UNIVERSITY OF RUHUNA

Faculty of Engineering

Mid-Semester 7 Examination in Engineering: June 2015

Module Number: CE7324 **Module Name: Geotechnical Engineering Design**

[Two Hours]

[Answer all questions, each question carries 5 marks]

Q1. In order to construct a car park for a multi storey building in a city center, it is necessary excavate up to a depth of 6.0 m from the existing ground level. The water table is at the ground surface. The design engineer has proposed to construct a 12.0 m high diaphragm wall along the perimeter of the proposed excavation. The floor slab with the cill beam at the ground level will be acting as a prop for the diaphragm wall. During the construction, the car park is to be kept dry by continuous pumping of water.

Soil investigation revealed that subsurface consists of 15.0 m thick silty sand layer followed by bed rock. The unit weight of saturated silty sand is 18.5 kN/m^3. The drain shear strength parameters, with usual notations, of the silty sand are found to be $c' = 0\ kN/m^2$ and $\varphi' = 34^\circ$. The unit weight of water can be taken as 9.81 kN/m^3.

a) What would be the expected pore water pressure at toe of the diaphragm wall?

[1.5 Marks]

b) At steady state flow condition, evaluate the stability of the proposed diaphragm wall according to BS 8002 using Free Earth Support method. Figure Q1.1 and Figure Q1.2 may useful in the calculations.

[3.0 Marks]

c) Suggest a suitable method to improve the stability of the diaphragm wall.

[0.5 Marks]

Q2. A 4.0 m high gabion wall has been proposed to stabilize a water front slope as shown in Figure Q2.1. The retained soil has effective shear strength parameters, with usual notations, of c′ = 10 kN/m^2 and $\varphi' = 36°$. The bulk unit weight of retained material is 20 kN/m^3. During the rainy season, there is a possibility that water table can be risen up to the ground surface. The unit weight of gabion can be taken as 16 kN/m^3. The unit weight of water is 9.81 kN/m^3.

a) Why is it important to use gabion structures as retaining walls in water front slopes?

[0.5 Marks]

b) Determine the design shear strength parameters for the long term stability of the retaining wall according to BS8002.

[0.5 Marks]

c) Evaluate the long term stability of the retaining wall against overturning according to BS8002.
Figure Q1.1 may useful in the calculations.

[3.0 Marks]

d) If the allowable bearing capacity of the founding soil is 150 kN/m^2, evaluate the stability of the retaining wall against bearing failure according to BS8002.

[1.0 Marks]

Q3. In Kandy City Development Project, it was decided to widen some sections of the road in DharmasokaMawatha. At chainage 1+750, it is necessary to construct a 4.0 m high mass concrete retaining wall as shown in Figure Q3.1. The bulk unit weights of the soil and concrete are 20 kN/m^3 and 24 kN/m^3, respectively. The effective shear strength parameters, with usual notations, of the soil are found to be $c' = 0\ kN/m^2$ and $\varphi' = 30^\circ$. The water table is at the ground surface of the retained side.

Design active earth pressure on the wall is to be estimated using the Coulomb's trial wedge approach. Four trial wedges are proposed for the analysis. The basic data for three trail wedges such as weight (W), slope of the wedge to the horizontal(θ), pore water force at the failure surface (U) and length of the ground surface on the failure wedge (s) are given in Table Q3.1. It is expected to check the stability of the proposed retaining wall section according to BS 8002 assuming that back of the wall surface is smooth.

a) Evaluate the design active earth force on the retaining wall according to BS8002 by drawing force polygons for the four trial wedges. Force polygon should be drawn to a scale of 1 mm = 10 kN, and assume that there is no any tension cracks behind the retaining wall.

[3.5 Marks]

c) Assuming that properties of the founding material is same as that of the retained soil, check whether the given wall section satisfies the stability criterion against sliding according to BS8002.

[1.5 Marks]

Q4. There are a lot of rainfall induced landslides, particularly in residual soil, in the up country of Sri Lanka. As such, it was decided to evaluate the stability of a natural slope formed of residual soil behind a famous school in Kandy district. Based on the past experience on slides in the area, the evaluation is to be carried out using a shallow translational sliding mechanism.

