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THE OPEN UNIVERSITY OF SRI LANKA
Department of Civil Engineering
Diploma in Technology - Level 4

CEX 4234- WATER SUPPLY AND SEWERAGE ENGINEERING

FINAL EXAMINATION - 2007/2008

Time Allowed: Three Hours *Index No.* | | | | |

Date: 10th May, 2008 **Time: 0930 - 1230**

Answer any FIVE questions. All questions carry equal marks.

Q1.

(a) The importance of providing a good water supply scheme to the inhabitants of a community cannot be over-rated under any circumstances. The National Water Supply and Drainage Board (NWSDB) has decided to expand the existing water supply scheme of Gampaha town to provide a better service to the people at the city.

(i) As the Engineer in-charge of the project, what information would you collect during the planning stages of this water supply scheme? (02 marks)

(ii) Prepare a list of project elements, which you would include in the above water supply scheme. (02 marks)

(iii)If you are asked to submit the engineering drawings for the above project, what drawings or maps would you prepare? (02 marks)

(b) Bambarakirialla is a rural village in the Hunnasgiriya mountain region which does not have pipe- borne water. In the dry season, most water streams go dry and the people have to walk far to fetch water to fulfil their daily water needs.

(i) What are the national and international organizations that support the development of rural water supply? (1.5 marks)

(ii) Nikalaoya stream, which flows through a tea estate is the only water source identified to supply water to the above rural water supply scheme. Discuss the suitability of using this as the water source considering water quality aspects. (03 marks)

(iii) Present population (as of 2008) of the Bambarakiriella GS division is about 2900 people. Estimate the future population in 20 years. Assume the population growth per decade is constant and geometric mean for three decades is 0.085. (03 marks)

(c) A fully confined aquifer, which is 15 m deep, is used to supply water for Mahaweli System 'C'. Two monitoring wells were placed 30 m and 60 m away from the tube well. In the test run following observations were made on a 30 cm tube well.

Rate of pumping = 1000 l/min

Draw down in the test well placed 30 m away =1.5 m

Drawdown in the test well placed 60 m away = 0.6 m

If there is an agro-well 100 m away from the tube well, check whether pumping water from this tube well affects the agro-well (assume the coefficient of the permeability of soil is 30 m/day). (6.5 marks)

Q2.

(a) Pumping water is necessary when flow under gravity is not possible, or when water has to be raised from a lower to a higher elevation. You are required to select a pump set for a water supply scheme in a city in the North Western Province. The following information is available:

Population to be served: 10,000 people
Per capita demand: 150 l/c/d
Reduced level of bottom of the tank: 332.00 m
Reduced level of the ground: 330.00 m
Reduced level of the water table: 322.00 m
The height to which the water has to be pumped above the bottom level of tank: 3 m

(i) Calculate the design discharge of the tube well? (01 mark)

(ii) If pumping is carried out only for 16 hours/day, neglecting minor losses calculate the Water Horse Power of the pump required to supply water to the above city. (03marks)

(iii) If efficiency of the pump is 70% what is the Brake Horse Power of the pump? (03 marks)

(b) Intakes and transmission main are important in water supply schemes as they collect and distribute water.

(i) What are the factors that have to be considered in selecting a site for a river intake? (1.5 marks)

(ii) List the types of river intakes. Explain how each type helps in collecting water? (03 marks)

(iii) What are the factors that have to be considered when designing a transmission main to deliver water? (1.5 marks)

(c) (i) What types of pipes (pipe materials) would you recommended for following places? Give reasons for your recommendations. (04 marks)

(1) A long gravity main pipe conveying water to the treatment plant from the source

(2) A distribution pipe carrying treated water from the treatment plant to the city

(3) Pipes used for distributing water inside buildings

(4) Pipes that convey hot water

(ii) How are cast iron pipes re-joined using spigot and socket joints? You may draw a sketch to show the joint. List other pipe joints, which are used for cast iron pipes? (03 marks)

Q3.

(a) Coagulation is important in water treatment to reduce suspended solids.

(i) An alternative coagulant for alum is ferric sulphate. Explain impacts of adding ferric on pH and alkalinity. (03 marks)

(ii) Determine the daily requirement of alum, lime and polyelctrolyte to coagulate a flow of 20,000 m^3/day, if the results of jar test indicate that the optimum coagulation when 1 litre of water was dosed 5ml of 10mg/l of alum solution, 2ml of 10mg/l suspension of lime and 0.3mg/l of a commercial polyelectrolyte. (05 marks)

(b) A city has population of 20,000 with an average rate of demand is 100lpcd.

