Name: David Maidment

CE 365K Hydraulic Engineering Design **First Exam** **Spring 2013**

There are four questions on this exam. Please do all four questions.

20

1. Hydraulic Engineering as a Profession

(a) Define the term "Profession" and briefly explain what it means to be a "Professional Engineer".

3 A profession is "a vocation founded upon specialized training, the purpose of which is to supply objective counsel and service to others."

7

4 Being a professional civil engineer means being responsible for public safety, for doing sound work, for constantly checking the accuracy and correctness of your work, for upholding ethical standards in dealing with clients and co-workers, for being vigilant in checking for all possible contingencies that might affect your projects.

(b) Hydraulic engineering to deal with stormwater has evolved through the years. Name four goals of hydraulic engineering design over this period.

(i) Stormwater runoff disposal

(ii) Stormwater detention

4

(iii) Water quality control

(iv) low impact development

(c) Hydraulic Engineering can be applied on many spatial scales. Using examples presented in class, briefly describe how hydraulic engineering can be applied at:

Local Scale – a small area within a city

9 To design the inlets from a street & pipe drainage for storm runoff eg Dean Kea

City Scale

To design flood storage & conveyance for a whole city eg Jeddah

National Scale

To assess flood insurance (and flood mapping) across the United States eg for Biggert-Waters Act.

20 **2. Hydraulic Engineering Design**

(a) Define the term "Design"

4 To devise a plan to serve a function

(b) Outline a step by step process by which a hydraulic design can be completed

Representation – describing the study area

Process – how does it operate

6 Evaluation – is the study area working well?

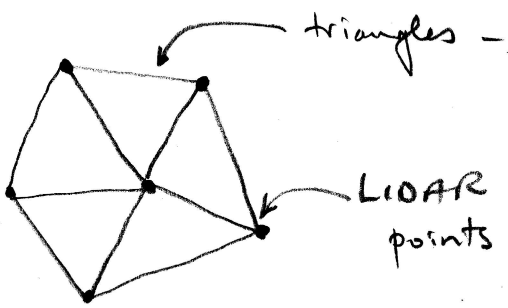
Change – how might the study area be altered?

Impact – what differences would change cause?

Decision – how should the study area be changed?

(c) LIDAR data have been used to extract cross-sections for study of Dean Keaton St. Using a sketch, show how a planar representation of a surface formed from LIDAR data. What is this surface called?

6



Surface is called a Triangulated Irregular Network (TIN).

(d) Define the term "time of concentration" and briefly explain how this concept is used in hydraulic engineering design.

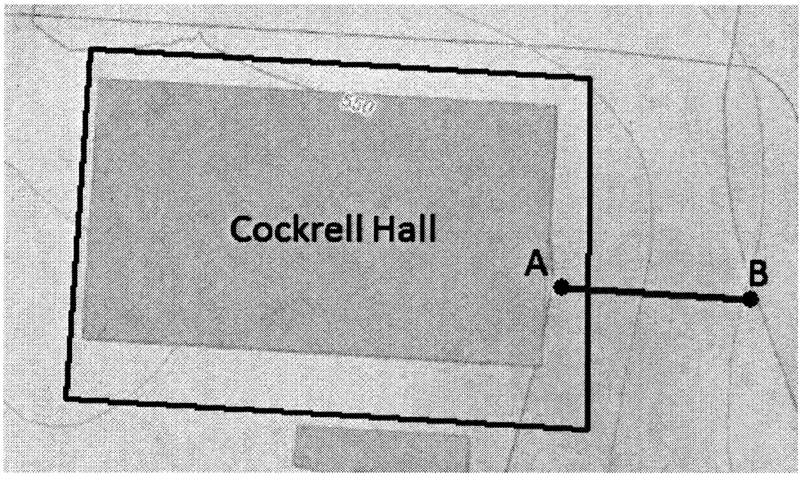
4 Time of concentration – the time taken for water to flow from farthest point of a watershed to outlet

– used to define duration of design storm rainfall from an Intensity-Duration-Frequency curve.

