University Of Technology
Building and Construction Eng. Dept.
Final Exam – 1st Attempt – 2014/2015

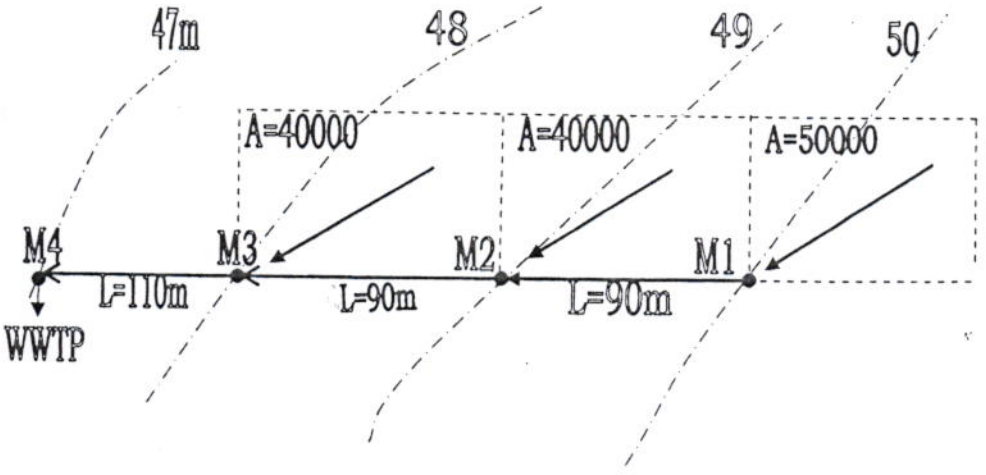
Branch : San. & Env. Eng. **Class: 3rd**
subject : Networks of Water **Time : 3 hr**
Examiner : S.A. Al-Bayati, Ph.D. **Date : 31/5/ 2015**

ملاحظات: ١.أجب عن **خمسة** أسئلة بضمنها **الأول**. ٢.الدرجات موزعة بالتساوي على الاسئلة.

٣.تعاد الأسئلة والمرفقات كافة(دون كتابة عليها) وسط الدفتر الامتحاني. **الاسم:**

Q.1 Design a sanitary sewer system (3- pipelines) for the residential area shown below (M=manhole, A=area (m^2) & L=pipe length between two manholes). The conditions are:

1. min. sewer size = 200mm.
2. roughness coefficient, n = 0.013
3. min. velocity = **0.6m/s**
4. min. allowable cover over the crown = **1.9 m**
5. max. population density = **11000p /km^2**.
6. max. rate of sewage flow + infiltration = **1600 L/day.capita** [20%]

