UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2013/2014

COURSE NAME	:	GEOSYNTHETICS ENGINEERING
COURSE CODE	:	BFG 4043/ BFG40403
PROGRAMME	:	4 BFF
EXAMINATION DATE	:	JUNE 2014
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTION IN SECTION **A** AND **THREE (3)** QUESTION IN **SECTION B**

THIS QUESTION PAPER CONSISTS OF **FOURTEEN (14)** PAGES

SECTION A

Q1 (a) Briefly explains the definition for the terms below:

(i) Geocell
(ii) Geocomposite
(iii) Geogrid
(iv) Geomembrane
(v) Geonet
(vi) Geopipe
(vii) Geosynthetic Clay Liner

(7 marks)

(b) Simply explains these **FOUR (4)** materials:

(i) Woven
(ii) Nonwoven
(iii) Knitted
(iv) Stitched

(5 marks)

(c) Table **1** provides a list of important properties related to the basic functions of geosynthetics. Reinforcement and Filtration functions have been listed out.

List down **THREE (3)** geosynthetic properties for separation and drainage.

(5 marks)

(d) Simply define the terms of separation, filtration, drainage and reinforcement as shown in Figure **Q1(c)**.

(8 marks)

SECTION B

Q2 (a) The basic design approach for geosynthetic-reinforced foundation soils must consider their modes (or mechanisms) of failure.

List down **THREE (3)** modes of failure for shallow foundations and embankments.

(5 marks)

(b) Design a 10 m high geotextile-wrapped retaining wall that to carry an area of equivalent dead load of 15 kN/m^2 with the following data:

For the granular backfill:
Unit weight, $\gamma_b = 18$ kN/m^3
Angle of internal friction, $\phi_b = 32°$

For geotextile:
Allowable tensile strength, $\sigma_G = 35$ kN/m
Friction angle with granular soil of, $\delta = 29°$

For the foundation soil:
Cohesion, c = 30 kN/m^2
Unit weight, $\gamma = 16.8$ kN/m^3
Angle of internal friction, $\phi = 15°$

Foundation soil-geotextile interface shear parameters
Friction angle, $\phi_r = 0.95\phi$
Adhesion, $c_a = 0.90c$

Factor of safety against geotextile rupture = 1.5
Factor of safety against geotextile pullout = 1.5

The orientation of the geotextile is perpendicular to the wall face and the edges are to be overlapped or sewn to handle the weft (cross machine) direction.

(i) Determine the horizontal pressure as a function of the depth Z in order to calculate the spacing of the individual layers.

(ii) Determine the length of the fabric layers.

(iii) Analyze the wall for its overturning and sliding stability.

(20 marks)

Q3 (a) To achieve satisfactory filter performance by geosynthetics, especially geotextiles, certain functions must be fulfilled during the design life of the application.

Briefly explains **FOUR (4)** functions for the filtration design.

(5 marks)

(b) A geotextile-wrapped trench drain is to be constructed to drain a soil mass. Table **2** summarises the sieving tests for three samples.

(i) Plot a particle size distribution and determine the coefficient of uniformity, C_u for all samples.

(4 marks)

(ii) Design the geotextile filter for its hydraulic properties based on its retention criteria, permeability criteria, permittivity criteria, and clogging criteria.

(4 marks)

(iii) Select a suitable sample for the filtration design and justify your answer.

(2 marks)

(c) A silt fence with 60 m long relatively smooth surface construction site will be constructed at location A for a 10 year recurring design. A topsoil has been stripped and the average slope inclination is 5%.

With **TWO (2)** criteria of a storm intensity 100 mm/hr and 200 mm/hr,

(i) Determine the height of the silt fence.

(ii) Determine the strength of the geotextile by referring to Figure **Q3(b)(i).**

(iii) Proposed a type of posts to be used for support by referring to Figure **Q3(b)(ii)**.

(10 marks)

Q4 (a) Figures **Q4(a)(i)** and **Q4(a)(ii)** illustrated the embankment over weak foundation soil with basal drainage layer; and with vertical drains and basal drainage layer. The geosynthetic as the basal layer in the embankment over soft foundation soil can serve one of the following basic functions or a combination of reinforcement, drainage and separation/filtration.

Briefly explains the basal layer functions as a drainage in embankment construction.

