University of Technology
Building and Construction Engineering Department
Final Exam 2012-2013/First Attempt

Subject: Sanitary Engineering
Division: Bld. & Proj. Management
Examiner: Walaa K. Ali

Year: Three
Time: 3 hours
Date: 23 / 6 /2013

Answer ***FOUR*** Questions Only

Q1:

A: Determine the volume of the storage tank required to provide the weekly demand of a city with the following data:

- Present population is 2000 capita.
- Design period is 25 years.
- Annual rate of growth is 3%.
- Average annual per capita consumption is 300lit/day.
- Future population can be forecasted using arithmetic method.

(10 marks)

B: A sewage pumping station serves a residential area of 20 hectare, the population density is 150 capita per hectare and the per capita extraction is 250 liter/day. Number of pumps is two, one of them is on duty and the other is standby. Determine the flow rate of each pump and the volume of wet well between start and stop levels of the pump assuming maximum number of starts is 6 per hour. Also check the detention time at minimum flow.

(15 marks)

Q2:

A: Find the maximum number of houses that can be served by 200, 250 uPVC sewers at minimum gradient. Consider the following design constraints and parameters:

- Minimum flushing velocity at full flow is 0.75 m/sec.
- Average per capita extraction 250 lit/day and peak factor =6.
- Assume 8 persons per house.
- Maximum depth at design flow shall be less than 2/3 of the sewer diameter.

(10 marks)

B: A settling basin is designed to have a surface overflow rate of 24 m/day. Determine the overall removal obtained for a suspension with size distribution given, the specific gravity of the particles is 1.2 and the water viscosity is 1.027 x 10^{-3} Pa.sec.

Particle size, mm	0.10	0.08	0.07	0.06	0.04	0.02	0.01
Weight fraction greater than size %	10	15	40	70	93	99	100

(15 marks)

Q3: A: Using the NRC formula to calculate the effluent BOD_5 of a two-stage trickling filter with the following flows, BOD_5 and dimensions:

- $Q = 2000\ m^3/day$
- $BOD_5 = 300$ mg /lit
- Volume of filter no. 1 = *500* m^3
- Volume of filter no. 2 = *500* m^3
- Filter depth = *2* m
- $r_1 = 1.25$, $r_2 = 1$

(10 marks)

B: A sand filter with an effective size of 0.6 mm and a uniformity coefficient of 1.3. Find the ratio of water used in backwashing to the production of filter if the rate of filtration is 120 m/day and the filter needs to be backwashed daily for 10 minutes duration. (15 marks)

Q4:

A: If a waste with BOD_5 of *300* mg/lit is discharged to a stream at an average temperature of *15*°C,

- What fraction of the BOD would be exerted in *10* days?
- How long would be required for the same degree of stabilization if the stream had a temperature of 30°C. Knowing that K_1 = 0.25/day at 20°C. (10 marks)

B: Design an activated sludge process (determine V, r and O_2 requirement (kg/day)) to yield an effluent BOD_5 of 20 mg/lit and suspended solids of *20* mg/lit. The influent BOD_5 is *160* mg/lit and the waste flow is 5000 m^3/day. Assume Y= 0.65, k_d= 0.05/day, θ_c=12 days, MLVSS= 3000 mg/lit, VSS/SS=0.8, x_r=10000 mg/lit. Assume any required data. (15 marks)

Q5:

A: A pump is to raise 120 m^3/hr against a static head of 20 m through a pipe 3000 m long. Determine the most economical pipe size. Power cost is 8 cent/kW-hr, the pump operates 15 hrs per day, the annual depreciation is 2.5%, the cost of installed pipe is 40$ for 150mm, 48$ for 200 mm, 64$ for 250 mm and 72$ for 300 mm per meter length. Assume the overall pumping efficiency of 65%. (C=120). Ignore minor losses. (15 marks)