30

3. Storm Drainage from ECJ

Stormwater from Cockrell Hall and its surrounds drains to Waller Creek through pipe AB as shown below. The drainage area at the inlet point A is 46,800 ft^2. The elevation of points A and B are 536.1 ft and 530.8 ft above datum, respectively. The pipe is 95 ft long.



(a) Determine the design discharge (cfs) at point A for a 10 year storm. Make whatever assumptions you feel justified to arrive at this result and state what you have assumed. Some tables of design data are attached at the end of this exam to help you with this calculation. 1 acre = 43,560 ft^2.

area, A = 46,800 / 43560 acres = 1.07 acres

runoff Coeff for concrete, 10yr storm is C = 0.83 (from table at end)

assume t_c = 5 min as for other areas we've studied

10 i = 8.57 inches/hr for return period = 10yrs, duration 5 min (from table at end)

∴ Q = C i A

= 0.83 × 8.57 × 1.07

Q = 7.64 cfs

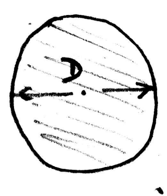
(b) Determine the slope of the pipe AB

3 Slope = $\frac{Z_A - Z_B}{L} = \frac{536.1 - 530.8}{95} = \frac{5.3}{95} = 0.0557$

(c) Beginning with Manning's equation using US units, show that for a pipe flowing full, the diameter is related to the other flow variables as

$$D = 1.33\left(\frac{Qn}{\sqrt{S_o}}\right)^{\frac{3}{8}}$$

For pipe flowing full



$A = \frac{\pi}{4} D^2$

$P = \pi D$

$\therefore R = \frac{A}{P} = \frac{\pi/4\, D^2}{\pi D}$

$R = D/4$

Manning's eqn: $Q = \frac{1.49}{n} A R^{2/3} S_o^{1/2}$

$= \frac{1.49}{n} \frac{\pi}{4} D^2 . \left(\frac{D}{4}\right)^{2/3} S_o^{1/2}$

$\therefore \frac{Qn}{\sqrt{S_o}} = 1.49 . \frac{\pi}{4} . \left(\frac{1}{4}\right)^{2/3} . D^{8/3}$

10

$= 0.4644\, D^{8/3}$

$\therefore D = \left(\frac{1}{0.4644}\right)^{3/8} \left(\frac{Qn}{\sqrt{S_o}}\right)^{3/8}$

$= (2.153)^{3/8} \left(\frac{Qn}{\sqrt{S_o}}\right)^{3/8}$

or $D = 1.33 \left(\frac{Qn}{\sqrt{S_o}}\right)^{3/8}$ as required.

(d) Determine the required diameter for pipe AB. Assume that concrete pipes of diameters 8", 10", 12", 15", 18" and in 3" increments thereafter to 36" are available. Take Manning's "n" = 0.015.