(i) Differentiate slow sand filter and the rapid sand filter. (02 marks)

(ii)Design a slow sand filter to treat maximum daily demand of water supply. Average rate of filtration for slow sand filter is 150liters/m^2/h. Also assuming filtration rates, design a rapid gravity filter for the same supply. If the filter is required as an extension to a land-locked urban treatment plant, which filter do you recommend? (05 marks)

(c) (i) Discuss thee advantage and disadvantage of using chlorine as an disinfectant? (02 marks)

(ii) Explain the process of breakpoint chlorination. (01 marks)

(iii)Calculate the amount of Cl_2 required disinfecting supply of 20,000 m^3/day with a free residual of 1mg/l, if the chlorine dose is 10mg/l. (02 marks)

Q4.

(a) Elevated water storage tanks and towers are familiar sights in most communities.

(i) What benefits does equalizing storage provide in a water distribution system? (02 marks)

(ii) Is it preferable to have a single large water storage tank located near the pumping station or to have several smaller tanks located near the major centres of water demand? Explain briefly. (2.5 marks)

(iii) If two identical pumps operate in parallel in a water distribution system, would the total discharge be twice the discharge from one pump alone? Why? (03 marks)

(b) Equivalent pipes are used for simplifying distribution systems for analytical purposes. ABC is a part of distribution system going to establish in a city. Determine the theoretical diameter of a single 1000m long pipe line from A to C that would be equivalent to the looped piped line shown in figure Q4 (b). (Hazen William Constant; C=100 for the pipe material) (7.5 marks)

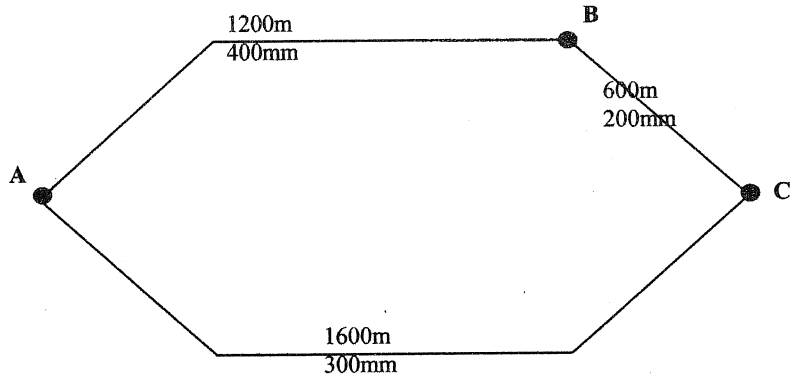

Figure Q4. Illustration for Problem Q4 (b)

(c) Leakages in pipe joints are common no matter how well a pipe line is constructed. The maximum allowable rate of leakages can be calculated using a common formula:

$$Q_L = \frac{N \times D \times P^{1/2}}{C}$$

Where; Q_L = Allowable leakage

N = Number of joints in length of main tested
D = Pipe diameter, mm
P = Test pressure , kPa
C = A constant : 32,600 for SI units

A 350m- long section of a newly installed 280 diameter water main is pressure tested for leakage. It was observed that during the 1 hour test period, a volume of 10L of water was pumped into the pipeline to maintain the required pressure of 1000kPa. The pipe sections are 7m long between joints. Has the allowable rate of leakage been exceeded? (05 marks)

Q5.

(a) Sewer appurtenances are devices necessary in addition to pipes and conduits, for the purpose of functioning of any complete system of system of sanitary, storm or combined sewers.

(i) List four purposes of a sewer manhole in sewer system. (01 mark)
(ii) What are the differences between drop manhole and inverted siphon? (02 marks)
(iii)Describe two types of lift stations. Under what circumstances a lift station might be needed? (02 marks)
(iv) Some times sewer pipelines are over design. Is it a good practice? Why? (02 marks)

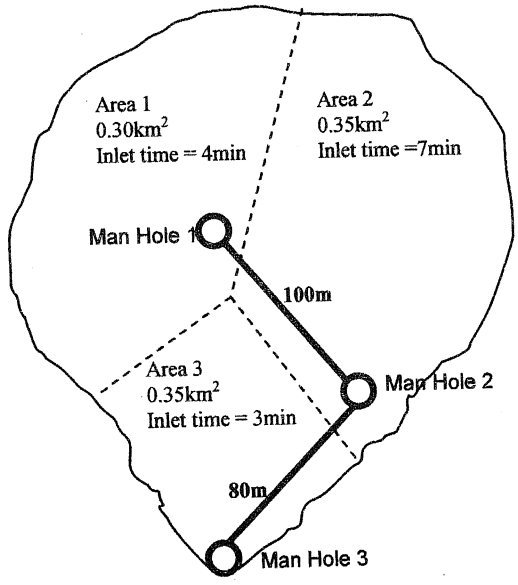

Figure Q5 Illustration for question 5(b)

(b) A figure shows the drainage basin of 1km² comprises as shown in the figure Q5. Drainage areas, length of the lines and inlet time are described in the figure.

