Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER II
SESSION 2019/2020

COURSE NAME	:	WASTEWATER ENGINEERING DESIGN
COURSE CODE	:	BFA40403
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JULY 2020
DURATION	:	6 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

Q1 (a) A mechanical bar screen is to be used in an approach channel with a maximum velocity of 0.65 m/s, and a peak design flow of 0.631 m^3/s. The bars are 10 mm width and openings are 25 mm wide, the angle of inclination is 60°. Determine:

(i) The cross section of the bar screen, and the dimension needed if the upstream depth of wastewater is 1.12 m.

(4 marks)

(ii) The number of bars.

(3 marks)

(iii) The inclined length of bars.

(3 marks)

(b) Design an aerated grit chamber for the treatment of municipal wastewater. The average flow rate is 0.473 m^3/s and the peak flow is 2.29 times the average flow. Determine.

(i) The grit chamber volume if the average detention time at the peak flow rate is 3 minutes. Provide two chambers to facilitate periodic cleaning and maintenance.

(5 marks)

(ii) The dimensions of each grit chamber. The grit chamber width is 1.5 times the depth, and the length is 4 times the width.

(5 marks)

(iii) The air supply requirement if $0.3 m^3$/min per meter of grit chamber length is to be provided.

(3 marks)

(iv) The quantity of grit at peak flow. Assume a value of 0.015 $m^3/10^3$ m^3 at peak flow.

(2 marks)

Q2 A primary sedimentation tank for a municipal wastewater treatment plant is to be designed for an average flow of 8,000 m^3/d. The regulatory agency criteria for primary sedimentation tanks are as follows: peak overflow rate = 40 m^3/m^2-d, minimum side water depth = 4 m, and channel width = 6 m. The ratio of the peak hourly flow to the average hourly flow is 2.5. Calculate:

(i) The required surface area of the sedimentation tank. Use a minimum of **TWO (2)** sedimentation tanks.

(5 marks)

(ii) The tank length and tank volume.

(5 marks)

(iii) The detention time and overflow rate at peak flow.

(5 marks)

(iv) The scour velocity if the diameter of particles is 100 μm. Use $s = 1.25$, $f = 0.025$, $g = 9.81$ m/s^2 and $k = 0.05$. Compare the scour velocity to the peak flow horizontal velocity.

(5 marks)

(v) The removal rate of BOD and TSS at peak flow. Assume the empirical constants for BOD (a = 0.018, b = 0.020) and TSS (a = 0.0075, b = 0.014).

(5 marks)

Q3 Design a Sequencing Batch Reactor (SBR) process to treat a domestic wastewater using the following design data:

Design condition and assumptions:

Use 2 SBR tanks
Design flow rate = 22,700 m^3/d
Total liquid depth when full = 6 m
Decant depth = 30% of tank depth
MLSS = 3000 mg/L
Settled sludge concentration = 6,000 mg/L
Clear liquid above the sludge blanket = 35%
Anoxic fill = 135 min
Aerated fill = 45 min
React = 90 min
Settle = 45 min
Decant = 30 min
Idle = 15 min

Determine:

(i) The fill volume for one SBR.

(6 marks)

(ii) The fill fraction per cycle.

(6 marks)

(iii) The volume of the tank.

(4 marks)

(iv) The dimensions of the tank.

(4 marks)

(v) The overall hydraulic retention time.

(5 marks)

Q4 (a) Explain briefly **FIVE (5)** basic processes for sludge treatment.

(5 marks)

(b) Determine the daily primary sludge production for a wastewater treatment plant having the following operating characteristics:

Operating Data:
Flow = 0.0500 m^3/s
Influent Suspended Solids = 155 mg/L
Removal efficiency = 53%
Volatile solids = 70%
Specific gravity of volatile solids = 0.970
Fixed solids = 30%
Specific gravity of fixed solids = 2.50
Sludge concentration = 4.50%

(10 marks)

(c) Design a gravity thickener for a wastewater treatment plant having primary and waste activated sludge with the following characteristics:

Type of sludge	Specific gravity	Solids, %	Flowrate, m^3/d
Average design conditions:			
Primary sludge	1.03	3.3	400
Waste activated	1.005	0.2	2250
Peak design conditions:			
Primary sludge	1.03	3.4	420
Waste Activated	1.005	0.23	2500

Assume:
Specific gravity of the combined sludge = 1.02
Solids loading rate = 50 $kg/m^2.d$
Provide two thickeners

(10 marks)

Q5 Anaerobically digested sludge from a wastewater treatment facility is to be treated by land application to an agricultural site at which corn will be grown. The wastewater treatment plant serves a population of 10,000 persons and produces 200 metric tons of dry sludge per year. The sludge will be applied as a liquid by surface distribution. The design is to be based on the nitrogen needs of the corn crop and is to be limited by a cumulative cadmium loading of 11 kg Cd/ha for the length of time the site can be used. The sludge contains 100 mgCD/kg of dry sludge, 1% ammonia nitrogen, 2.2% organic nitrogen and no nitrate nitrogen.

Assume:
Mineralization rate for the first year = 0.20
Mineralization rate for the second year = 0.10
Mineralization rate for the third year = 0.05
Mineralization rate for the fourth to eighth years = 0.03
Volatilization factor, $k_v = 0.5$
Nitrogen uptake rate for corn, U_n = 180 kg-N/ha-yr
Conversion constant = 1000 kg/mt

Determine:

(i) The allowable annual dry sludge application rate. The nitrogen available from mineralization is negligible after the ninth year.

(10 marks)

(ii) The cadmium-limited allowable amount of sludge.

(5 marks)

(iii) The land area required.

(5 marks)

(iv) The design life of the site for sludge application.

(5 marks)

– END OF QUESTIONS –