UNIVERSITI SAINS MALAYSIA

First Semester Examination
2009/2010 Academic Session

November 2009

IEK 308 – Industrial Wastewater Treatment Plant Design
[Rekabentuk Loji Pengolahan Air Sisa Industri]

Duration: 3 hours
[Masa: 3 jam]

Please check that this examination paper consists of ELEVEN pages of printed material before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi SEBELAS muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

Instructions: Answer **FOUR** (4) questions. You may answer the questions either in Bahasa Malaysia or in English.

*[**Arahan:** Jawab **EMPAT** (4) soalan. Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]*

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.]

1. Determine the in-line storage volume required to equalize the flowrate of the given data:

Time Period	Cumulative Volume of Flow at end of time period (m^3)
Midnight-1 am	990
1 am -2 am	1782
2 am -3 am	2376
3 am -4am	2844
4 am -5am	3222
5 am -6 am	3582
6 am -7 am	4014
7 am -8 am	4752
8 am -9 am	6030
9 am -10 am	7506
10 am -11 am	9036
11 am -Noon	10584
Noon-1pm	12114
1 pm -2 pm	13572
2 pm -3 pm	14958
3 pm -4 pm	16218
4 pm -5 pm	17388
5 pm -6 pm	18558
6 pm -7 pm	19746
7 pm -8 pm	21060
8 pm -9 pm	22500
9 pm -10 pm	23940
10 pm -11 pm	25308
11 pm -Midnight	26550

(100 marks)

2. The average flowrate at a small wastewater treatment plant is 20,000m^3/d. The highest peak daily flowrate is 50,000 m^3/d. Design a rectangular primary sedimentation tank with a channel width of 6 m. Use a minimum of two tanks. The overflow rate is to be designed at 40 m^3/m^2 d at an average flow. The design side water depth is to be 4m. Determine the followings:

   (a) Surface area required
   (b) Determine the tank length
   (c) Determine the detention time and overflow rate at average flow
   (d) Determine the detention time and overflow rate at peak flow

Primary Sedimentation Tank	Units	SI Units	
		Range	Typical
Detention Time	Hours	1.5-2.5	2.0
Overflow Rate Average Flow Peak Flow	 m^3/m^2 d m^3/m^2 d	 30-50 80-120	 40 100
Weir Loading	m^3/m^2 d	125-500	250

(100 marks)

3. The average flowrate at a small wastewater treatment plant is 20,000m^3/d. The highest peak daily flowrate is 50,000 m^3/d. Design a rectangular primary sedimentation tank with a channel width of 6 m. Use a minimum of two tanks. The overflow rate is to be designed at 40 m^3/m^2 d at an average flow. The design side water depth is to be 4m. Determine the followings:

   (a) Calculate the peak flow horizontal velocity. Compare the velocity to the design horizontal scour velocity to determine whether the settled material will become resuspended.
   Use the following equation for determination of horizontal scour velocity V_h;

$$V_h = (8k (s-1) gd/f)$$

   Where,

Cohesion coefficient,	k= 0.5
Specific gravity,	s= 1.25
Acceleration due to gravity,	g = 9.81 m/s ^{2}
Diameter of particles,	d=100 microns = 100 x10^{-6}m
Darcy-Weisbuch Friction factor,	f=0.025

   (b) Determine the removal rates R of BOD and TSS at average and peak flow rates. The BOD and TSS removal rates R can be estimated using the following equation:

$$R = (t / (a + bt)$$

   Where,

   R = expected removal efficiency
   t = detention times T
   a, b = empirical constants

Item	a	b
BOD	0.018	0.020
TSS	0.0075	0.014

(100 marks)

…5/-

4. Design a floatation thickener

   (a) with pressurized recycle
   (b) without pressurized recycle

   to thicken the solids in a activated sludge system from 0.3 to 0.4 percent. Determine what is the required surface area A?

   The following equations and data are related to the proposed floatation system to be designed.