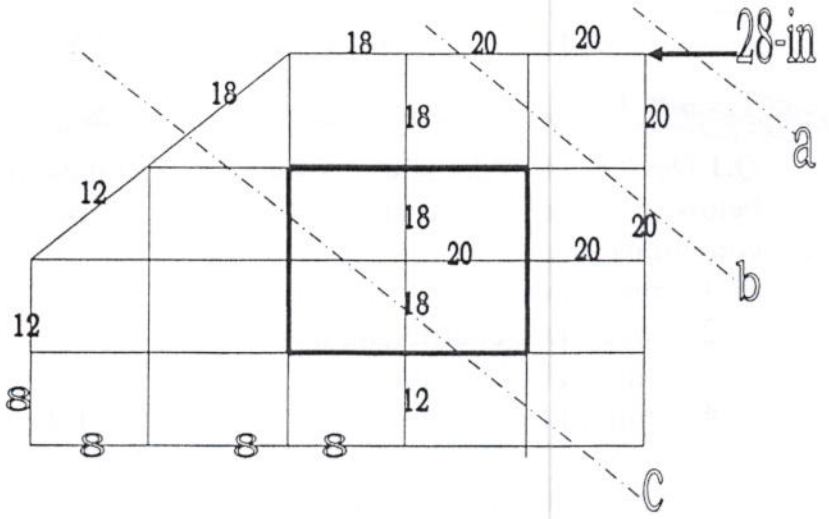


Q.2 A water supply system serving a city with: average daily demand = **160**L/s, max. daily demand = **250**L/s, & peak hourly demand = **340**L/s. Required fire flow **280**L/s resulting in a max. **4**h rate of **530**L/s (max. daily demand + fire flow). The required min. pressure in the main city center is **34**m except during fire flow. The piping system diameter is **550**mm with Hazen Williams coefficient, C = **100**. Distance between pumping station and city center is **7.5**km. Consider the system with storage, and find the pumping heads for this case **only**. Use storage= **3500**m^3, with elevation = **36**m, at **2.5** km beyond load center. [20%]

Q.3 Analyze the shown network by Section Method. The hydraulic gradient is 0.0023. Use C = 100 in Hazen Williams formula & maximum daily use is

160gpcd. All pipes without numbers are 6-in. The fire demand & population for each section are taken from the table below: [20%]

Section	a-a	b-b	c-c
Population	21000	17000	7000
Fire flow (mgd)	6.1	6.1	6.1



Q.4

a) What is the maximum free flow head in a Parshall flume with a throat width of 2ft & flow rate of 30cfs? [10%]

b) Explain the process of **fold and formed PVC** pipe. [10%]

Q.5

a) A water pumping station at **400m** elevation uses pumps which require **42kPa** net positive suction pressure when delivering water at **40°C**. What is the allowable suction lift of these pumps if all losses are **20kPa**? [10%]

b) Explain the following; check valve, centrifugal pump, flushing device, & sag pipe usefulness. [10%]

Q.6

a) A six-story ordinary construction with 800 m^2 per floor is connected to a four story fire resistive construction with 850 m^2 per floor. Determine the fire flow required for them. $\mathbf{F = 3.7\ C\sqrt{A}}$. [10%]

b) Explain the following: protection devices from water hammer, rational method, pipe profiling sonar usefulness, & open wells advantages. [10%]

مع التوفيق

Sheet

Q.1

Line no	From M	To M	length m	Inc. of area m^2	Inc. Pop. person	Total Tribi P-P. person	Sewage flow L/day	Sewage flow m^3/min
1	1	2	90	50000	550	550	880000	0.61
2	2	3	90	40000	440	990	1584000	1.10
3	3	4	110	40000	440	1430	2288000	1.59

Line no	G.E Upper	G.E Lower	Dia mm	Grade of Sewer	Fall m	V_f m/s	Q_f m^3/min	Q/Q_f	V/V_f	V m/s
1	50	49	200	0.005	0.45	0.77	1.55	0.39	0.8	0.62
2	49	48	200	0.0065	0.59	0.85	1.7	0.65	0.93	0.79
3	48	47	200	0.0095	1.05	1.05	2.0	0.8	0.97	1.02

Line no	Inv. E. Upper	Inv. E. Lower
1	47.9	47.45
2	47.45	46.86
3	46.86	45.81

Q.2

- Av. daily d. (160 L/s) — 4

P.h. = 36 + 1.3 * 7.5 = 45.75 m

- Max. daily d. (250 L/s) — 4

P.h. = 36 + 3.0 * 7.5 = 58.5 m

- Peak hourly d. (340 L/s)

P. design on max. daily = 250 L/s

From Storage = 340 − 250 = 90 L/s

H.G.L. at head center = 34 − 0.45 * 2.5 = 32.9 m

P.h = 32.9 + 3 * 7.5 = 55.4 m — 6

- Max. daily d. + Fire flow (530 L/s)

S. Fire flow: $\frac{3500\ m^3}{4}\ \frac{h}{3600\ s}\ \frac{1000\ L}{m^3} = 243$ L/s

H.G.L. at load center = 34 − 2.8 * 2.5 = 27 m

P. rate = 530 − 243 = 287 L/s > 250 L/s

increase pump capacity to 287 L/s, P.h = 27 + 3.9 + 7.5 = 56.3 m — 6

Q.3

Section a-a

a. Demand : $21000 \times 10^{-6} \times 160 + 6.1 = 9.46$ mgd

b. pipes : 1-28" ⇒ Diagram → Q = 10 mgd

c. Deficit = 9.5 - 10 = 0.5 mgd

d. 28" must carry Q = 9.5 mgd with $h_L = 0.00224 V = 3.5$ ft/s ok.