The natural ground slope is found to make an angle of 45° with the horizontal. Undisturbed soil samples were obtained from the slope at various depths and effective shear strength parameters were found through laboratory Triaxial tests. Based on the results, it was found that the effective angle of internal friction (φ') is constant with the depth and is equal to 30°. However, the effective cohesion (c') varies with the depth in such a way that $c' = 10 + 2H$, where H is the depth from the ground surface in meters (m) and c' is given in kN/m^2. The dry and saturated unit weights of the residual soil were found to be 16.5 kN/m^3 and 18.5 kN/m^3, respectively. Unit weight of the water can be taken as 9.81 kN/m^3.

a) If the ground water table is at a depth of $(1-m)H$ from the ground surface, where $0 \le m \le 1.0$, and seepage can take place parallel to the ground surface, derive an expression for the factor of safety against shallow translational sliding for this partially submerged condition with usual notations.

[2.0 Marks]

b) There is a possibility that water table can be risen up to the ground surface during the heavy rainy period. Would there be a failure in the slope due to heavy rain considering trial failure surface at a depth of 5.0 m from the ground surface?

[1.0 Marks]

c) If the water table is at a depth of 2.0 m, what would be the expected factor of safety against sliding for the above trial failure surface?

[1.0 Marks]

d) If the soil is completely dry, what would be the expected factor of safety against sliding for the above trial failure surface?

[1.0 Marks]