(i) What is the maximum time of concentration of the drainage basin? (03 marks)
(ii) Considering 5 year storm, estimate the rainfall intensity. Rainfall curves derives from storm records are given. (02 marks)

(iii)Assuming the runoff coefficient for entire area is 0.50, using rational formula, Q=0.278 CIA, estimate the storm water flow at man hole 3 in l/s. (02 marks)

(c) A trunk sewer is to be designed to receive flow from a 1km^2 area of a community lived in the above drainage basin, where the population density is 50 persons /ha. The average per capita sewage flow is taken to be 400l/d.

(i)What is the design flow for the trunk sewer in liters per second? (02 marks)

(ii) It is proposed to dispose storm water and trunk sewer together what will be the size of the main sewer line to carry water without any depositions. (04 marks)

Q6.

(a) A wastewater treatment plant employs a completely mixed activated sludge system. Following information are given:

Per capita water demand of the area	=225L/day
Population equivalent	= 50,000
Influent BOD	= 250mg/l
Influent suspended solids	= 400mg/l
Required effluent BOD	= 12 mg/l
SS in the effluent	= 50mg/l
MLSS in aeration basin	= 2500mg/l

(i)Estimate the volume of the aeration basin (1.5 marks)

(ii)The hydraulic retention time (1.5 marks)

(iii)Food to microorganism ratio (1.5 marks)

(iv) BOD and SS removal efficiency (02 marks)

(b) The water usage of a restaurant is about 10,000l/day. Its daily wastewater production is about 80% of the water consumption. It produces oily wastewater. For environmental protection licensee (EPL) the restaurant owner need to install a waste water treatment plant.

(i) If you are asked to submit a proposal for a wastewater treatment plant, what unit processes are you introduced to purify the above wastewater? Describe your process using a flow diagram. (03 marks)

(ii) What alternative biological treatment units do you suggest in the above flow diagram? (1.5 marks)

(iii)If aerator is introduced to the above system, what will be the volume of the aerator? Assume the retention time according to the selected treatment process. (03 marks)

(c) (i)A milk processing factory discharges their wastewater in to the nearby river. The BOD_5^{20} of the wastewater of milk processing factory is 1200mg/l and it flows with the rate of 5m^3/day. The river has a flow of 25m3/d and with BOD_5^{20} of 30mg/l. Assuming the complete mixing at the tributary, estimate the BOD_5^{20} level just at the down stream. (03 marks)

(ii) The BOD_5^{20} of a wastewater sample taken from this river has been measured as 600mg/l. If the reaction rate constants 0.23/day, what would be the ultimate BOD of waste? Also compute the five day BOD at the temperature 28°C. (03 marks)

Hint: $k=k_{20}\,\theta^{(T-20)}$; $BOD_5 = Lo\,(1-e^{-kt})$; $\theta = 1.047$]

Q7.

(a) The concentration of solids has a very significant effect on the total volume occupied by the liquid sludge. The total sludge volume is inversely proportional to the solids concentration. In a wastewater treatment plant, sewage sludge with a 6 percent concentration of solids occupies a total volume of $400m^3$.

(i) Estimate the water content of the sludge? (02 marks)

(ii) What is the mass of the sludge solids? (1.5 marks)

(iii)If the sludge is further concentrated (or dewatered) to a volume of 300 m^3, what will the solids concentration be? What will the water concentration be? (4.5 marks)

[Hint: sludge solids concentration (S) is expressed by $S = \frac{M}{V} \times 100$]

(b) Trickling filters are secondary treatment units in wastewater treatment plant.

(i) What are the advantageous of having trickling filters compared to the activated sludge treatment units? (02 marks)

(ii) What is the purpose of recirculation in a trickling filter? (1.5 marks)

(iii) How does temperature affect a trickling filter operation? (1.5 marks)

(c) (i) Name four different sludge treatment processes. (01 marks)

(ii) Mixing is important during sludge digestion. How mixing improves the digestion of sludge? Explain briefly. (02 marks)

(iii) The total solids remaining in digested sludge (combined primary and activated) is 57 g/capita/day. It is needed to design a sludge drying beds fpr digested sludge from an activated sludge plant serving for 20,000 people. Per capita area per year should be within the range of 0.175- 0.25. Also check for per capita area and estimate the no of beds needed if the area is 15 m long and 5m wide. Assume dry solids loading is $100kg/m^2$/year. (04 marks)