(5 marks)

(b) A proposed building site will be improved by applying a wick drains measuring 92 mm by 10 mm in a saturated silt having a horizontal coefficient of consolidation of 12 mm^2/min.

(i) Compute the required time to achieve 95% consolidation in a cross sectional area to be placed on a square and triangular patterns centers.

(8 marks)

(ii) Justify your results.

(2 marks)

(c) Flow capability of the geotextiles is the important criteria for a thick nonwoven needle-punched geotextiles as to be installed within the two common infrastructure in civil engineering, which is gravity drainage and pressure drainage.

(i) Briefly explains the flow capability roles in gravity drainage and pressure drainage designs.

(3 marks)

(ii) Sketch the placement of geotextile for a drainage function in gravity drainage and pressure drainage designs.

(4 marks)

(iii) Outline **FIVE (5)** designs element that involves for designing for drainage to ensure the safety design.

(3 marks)

Q5 (a) Pavement maintenance treatments are often ineffective and short lived due to their inability to both treat the cause of the problems and renew the existing pavement condition. Nevertheless, geosynthetics have proven to be cost effective tools for safeguarding roads and pavements in these designs.

Outline **THREE (3)** performance indicator and **THREE (3)** main applications for geosynthetics in road as a separator.

(5 marks)

(b) The installation of the materials can be carry out either manually or mechanically with equipment designed specifically for this application. In either case, the geosynthetic must not be allowed to wrinkle. Plus, The temperature of the asphalt should not be less than 121°C or exceed 163°C.

List out the other **SIX (6)** important installation criteria for designing for separation.

(5 marks)

(c) Regarding geotextiles used in separation:

(i) Determine the required burst pressure of a geotextile supporting 75 mm maximum size stone and heavy trucks with a tire inflation pressure of 1000 kPa. Apply $p \cong 0.75p_a$, cumulative reduction factor of 2.0, and a factor of safety of 2.0.

(ii) Determine the required burst pressure of a geotextile under the same conditions in part except that now the road will haul only light vehicles of tire inflation pressure of 500 kPa.

(8 marks)

(d) Burst resistance, tensile strength, puncturing force, and impact (tear) resistance are the critical criteria in designing with geotextiles for a separator function.

Define the terms and roughly sketch for a geotextile being subjected to tensile stress as surface pressure, and geotextile being forced up into voids of stone base by traffic tire loads.

(7 marks)

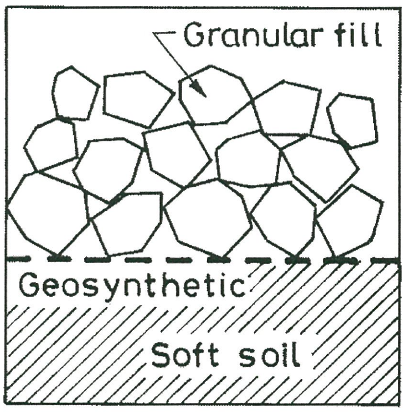
-END OF QUESTION-

FINAL EXAMINATION

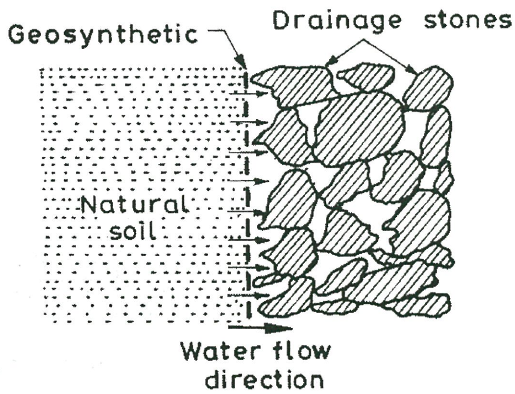
SEMESTER/SESSION : SEM II/2013/2014 PROGRAMME : 4 BFF
COURSE NAME : GEOSYNTHETICS ENGINEERING COURSE CODE : BFG 40403/ BFG 4043

Table 1: Important Properties of Geosynthetics Related to Their Basic Functions

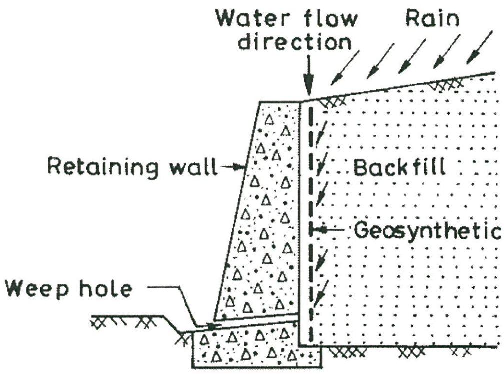
Reinforcement	Separation	Filtration	Drainage
strength, stiffness, soil–geosynthetic interface haracteristics (frictional and interlocking characteristics), creep, stress relaxation, and durability	X	characteristic opening size, permittivity, clogging, puncture strength, and durability	Y