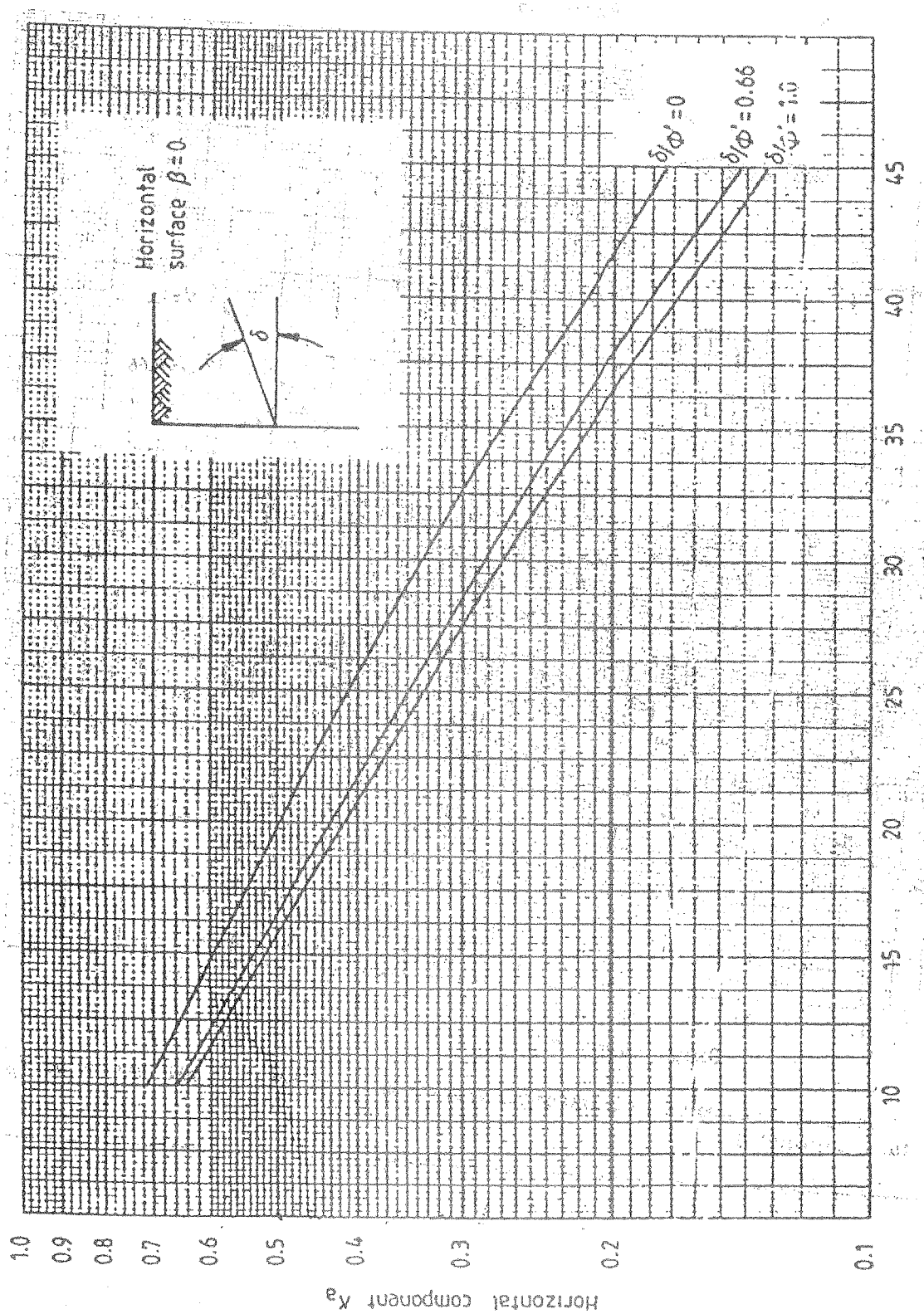

Figure Q1.1 Variation of K_A with φ'_{design}

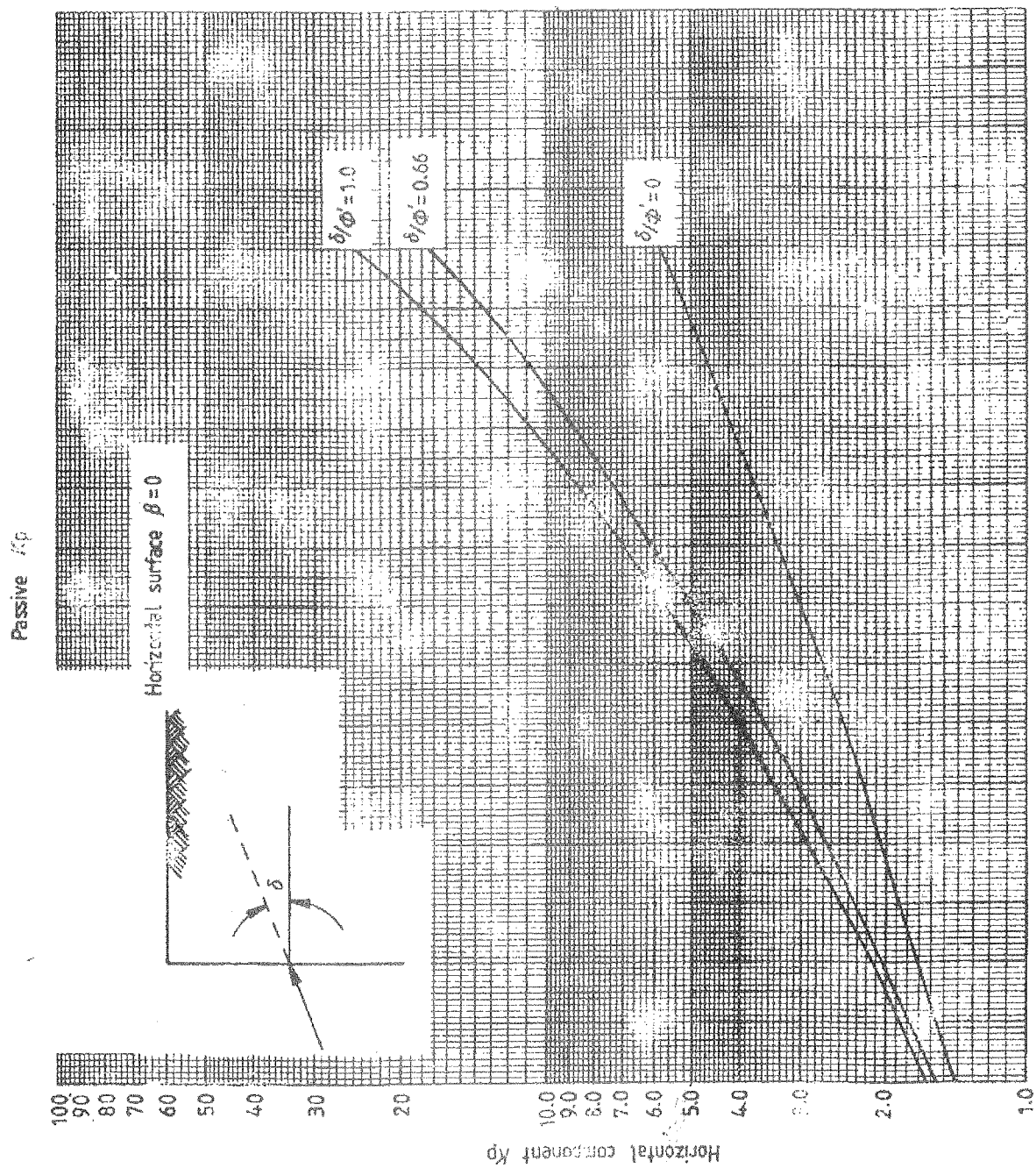

Figure Q1.2 Variation of K_P with φ'_{design}

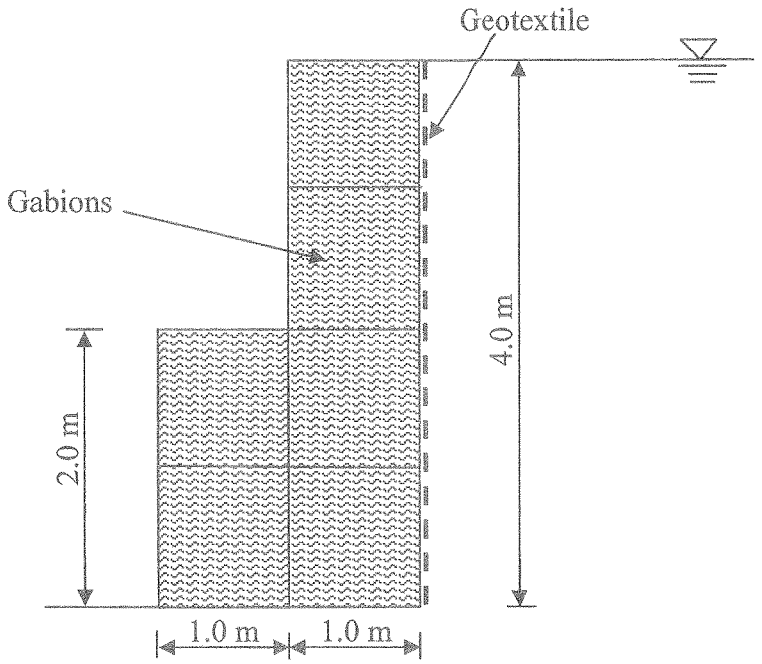

Figure Q2.1 Cross section of retaining wall