   With recycle: $A/S = 1.3\ s_a\ (fP-1)R/\ QS_a$

   Without recycle: $A/S = 1.3\ s_a\ (fP-1)/\ S_a$

   Given that;

Optimum ratio of	A/S	=	0.008 mL/mg
Temperature	T	=	20^oC
Air solubility	s_a	=	18.7 mL/L
Recycle system pressure	P	=	275 kPa
Non recycle system pressure	P	=	(p + 101.35)/101.35
Fraction of saturation	f	=	0.5
Surface loading rate		=	$8L/m^2$. min
Sludge flowrate	Q	=	$400m^3/d$
Influent suspended solids	Sa	=	3000 g/m^3 or mg/L
Pressurised Recycle	R	=	m^3/d

(100 marks)

5. Based on a laboratory testing it was found that 1.5 mole of Aluminum will be required to precipitate one mole of Phosphorus. The flow rate of the wastewater is 12,000m^3/d. Determine the amount of liquid alum required to precipitate phosphorus in a wastewater that contains 8mg/L of phosphorus. Also determine the amount of alum storage capacity that is required if a 30 day supply is to be stored at the treatment facility.

Formula for liquid alum:	$Al_2(SO_4)_3.18H_2O$	
Alum strength	=	48 percent
Density of liquid alum solution	=	1.2 kg/L
Molecular weight of alum	=	666.5
Mwt Al	=	26.98,
Mwt P	=	30.97

Given that the equation of reaction theoretically:

$$Al^{3+} + H_nPO_4^{3-n} \rightarrow AlPO_4 + nH^+$$

One mole of Al per mole of P.

(100 marks)

1. *Tentukan kapasiti isipadu penyimpanan yang diperlukan untuk menyamakan kadar aliran bagi data yang diberi di bawah?*

Tempoh Masa	*Isipadu kumulatif bagi aliran pada tempoh akhir masa, (m^3)*
Tengahmalam-1 am	*990*
1 am -2 am	*1782*
2 am -3 am	*2376*
3 am -4 am	*2844*
4 am -5 am	*3222*
5 am -6 am	*3582*
6 am -7 am	*4014*
7 am -8 am	*4752*
8 am -9 am	*6030*
9 am -10 am	*7506*
10 am -11 am	*9036*
11 am -Tengahari	*10584*
Tengahari-1 pm	*12114*
1 pm -2 pm	*13572*
2 pm -3 pm	*14958*
3 pm -4 pm	*16218*
4 pm -5 pm	*17388*
5 pm -6 pm	*18558*
6 pm -7 pm	*19746*
7 pm -8 pm	*21060*
8 pm -9 pm	*22500*
9 pm -10 pm	*23940*
10 pm -11 pm	*25308*
11 pm - Tengahmalam	*26550*

(100 markah)

2. *Purata kadar aliran bagi satu loji kecil rawatan air kumbahan ialah 20,000m^3/d. Kadar aliran harian puncak ialah 50,000 m^3/d. Rekabentukkan satu tangki pemendapan primer segiempat tepat dengan saluran lebarnya 6 m. Paling minima dua buah tangki diperlukan. Kadar limpahan perlu direkabentuk pada kadar purata aliran iaitu 40 m^3/m^2 d. Rekabentuk bagi ukuran sisi kedalaman air ialah 4m. Tentukan perkara berikut:*

   (a) *Luas permukaan yang diperlukan*
   (b) *Tentukan berapakah panjang tangki*
   (c) *Tentukan masa tahanan dan kadar limpahan pada aliran purata*
   (d) *Tentukan masa tahanan dan kadar limpahan pada aliran puncak*

Tangki mendapan primari	*Units*	*SI Units*	*Tipikal*
		Julat	
Masa Tahanan	*Jam*	*1.5-2.5*	*2.0*
Kadar Limpahan			
Aliran Purata	m^3/m^2 *d*	*30-50*	*40*
Aliran Puncak	m^3/m^2 *d*	*80-120*	*100*
Muatan Weir	m^3/m^2 *d*	*125-500*	*250*

(100 markah)

