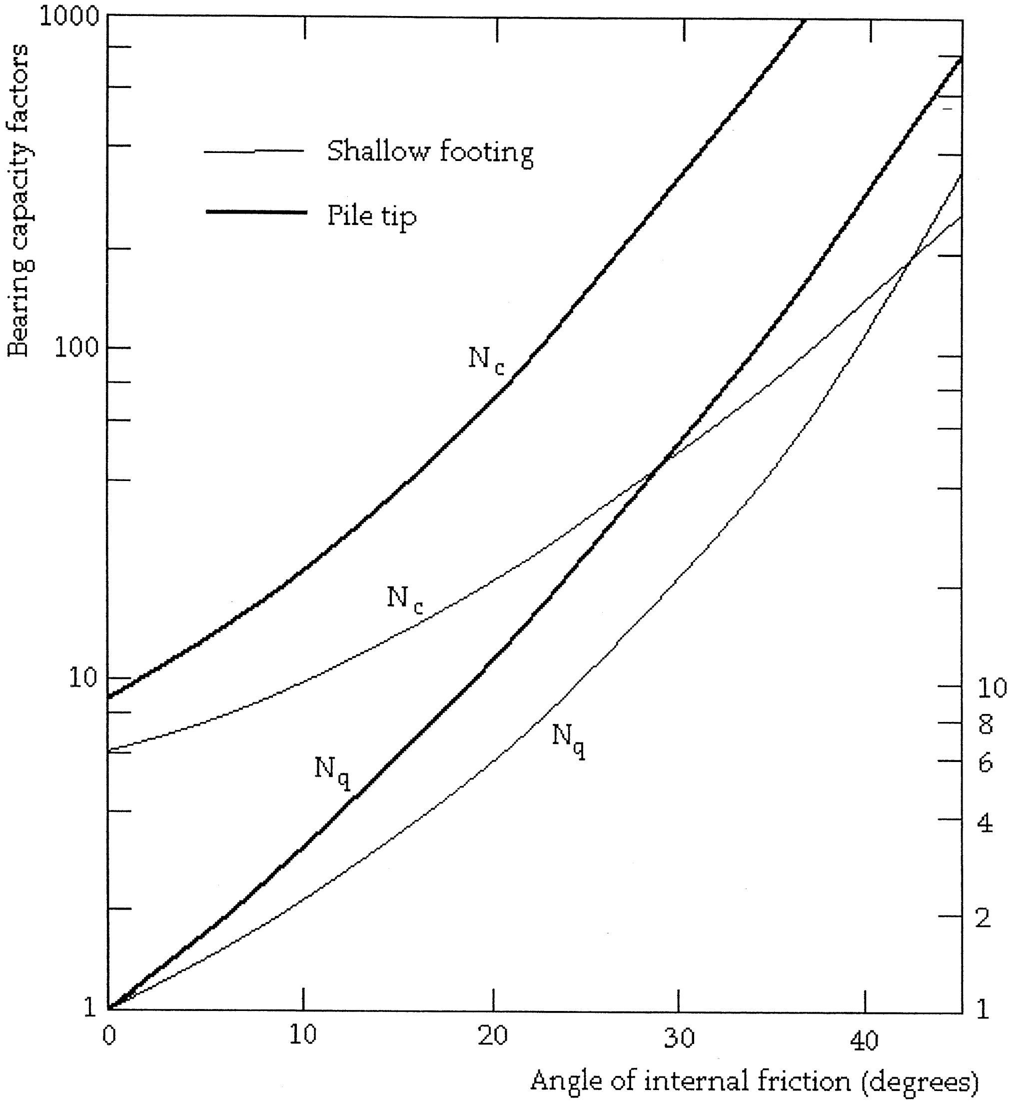


Fig. 8


Zone B
Case 1 Critical circle through toe (full lines)
Case 2 Critical circle below toe (dotted line)
Case 3 Strong stratum at D = H (dashed line)
Zone B
Zone A
φ = 0°
5
10
15
20
25°
H
D
Case 3
Case 2
Case 1
Zone A
Critical circle through toe
Stability number, N_s
0.25
0.20
0.15
0.10
0.05
0
0
10
20
30
40
50
60
70
80
90°
Slope β


α
1.2
1.0
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250
300
350
400
c_u (kPa)



Bearing capacity factors
1000
100
10
1
Shallow footing
Pile tip
N c
N c
N q
N q
10
8
6
4
2
1
0
10
20
30
40
Angle of internal friction (degrees)