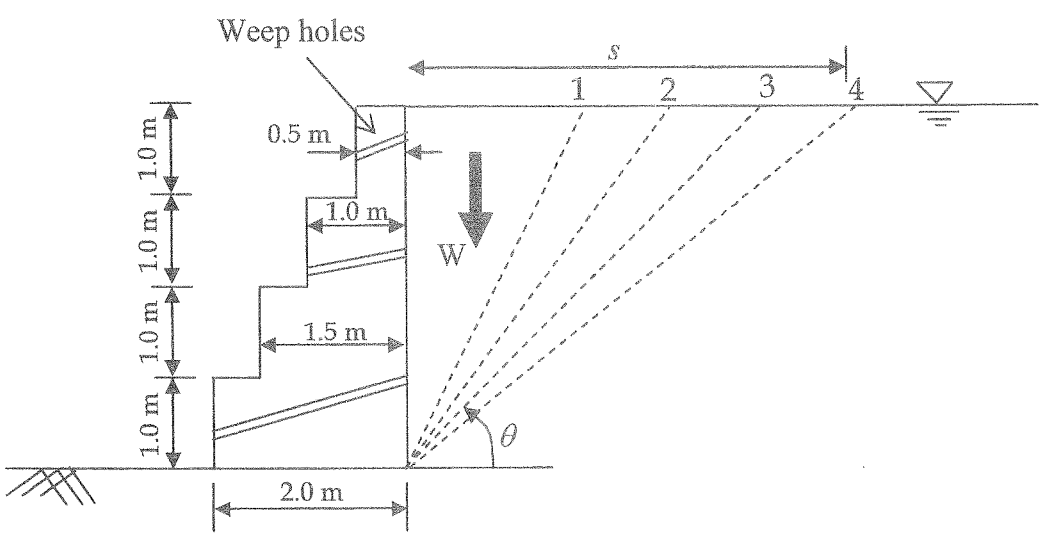

Figure Q3.1– Trial wedges

Table Q3.1 - The basic data for trial wedges

Wedge Number	$\theta°$	W (kN/m)	U(kN/m)	s (m)
1	70	30.9	5.36	1.45
2	65	46.4	7.41	1.87
3	55	61.8	11.17	2.80
4	50	77.3	14.16	3.36