With above eqn, $n = 0.015$, $S_o = 0.0557$ from previous page

$Q = 7.64$ cfs

$\therefore D = 1.33 \left(\frac{7.64 \times 0.015}{\sqrt{0.0557}}\right)^{3/8}$

7

$= 1.33\, (0.4855)^{3/8}$

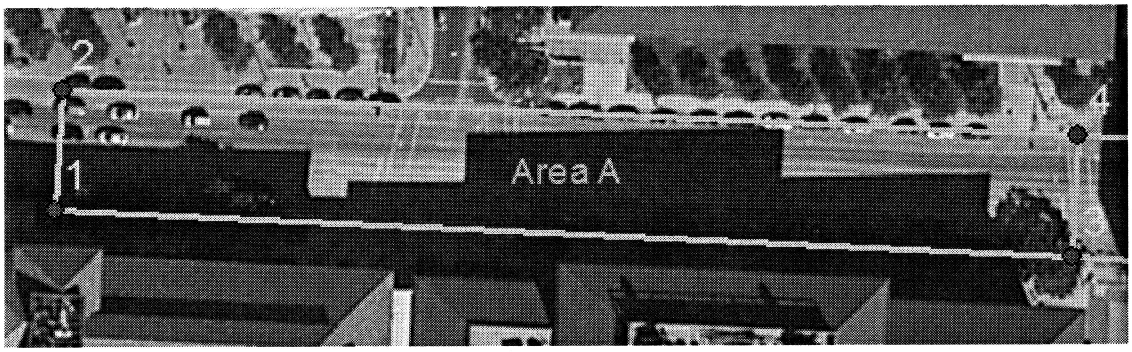
$= 1.014$ ft

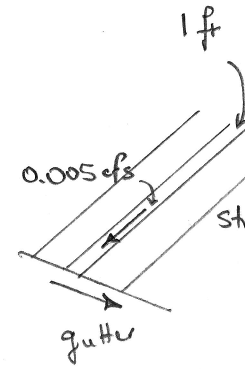
$= 12.17"$

round up to 15" pipe. Actual pipe is 12" in diameter

30 **4. Drainage from a Street**

In the image below, Area A covers Dean Keaton St from the high point near the Student Services Building (CrossSection 12) to the first stormwater inlets on either side of the street (CrossSection 34). The street is 65 f t wide. Take the transverse slope, $S_x = 0.02$ and the longitudinal slope $S_o = 0.05$. The length 13 is 550 ft. Manning's "n" = 0.016. Assume that during the design storm, the flow from the street into the gutter 13 = 0.005 cfs per ft of gutter





(a) Compute the width of the flow (ft) onto the street at Location 3 just upstream of the inlet, and the depth of the flow (in) at that location.

Flow at point 3 = $Q = 550 \times 0.005 = 2.75$ cfs

For flow in the gutter, the top width, T, is given by

$$Q = \frac{0.56}{n} S_x^{5/3} T^{8/3} S_o^{1/2}$$

15

$$\therefore \quad 2.75 = \frac{0.56}{0.016} (0.02)^{5/3} T^{8/3} (0.05)^{1/2}$$

$$= 0.01153 \, T^{8/3}$$

$$\therefore \quad T = \left(\frac{2.75}{0.1153}\right)^{3/8}$$

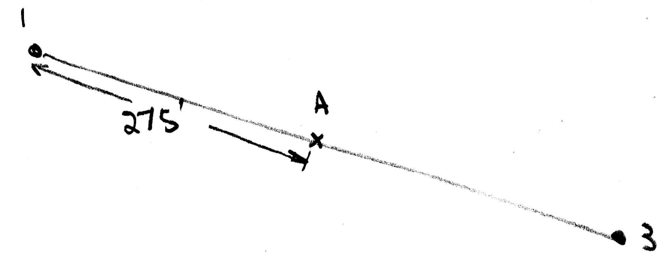
$$T = 7.79 \text{ ft}$$

$$\text{depth } d = 7.79 \times 0.02$$

$$= 0.155 \text{ ft}$$

$$d = 1.9''$$

(b) Suppose a new 10ft inlet was introduced halfway between locations 1 and 3. By how much would the width and depth of flow at location 3 be reduced? Do you think these reductions are sufficiently significant to warrant this additional inlet?



