



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



Subject: Sanitary Engineering
Division: Water and Dams Eng.
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%.
- 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.

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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 1.027×10^{-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 BOD₅ of a two-stage trickling filter with the following flows, BOD₅ and dimensions:

- $Q = 2000 \text{ m}^3/\text{day}$
- $\text{BOD}_5 = 300 \text{ mg/lit}$
- 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)

الهندسة الصحية / المطهرة الثالثة / دور اول / حلول نموذجية

Q, A, $P_t = P_0 + k \Delta t$
 $= 2000 + 0.03 \times 2000 \times 25$
 $= 3500 \text{ capita}$

max. weekly demand $= 1.48 \times 3000$
 $= 444 \text{ l/cap-day}$

Req. storage $= \frac{444}{1000} \times 7 \times 3500$
 $= 10878 \text{ m}^3$

B: Population = Pop. density \times Area
 $= 3000 \text{ cap.}$

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

$Q_{\text{peak}} = 3000 \times 250 \times 4.16 / 1000 / 24$
 $= 130 \text{ m}^3/\text{hr}$

As the no of duty pumps = 1
 $\therefore Q_p = 130 \text{ m}^3/\text{hr}$

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

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

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

$\therefore \text{det. time at min. flow} = \frac{5.42}{9.38} \times 60 = 34 \text{ min}$
 $> 30 \therefore \text{not o.k.}$

Q₂: A:
 At minimum gradient, $V = \text{flushing velocity} = 0.75 \text{ m/sec}$

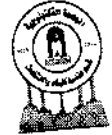
$\Rightarrow Q = 0.75 \times \pi D^2 / 4$
 $= 0.0236 \text{ m}^3/\text{sec}$ for $D = 200 \text{ mm}$
 $= 0.0368 \text{ m}^3/\text{sec}$ for $D = 250 \text{ mm}$

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

then $q = 0.019 \text{ m}^3/\text{sec}$ for $D = 200 \text{ mm}$
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(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 BOD₅ 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 $K_1 = 0.25/\text{day}$ at 20°C. (10 marks)

B: Design an activated sludge process (determine V, r and O₂ requirement (kg/day)) to yield an effluent BOD₅ of 20 mg/lit and suspended solids of 20 mg/lit. The influent BOD₅ is 160 mg/lit and the waste flow is 5000 m³/day. Assume $Y = 0.65$, $k_d = 0.05/\text{day}$, $\theta_c = 12$ 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 m³/hr against a static head of 20 m through a pipe 3000 m long.

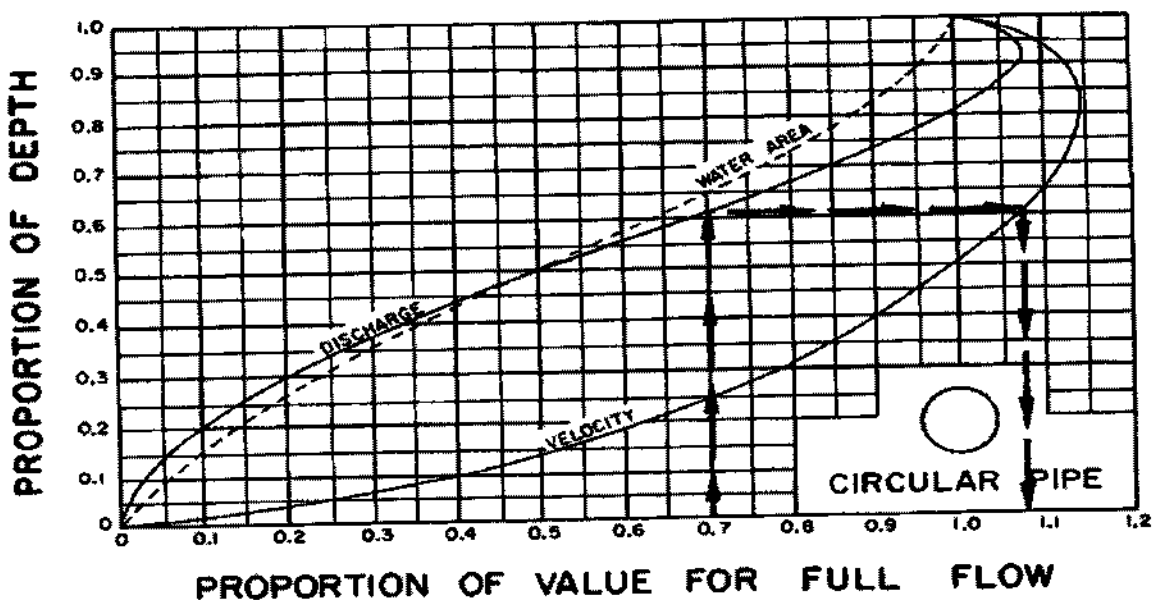
Determine the most economical pipe size. Power cost is 8 cent/kW-hr, the pump operates 15 hrs per day, the annual depreciation is 2.5%, the cost of installed pipe is 40\$ for 150mm, 48\$ for 200 mm, 64\$ for 250 mm and 72\$ for 250 mm per meter length. Assume the overall pumping efficiency of 65%. (C=120). Ignore minor losses (15 marks)