3. *Purata kadar aliran bagi satu loji kecil rawatan air kumbahan ialah 20,000m^3/d. Kadar aliran harian puncak ialah 50,000 m^3/d. Rekabentukkan satu tangki pemendapan primari segiempat tepat dengan saluran lebarnya 6m. Paling minima dua buah tangki diperlukan. Kadar limpahan perlu direkabentuk pada kadar purata aliran ia itu 40m^3/m^2 d. Rekabentuk bagi ukuran sisi kedalaman air ialah 4m.*

   (a) *Kira Halaju mendatar aliran puncak. Bandingkan halaju dengan halaju kaut mendatar rekabentuk untuk menentukan andainya bahan yang termendap mungkin akan terampai.*
   Gunakan persamaan berikut bagi menentukan halaju kaut mendatar V_h;

$$V_h = (8k (s-1) gd/f)$$

   Dimana,

Koeffisien kelekitan	*k*	=	*0.5*
Spesifik graviti,	*s*	=	*1.25*
Pecutan oleh graviti,	*g*	=	*9.81 m/s ^{2}*
Garis pusat zarah,	*d*	=	*100microns = 100 x10^{-6}m*
Darcy-Weisbuch factor geseran,	*f*	=	*0.025*

   (b) *Tentukan kadar penyingkiran R bagi BOD dan TSS pada kadar aliran purata dan kadar aliran puncak.*
   Kadar penyingkiran R bagi BOD dan TSS boleh diramalkan dengan menggunakan persamaan seperti yang diberikan di bawah;

$$R = (t / (a + bt)$$

   Dimana,

   R = anggaran efisiensi penyingkiran
   t = masa tahanan T
   a, b = empirikal malar

Item	*a*	*b*
BOD	*0.018*	*0.020*
TSS	*0.0075*	*0.014*

(100 markah)

…10/-

4. *Rekabentukan satu alat pemekat apungan*

   (a) beserta kitar penekan
   (b) tanpa kitar penekan

   untuk memekat pepejal didalam sistem enap cemar teraktif dari 0.3 ke 0.4 peratus. Tentukan berapakah luas permukaan A yang diperlukan?

   Berikut adalah persamaan dan data yang berkaitan untuk rekabentuk sistem apungan yang dicadangkan.

   Dengan kitaran: $A/S = 1.3\ s_a\ (fP-1)R/\ QS_a$

   Tanpa kitaran: $A/S = 1.3\ s_a\ (fP-1)/\ S_a$

   Diberi bahawa;

Nisbah optimum	A/S	=	$0.008\ mL/mg$
Suhu	T	=	20^oC
Kebolehlarutan udara	s_a	=	$18.7\ mL/L$
Sistem kitar tekanan	P	=	$275\ kPa$
Sistem tanpa kitar tekanan	P	=	$(p + 101.35)/101.35$
Pecahan ketepuan udara	f	=	0.5
Kadar muatan permukaan		=	$8L/m^2\ .\ min$
Kadar aliran enap cemar	Q	=	$400m^3/d$
Input pepejal terampai	Sa	=	$3000\ g/m^3$ *or* mg/L
Kitar tekanan	R	=	m^3/d

(100 markah)

5. *Berpandukan pada satu ujikaji telah diketahui bahawa 1.5 mol aluminum diperlukan untuk memendakkan satu mol fosforus. Kadar aliran untuk air kumbahan ialah 12,000 m^3/d. Tentukan berapakah jumlah cecair alum yang diperlukan untuk memendapkan fosforus didalam air kumbahan yang mengandungi 8mg/L fosforus. Tentukan juga jumlah kapasiti simpanan alum yang diperlukan jika bekalan untuk 30 hari perlu disimpan di tapak rawatan.*

Formula untuk cecair alum:	$Al_2(SO_4)_3.18H_2O$	
Kepekatan alum	=	*48 peratus*
Ketumpatan larutan cecair alum	=	*1.2 kg/L*
Berat molekul alum	=	*666.5*
Berat molekul Al	=	*26.98,*
Berat molekul P	=	*30.97*

Diberi bahawa persamaan bagi tindakbalas secara teori:

$$Al^{3+} + H_nPO_4^{3-n} \rightarrow AlPO_4 + nH^+$$

Satu mol Al bagi setiap mol P.

(100 markah)

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