Section b-b

a. $17000 \times 10^{-6} \times 160 + 6.1 = 8.82$ mgd

b. pipes : 2-20" → Q = 2 * 4.6 = 9.2 mgd

2-6" 2 * 0.17 = 0.34 mgd

9.5 mgd

c. Def : 8.8 - 9.5 = -0.7 mgd

d. 20" & 6"s must carry Q = 8.8 mgd ok

Section c-c

a. $17000 \times 10^{-6} \times 160 + 6.1 = 7.22$ mgd

b. 2-18" → Q = 2 * 3.2 = 6.4 mgd

6-6" 6 * 0.17 = 1.0 mgd

7.4 mgd

c. 7.22 - 7.4 = -0.2 mgd

d. 2-18" & 6-6" must carry Q = 7.2 mgd ok

Q.4

a) $Q = 4Bh^{1.522B^{0.026}}$

$30 = 4(2)h^{1.522(2)^{0.026}}$

$h = \left(\frac{15}{4}\right)^{\frac{1}{1.5497}} = 2.35 \text{ ft}$

b)
1. PVC pipe is heated & folded into a smaller dia. at the factory.
2. Pipe must be brushed & cleaned
3. PVC pipe is pulled into sewer.
4. PVC pipe is heated & pressurized to unfold & form to the shape of host pipe.
5. PVC pipe is cooled.
6. Open laterals with robotic machines.

Q.5

a. From Table (5)

$$\frac{57}{152} \quad \frac{x}{2} \Rightarrow x = \frac{57 * 2}{152} = 0.75 \text{ kPa}$$

$$(P_b)_{Table} = 96 + 0.75 = 96.75 \text{ kPa}$$

$$P_b = 96.75 - 3.5 = 93.25 \text{ kPa}$$

Table (6): $X = \frac{3.3 * 2.27}{5.5} = 1.36 \Rightarrow P_v = 7.45 \text{ kPa}$

$$NPSH_{av} = P_b + P_s - \text{losses} - P_v$$

$$= 93.25 + (-P_s) - 20 - 7.45 = 65.8 - P_s$$

$$NPSH_{req.} = 42 = 65.8 - P_s \Rightarrow P_s = 23.8 \text{ kPa}$$

b. C- Valve: used to permit flow in one direction. It opens under the influence of pressure & closes automatically when flow ceases.

Centrifugal pump: contains volute, & impeller, gives high head.

flushing d.: automatic flush tanks, used at upper end of laterals, in sewer system.

Sag pipe: It used to pass the sewer under obstruction, highway or river.

Q.6

a) $A = 6(800) + 4(850) = 8200\ m^2$

$\frac{6(800)}{8200} = 0.585$, $\frac{4(850)}{8200} = 0.415$

$F = 3.7[0.585(1)\sqrt{8200} + 0.415(0.6)\sqrt{8200}] = 279\ l/s$

$< 500\ l/s$
$380\ l/s$

b) W.H : automatically controlled valves
pressure relief valve
vacuum relief valve
Surge Tank & air chamber.

Rational method : It relates flow to rainfall intensity, tributary area & coefficient of runoff, $Q = CIA$.

PPS usefulness: provide information on structural damage, blockages, sediments, large cracks, & location of lateral lines.

Open wells advantages :
Not required sophisticated equipment & skilled personal for construction
Easy operation by man, manual power, simple pumps
Can be modified.