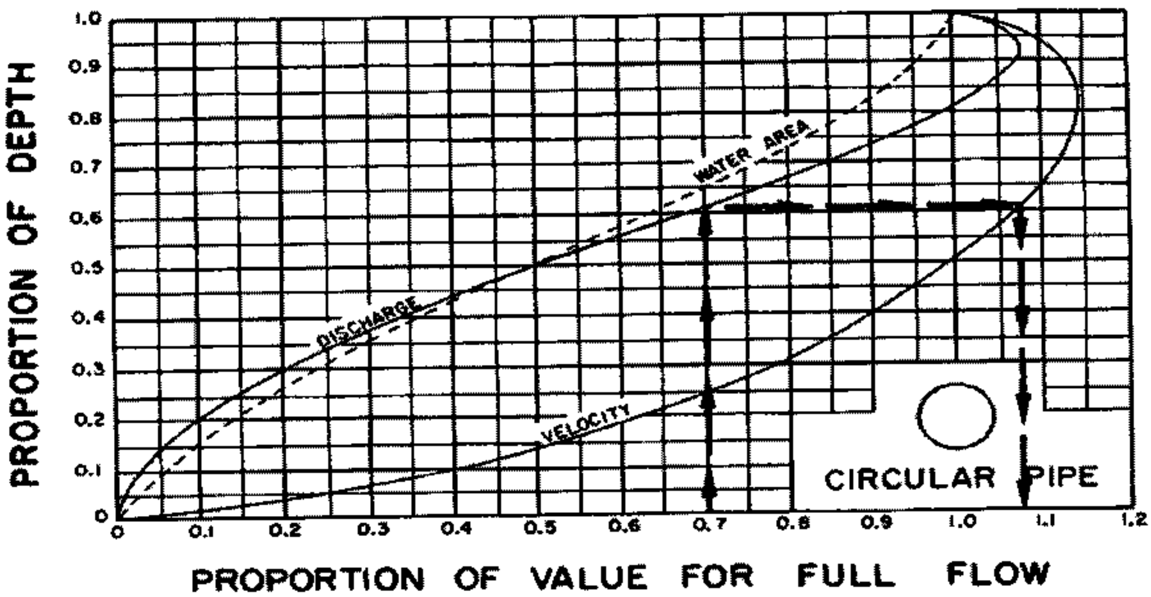
B: The stormwater runoff in a gutter at an inlet is 60m^3/hr. The transverse slope of the gutter is 1.5% and the longitudinal slope is 0.3%. n=0.015. Gutter depression is 25mm. Determine:

- Required length of the curb inlet.
- The distance of water extension from the curb line.

$$Q = 22.61\frac{z}{n}\, s^{0.5}\, y^{8/3} \quad (\text{m}^3/\text{min}, \text{m})$$

(10 marks)

Depth of flow in gutter, mm	15	30	60
Depth of depression, mm	25	25	25
Average capacity per m of length, m^3/min	0.351	0.479	0.786



1/

Q1 A. $P_t = P_o + k \Delta t$

$= 2000 + 0.03 \times 2000 \times 25$

$= 3500$ capita

max. weekly demand $= 1.48 \times 300$

$= 444$ l/cap. day

Req. storage $= \frac{444}{1000} \times 7 \times 3500$

$= 10878\ m^3$

B. Population = Pop. density x Area

$= 3000$ cap.

$P_f = \frac{5}{pop^{1/6}} = 4.16$

$Q_{peak} = 3000 \times 250 \times 4.16 / 1000 / 24$

$= 130\ m^3/hr$

As the no of duty pumps = 1

$\therefore Q_p = 130\ m^3/hr$

$t_c = \frac{60}{\text{max. no. of starts per hour}} = \frac{60}{6} = 10$ min

$V_{min} = \frac{t_c Q_p}{4} = 5.42\ m^3$

$Q_{min} = 0.3\ Q_{av.} = 9.38\ m^3/hr$

$\therefore$ det. time at min. flow $= \frac{5.42}{9.38} \times 60 = 34$ min

> 30 $\therefore$ not o.k.

Q2 A.

At minimum gradient, V = flushing velocity = 0.75 m/sec

$\Rightarrow Q = 0.75 \times \pi D^2/4$

$= 0.0236\ m^3/sec$ for D = 200 mm

$= 0.0368\ m^3/sec$ for D = 250 mm

at $\frac{d}{D} = 0.67 \Rightarrow \frac{q}{Q} = 0.8$

then $q = 0.019\ m^3/sec$ for D = 200 mm

$= 0.029\ m^3/sec$ for D = 250 mm

q = No. of houses × 8 × 0.25 × 6 /24/3600

– no. of houses = 137 for D = 200 mm

= 209 for D = 250 mm

Q_2: B: Assume $N_R < 0.5$

$$V_s = \frac{g}{18\mu}(\rho_s - \rho)\, d^2$$

$$= \frac{9.8}{18 \times 1.027 \times 10^{-3}}(1200 - 1000)\, d^2$$

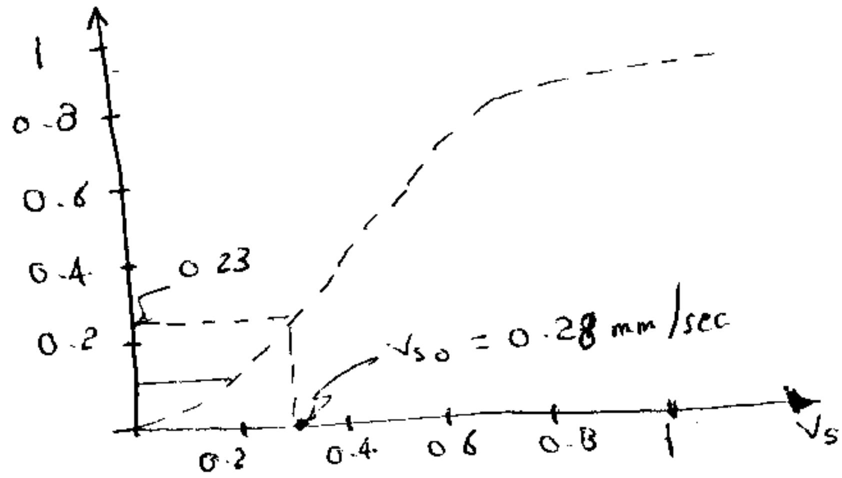
$$= 106\, d^2 \quad (V_s: \text{mm/sec},\ d = \text{mm})$$