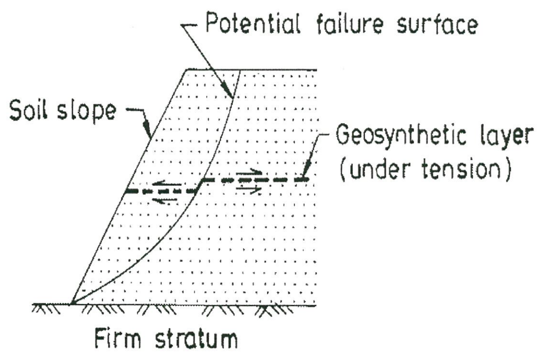
(i) separation



(ii) filtration



(iii) drainage



(ii) reinforcement

FIGURE Q1(c)

FINAL EXAMINATION

SEMESTER/SESSION : SEM II/2013/2014 PROGRAMME : 4 BFF
COURSE NAME : GEOSYNTHETICS ENGINEERING COURSE CODE : BFG 40403/ BFG 4043

FINAL EXAMINATION

SEMESTER/SESSION : SEM II/2013/2014 PROGRAMME : 4 BFF
COURSE NAME : GEOSYNTHETICS ENGINEERING COURSE CODE : BFG 40403/ BFG 4043

Table 2

Sieve Size (mm)	Percent Passing by Weight		
	Sample A	Sample B	Sample C
25	99	100	100
13	97	100	100
4.76	95	100	100
1.68	90	96	100
0.84	78	86	93
0.42	55	74	70
0.15	10	40	11
0.074	1	15	0

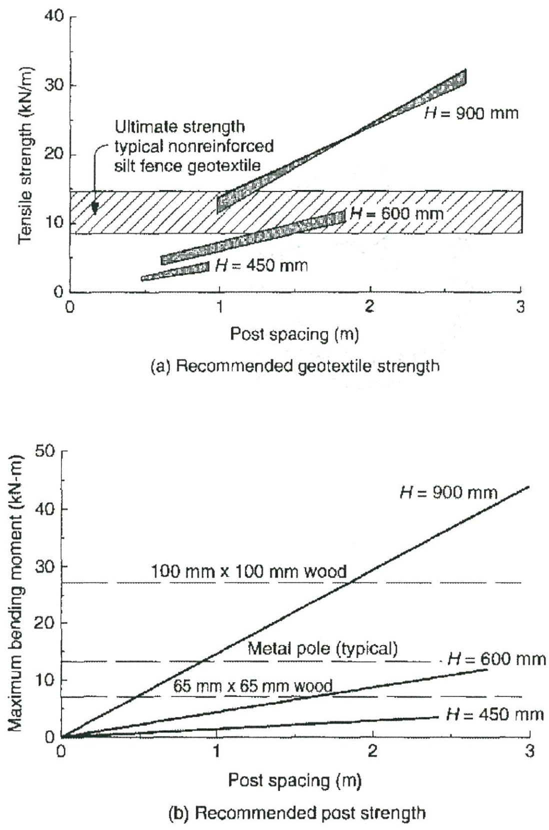


FIGURE Q3b(i): Design Recommendations for Silt Fence Geotextile and Post Strengths

FINAL EXAMINATION

SEMESTER/SESSION : SEM II/2013/2014 PROGRAMME : 4 BFF
COURSE NAME : GEOSYNTHETICS ENGINEERING COURSE CODE : BFG 40403/ BFG 4043

Table 3: Guidelines for Evaluating The Critical Nature or Severity of Drainage and Erosion Control Applications

A. Critical Nature of the Project		
Item	Critical	Less Critical
1 . Risk of loss of life and/or structural damage due to drain failure	high	None
2 . Repair costs versus installation costs of drain	>>>	= or <
3. Evidence o f drain clogging before potential catastrophic failure	None	Yes
B . Severity o f the Conditions		
Item	Severe	Less Severe
1 . Soil to be drained	Gap-graded , pipable, or dispersible	Well-graded or uniform
2 . Hydraulic gradient	High	Low
3. Flow conditions	Dynamic , cyclic, or pulsating	Steady state