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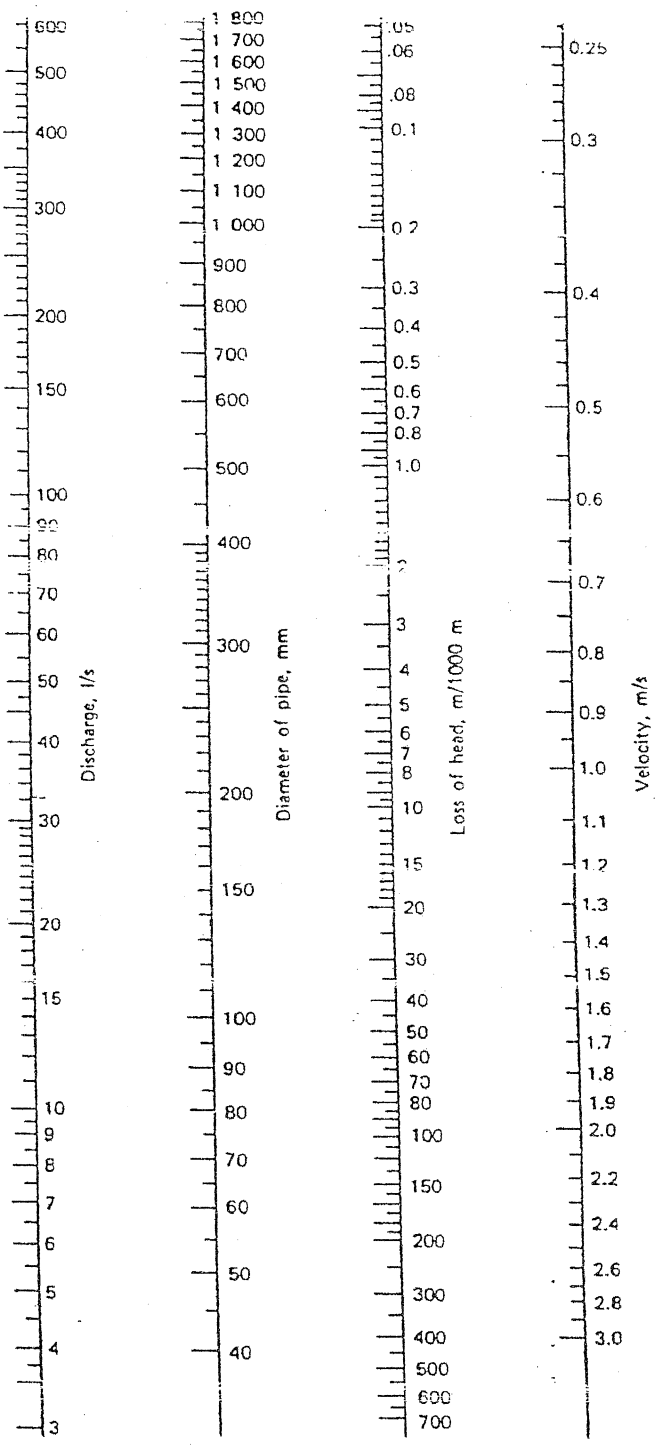
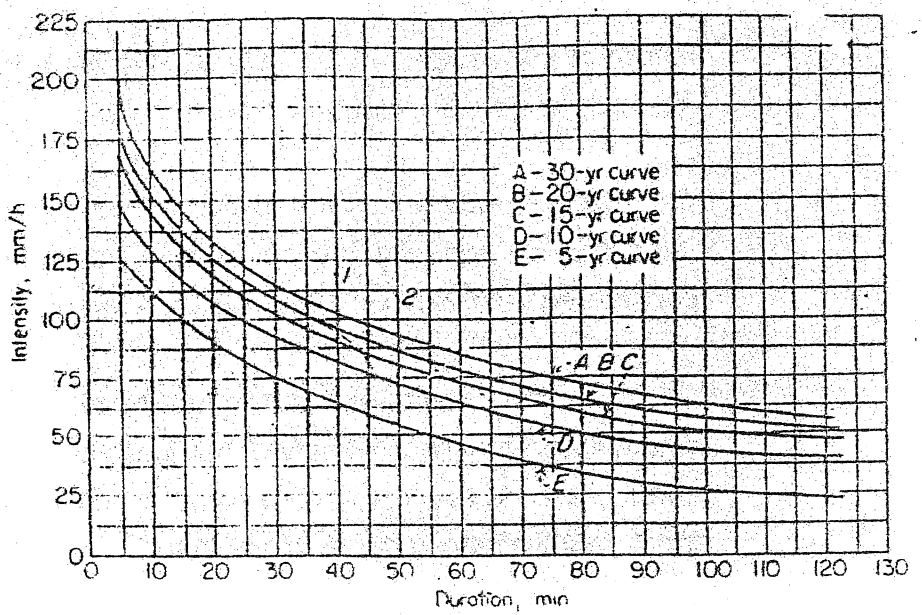


Nomograph for Hazen Williams Formula, [illegible] based on $C = 100$.



RAINFALL CURVES DERIVED FROM STORM RECORDS