weight fraction less than %	90	85	60	30	7	1	0
V_s mm/sec	1.06	0.68	0.52	0.38	0.17	0.04	0.011

check for N_R

V_{so} = 24 m/d

= 0.28 mm/sec



overall removal $= (1 - 0.23) + 0.13 \times \frac{0.21}{0.28} + 0.1 \times \frac{0.1}{0.28}$

= 0.9

= 90%

Q3: A:

For first stage.

$$E_1 = \frac{C_i - C_e}{C_i} = \frac{1}{1 + .532\sqrt{\frac{QC_i}{V_1F_1}}}$$

$$F_1 = \frac{1 + r_1}{(1 + 0.1r_1)^2} = 1.78 \quad , \quad Q = 1.39\ m^3/min$$

$$\Rightarrow E_1 = 0.73 \quad ; \quad C_e = 81\ mg/lit$$

For the second stage:

$$E_2 = \frac{C_e - C_e'}{C_e} = \frac{1}{1 + \frac{.532}{1 - E_1}\sqrt{\frac{QC_e}{V_2F_2}}}$$

$$F_2 = 1.65$$

$$\Rightarrow E_2 = 0.58$$

$$\therefore C_e' = 34\ mg/lit$$

B:

$$V_b = D_{60} = 1.3 \times 0.6 = 0.78\ m/min$$

$$\frac{\text{water used in backwashing}}{\text{produced water}} = \frac{0.78 \times a \times 10}{120 \times a} = 6.5\%$$

Q4: A:

$$BOD_5 = L(1 - e^{-K_1 t})$$

$$300 = L(1 - e^{-0.25 \times 5})$$

$$L = 420\ mg/lit$$

$$K_1^{15} = K_1^{20} \times 1.047^{15-20} = 0.20$$

$$\therefore BOD_{10}^{15} = 420(1 - e^{-0.2 \times 10}) = 363\ mg/lit$$

$$K_1^{30} = 0.25 \times 1.047^{10} = 0.4$$

$$363 = 420(1 - e^{-0.4t})$$

$$t = 5\ \text{days}$$

Q_4 B:

$$X V = Y Q \theta_c (S_o - S) / (1 + k_d \theta_c)$$

$$S = 20 - 0.63 \times 20 = 7.4 \text{ mg/lit}$$

$$X V = \frac{0.65 \times 5000 \times 12 \times (160 - 7.4)}{1 + 0.05 \times 12} / 10^3$$

$$= 3719 \text{ kg}$$

$$V = \frac{3719}{3} = 1240 \text{ m}^3$$

$$Q_r \times 10000 = (Q + Q_r) \times 3000$$

$$\therefore \frac{Q_r}{Q} = 0.428 \simeq 43\%$$

daily sludge production $= \frac{3719 / 0.8}{12} = 387.4$ kg/d

$$\therefore Q_w = \frac{387.4 \times 10^6}{10\,000} / 1000 = 38.74 \text{ m}^3/\text{d}$$

O_2 demand $= 1.47 (S_o - S) Q - 1.14 X_r Q_w$

$= 680$ kg/day

Q_5: A.

$$h_f = 10.7 \left(\frac{Q}{C}\right)^{1.85} \times L \times D^{-4.85}$$

$$= 8.46 \times 10^{-3} \times D^{-4.85}$$

$$TDH = 20 + h_f$$

$$\text{Power} = \frac{120}{3600} \times \frac{9.8}{0.65} \times TDH \simeq 0.5\, TDH$$

depreciation $= \frac{2.5}{100} \times$ cost/m $\times$ total length

operation cost $=$ Power $\times 15 \times 365 \times$ unit cost

$\Longrightarrow$ 300 mm is the economical size.

B. $Z = \frac{100}{1.5} = 66.67$

$$1 = 22.61 \times \frac{66.67}{0.015} (0.003)^{0.5} y^{8/3}$$

$\therefore y = 0.0395$ m $\simeq 40$ mm

From table $\Longrightarrow$ ave. cap./m $= 0.58$ m³/min

$\therefore$ length of inlet $= \frac{1}{0.58} = 1.72$ m

distance of water ext. $= Z \cdot y$

$= 2.67$ m