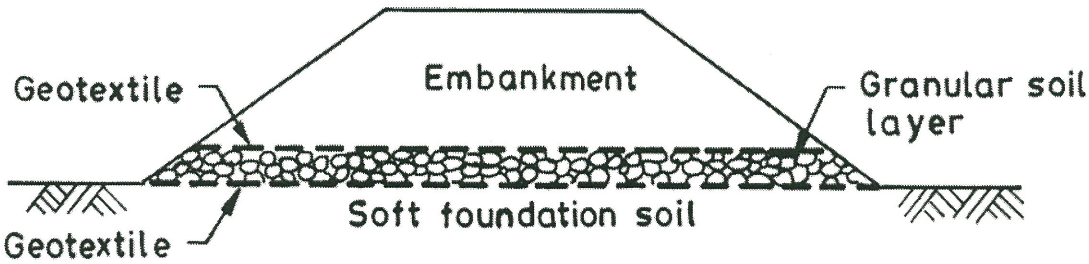


FIGURE Q4(a)(i): Embankment Over Weak Foundation Soil: (a) with Basal **Drainage Layer**

FINAL EXAMINATION

SEMESTER/SESSION : SEM II/2013/2014 PROGRAMME : 4 BFF
COURSE NAME : GEOSYNTHETICS ENGINEERING COURSE CODE : BFG 40403/ BFG 4043

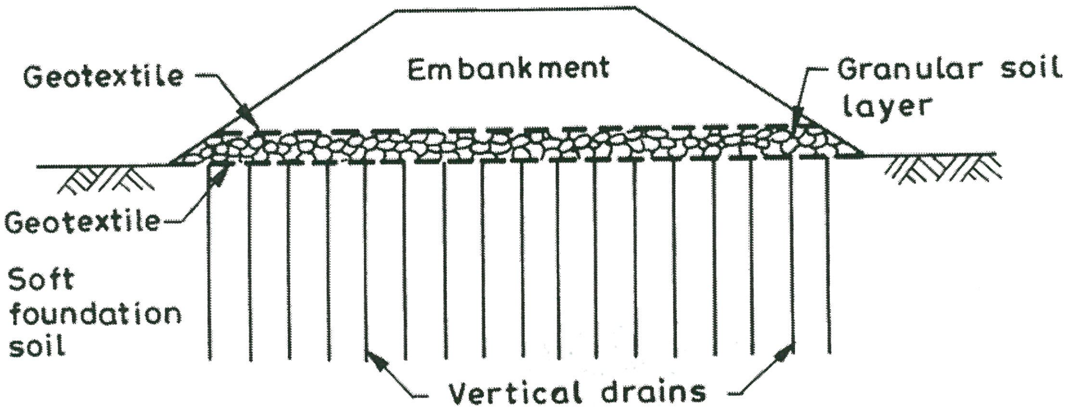


FIGURE Q4(a)(ii): Embankment Over Weak Foundation Soil with Vertical Drains and Basal Drainage Layer

FINAL EXAMINATION

SEMESTER/SESSION : SEM II/2013/2014
COURSE NAME : GEOSYNTHETICS ENGINEERING
PROGRAMME : 4 BFF
COURSE CODE : BFG 40403/ BFG 4043

Formulae

DESIGNING FOR SOIL REINFORCEMENT

$K_a = \tan^2(45 - \phi/2)$ $\sigma_h = \sigma_{hs} + \sigma_{hq} + \sigma_{hl}$

$T_{\text{allow}} = T_{\text{ult}}\left[\dfrac{1}{\text{RF}_{ID} + \text{RF}_{CR} + \text{RF}_{CBD}}\right]$ $S_v = \dfrac{T_{\text{allow}}}{\sigma_h \text{FS}}$