Now 1A = 275' = 550/2

$\therefore Q = 275 \times 0.005 = 1.375\,cfs$

$L_T = 0.6\, Q^{0.42}\, S_o^{0.3} \left(\dfrac{1}{n S_x}\right)^{0.6}$

15 $= 0.6 \times 1.375^{0.42} (0.05)^{0.3} / (0.016 \times 0.02)^{0.6}$

$= 34.9\,ft$

$\therefore E = 1 - (1 - L/L_T)^{1.8}$

$= 1 - (1 - 10/34.9)^{1.8}$

$= 0.455$

$\therefore$ flow into inlet $= 1.375 \times 0.455 = 0.625\,cfs$

$\therefore$ reduced flow at point 3 $= 2.75 - 0.625\,cfs$

$= 2.125\,cfs$

Same method as for previous solution

$Q = 0.01153\, T^{8/3}$

$\therefore 2.125 = 0.01153\, T^{8/3}$

$T = (2.125 / 0.01153)^{3/8} = 7.07\,ft$

$\therefore$ depth $= 7.07 \times 0.02 \times 12'' = 1.7''$

	Width	Depth
Before new inlet	7.8'	1.9
After new inlet	7.1	1.7

} probably not worth the reduction in width to install another inlet

TABLE 2-1
RATIONAL METHOD RUNOFF COEFFICIENTS FOR COMPOSITE ANALYSIS
Runoff Coefficient (C)

Character of Surface	Return Period						
	2 Years	5 Years	10 Years	25 Years	50 Years	100 Years	500 Years
DEVELOPED							
Asphaltic	0.73	0.77	0.81	0.86	0.90	0.95	1.00
Concrete	0.75	0.80	0.83	0.88	0.92	0.97	1.00
Grass Areas (Lawns, Parks, etc.)							
Poor Condition*							
Flat, 0-2%	0.32	0.34	0.37	0.40	0.44	0.47	0.58
Average, 2-7%	0.37	0.40	0.43	0.46	0.49	0.53	0.61
Steep, over 7%	0.40	0.43	0.45	0.49	0.52	0.55	0.62
Fair Condition**							
Flat, 0-2%	0.25	0.28	0.30	0.34	0.37	0.41	0.53
Average, 2-7%	0.33	0.36	0.38	0.42	0.45	0.49	0.58
Steep, over 7%	0.37	0.40	0.42	0.46	0.49	0.53	0.60
Good Condition***							
Flat, 0-2%	0.21	0.23	0.25	0.29	0.32	0.36	0.49
Average, 2-7%	0.29	0.32	0.35	0.39	0.42	0.46	0.56
Steep, over 7%	0.34	0.37	0.40	0.44	0.47	0.51	0.58
UNDEVELOPED							
Cultivated							
Flat, 0-2%	0.31	0.34	0.36	0.40	0.43	0.47	0.57
Average, 2-7%	0.35	0.38	0.41	0.44	0.48	0.51	0.60
Steep, over 7%	0.39	0.42	0.44	0.48	0.51	0.54	0.61
Pasture/Range							
Flat, 0-2%	0.25	0.28	0.30	0.34	0.37	0.41	0.53
Average, 2-7%	0.33	0.36	0.38	0.42	0.45	0.49	0.58
Steep, over 7%	0.37	0.40	0.42	0.46	0.49	0.53	0.60
Forest/Woodlands							
Flat, 0-2%	0.22	0.25	0.28	0.31	0.35	0.39	0.48
Average, 2-7%	0.31	0.34	0.36	0.40	0.43	0.47	0.56
Steep, over 7%	0.35	0.39	0.41	0.45	0.48	0.52	0.58

Table 2-4. Intensity-Duration-Frequency Table for Austin and Travis County
Intensity of Precipitation (inches per hour)

Recurrence Interval (year)	5 min*	15 min	30 min	1-hr	2-hr	3-hr	6-hr	12-hr	24-hr
2	5.76	3.92	2.64	1.72	1.08	0.773	0.445	0.255	0.143
5	7.39	5.04	3.42	2.28	1.45	1.04	0.593	0.339	0.208
10	8.57	5.88	3.96	2.68	1.71	1.24	0.702	0.401	0.254
25	10.1	7.04	4.72	3.28	2.10	1.52	0.857	0.492	0.318
50	11.2	8.04	5.36	3.79	2.44	1.76	0.990	0.572	0.370
100	12.5	9.16	6.08	4.37	2.83	2.04	1.14	0.663	0.424
250	14.5	10.9	7.14	5.26	3.43	2.46	1.37	0.806	0.501
500	15.9	12.4	8.04	6.06	3.97	2.84	1.58	0.934	0.564