B: The stormwater runoff in a gutter at an inlet is 60m³/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.

$$Q = 22.61 \frac{z}{n} s^{0.5} y^{8/3} \quad (\text{m}^3/\text{min}, \text{m}) \quad (10 \text{ marks})$$

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



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$$Q = \text{No. of houses} \times 8 \times 0.25 \times 6 / 24 / 3600$$

$$\begin{aligned} \text{no. of houses} &= 137 \text{ for } D = 200 \text{ mm} \\ &= 209 \text{ for } D = 250 \text{ mm} \end{aligned}$$

Q₂: B: Assume $N_R < 0.5$

$$V_s = \frac{g}{18\mu} (l_s - l) d^2$$

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

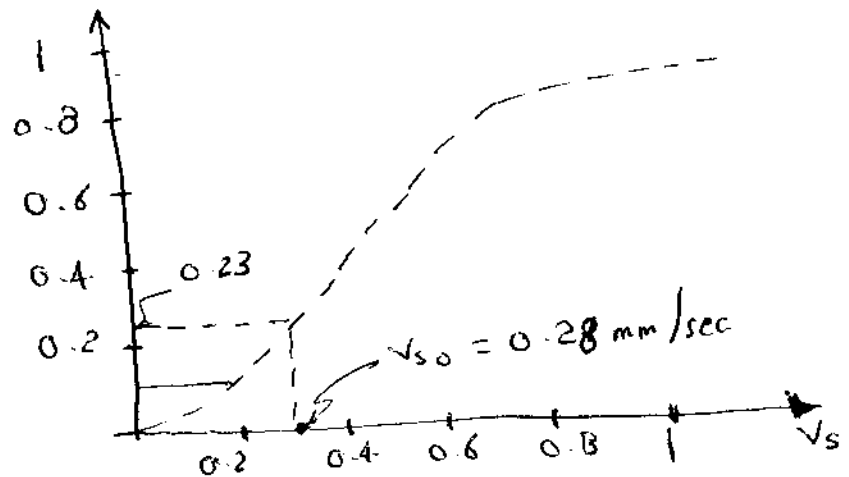
$$= 106 d^2 \quad (V_s: \text{mm/sec}, d = \text{mm})$$

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

$$\begin{aligned} V_{s0} &= 24 \text{ m/d} \\ &= 0.28 \text{ mm/sec} \end{aligned}$$



$$\begin{aligned} \text{overall removal} &= (1 - 0.23) + 0.13 \times \frac{0.21}{0.28} + 0.1 \times \frac{0.1}{0.28} \\ &= 0.9 \\ &= 90\% \end{aligned}$$

Q₃ A:

For first stage.

$$E_1 = \frac{C_i - C_e}{C_i} = \frac{1}{1 + 0.532 \sqrt{\frac{QC_i}{V_1 F_1}}}$$

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

$$\Rightarrow E_1 = 0.73, \quad C_e = 81 \text{ mg/lit}$$

For the second stage:

$$E_2 = \frac{C_e - C_e'}{C_e} = \frac{1}{1 + \frac{0.532}{1-E_1} \sqrt{\frac{QC_e}{V_2 F_2}}}$$

$$F_2 = 1.65$$

$$\Rightarrow E_2 = 0.58$$

$$\therefore C_e' = 34 \text{ mg/lit}$$

B: $v_b = D_{60} = 1.3 \times 0.6 = 0.78 \text{ m/min}$

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

Q₄ A:

$$\text{BOD}_5 = L(1 - e^{-k_1 t})$$

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

$$L = 420 \text{ mg/lit}$$

$$k_1^{15} = k_1^{20} \times 1.047^{15-20} = 0.20$$

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

$$k_1^{30} = 0.25 \times 1.047^{10} = 0.4$$

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

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

Q4-B:-

A/

$$xV = YQ\theta_c (S_0 - S) / (1 + k_d\theta_c)$$

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

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

$$= 3719 \text{ kg}$$

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

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

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

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

$$\therefore Q_w = \frac{387.4 \times 10^6}{10000} / 1000 = 38.74 \text{ m}^3/\text{d}$$

$$O_2 \text{ demand} = 1.47(S_0 - S)Q - 1.14 \times Q_r Q_w$$

$$= 580 \text{ kg/day}$$

Q5: A.

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

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

$$\text{TDH} = 20 + h_L$$

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

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

$$\text{operation cost} = \text{Power} \times 15 \times 365 \times \text{unit cost}$$

$\Rightarrow 300^{\text{mm}}$ is the economical size.

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

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

$$\therefore y = 0.0395 \text{ m} \approx 40 \text{ mm}$$

From table \Rightarrow ave. cap./m = $0.58 \text{ m}^3/\text{min}$

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

$$\text{distance of water ext.} = Z \cdot y$$

$$= 2.67 \text{ m}$$