$L_e = \dfrac{S_v \sigma_h \text{FS}}{2(c + \gamma Z \tan\delta)}$ $L_o = \dfrac{S_v \sigma_h \text{FS}}{4(c_a + \gamma Z \tan\delta)}$

$$\text{FS}_{\text{ot}} = \sum \frac{\text{resisting moments}}{\text{driving moments}} = \frac{w_n x_n + \ldots + y \cdot P_a \sin\delta}{z \cdot P_a \cos\delta}$$

$$\text{FS}_{\text{s}} = \sum \frac{\text{resisting forces}}{\text{driving forces}} = \frac{\left[c_a + \left(\dfrac{w_n + \ldots + P_a \sin\delta}{2}\right)\tan\delta\right]2}{P_a \cos\delta}$$

DESIGNING FOR SILT FENCES

$L_{\max} = 36.2e^{-11.1\alpha}$ $Q = 5 \times 10^{-4} IA$ $H = \sqrt{Qt\alpha}$

$T_{\text{ultimate}} = \text{FS}T_{\text{required}}$ $V = Qt$ $\text{FS} = \dfrac{T_{\text{allowable}}}{T_{\text{required}}}$

RETENTION CRITERIA

Steady State Flow Conditions:

AOS or $O_{95} \leq BD_{85}$

Steady State Flow Conditions: (with less than 50 % passing the 0.075 mm)

$B = 1 : C_U \leq 2$ or ≥ 8 $B = 0.5C_U : 2 \leq C_U \leq 4$ $B = 8/C_U : 4 < C_U < 8$

FINAL EXAMINATION

SEMESTER/SESSION : SEM II/2013/2014 PROGRAMME : 4 BFF
COURSE NAME : GEOSYNTHETICS ENGINEERING COURSE CODE : BFG 40403/ BFG 4043

Formulae

RETENTION CRITERIA

Steady State Flow Conditions: (with more than 50 % passing the 0.07
for wovens; $B = 1 : O_{95} \leq D_{85}$ for nonwovens; $B = 1.8 : O_{95} \leq 1.8D_{85}$

for both; AOS or ≤ 0.3 mm

Dynamic Flow Conditions:

$O_{95} \leq 0.5D_{85}$

PERMEABILITY/PERMITTIVITY CRITERIA

Permeability requirements:
for less critical applications and less severe conditions: $k_{geotextile} \geq k_{soil}$

for less critical applications and less severe conditions: $k_{geotextile} \geq 10k_{soil}$

Permittivity requirements:
$\psi \geq 0.5/\sec$ for < 15% passing 0.075 mm

$\psi \geq 0.2/\sec$ for 15% to 50% passing 0.075 mm

$\psi \geq 0.1/\sec$ for > 50% passing 0.075 mm

CLOGGING RESISTENCE

Less Critical/Less Severe Conditions

for less critical applications and less severe conditions; $C_U > 3$: $O_{95} \geq 3D_{15}$

if $C_U \leq 3$: select a geotextile with the maximum AOS

FINAL EXAMINATION

SEMESTER/SESSION : SEM II/2013/2014
COURSE NAME : GEOSYNTHETICS ENGINEERING
PROGRAMME : 4 BFF
COURSE CODE : BFG 40403/ BFG 4043

Formulae

CLOGGING RESISTENCE

in situations where clogging is a possibility (e. g. , gap-graded or silty soils) , the following optionalqualifiers may be applied :

for nonwovens; porosity of the geotextile: $n \geq 50\%$

for woven monofilament and slit film wovens; percent open area, $\text{POA} \geq 4\%$

DESIGNING FOR DRAINAGE

$$d_v = \sqrt{\frac{4 \times (\text{void area of wick drain})}{\pi}} \quad d_{sd} = \sqrt{\frac{d_v^{\,2}}{0.3}} \quad D_{\text{triangular}} = 1.05s$$

$$t = \frac{D^2}{8c_h}\left(\ln\frac{D}{d} - 0.75\right)\ln\frac{1}{1-\bar{U}} \quad \text{FS}=\frac{q_{\text{allow}}}{q_{\text{required}}} \quad D_{\text{square}} = 1.13s$$

DESIGNING FOR SEPARATOR

$$T_{\text{required}} = \tfrac{1}{2}p'd_v\left[f(\in)\right] \quad f(\in) = 0.25\left(\frac{2y}{b} + \frac{b}{2y}\right)$$

$$T_{\text{ult}} = \tfrac{1}{2}p_{\text{test}}d_{\text{test}}\left[f(\in)\right] \quad \text{FS}=\frac{T_{\text{allow}}}{T_{\text{required}}} = \frac{p_{\text{test}}d_{\text{test}}}{\prod \text{RF} \cdot p'd_v}$$