CE 365K Homework 4. Solution for Problem 15.1.7

15.1.7

The rainfall intensity is, with return period T = 10 years,

$$i = \frac{120 \times 10^{0.175}}{T_d + 27} = \frac{179.55}{T_d + 27}$$

The ground slopes along each pipe are computed in Table 15.1.7-1.

(1) Pipe	(2) Length (ft)	(3) Upstream ground elevation (ft)	(4) Downstream ground elevation (ft)	(5) Ground slope (ft/ft)
AC	500	504	499	0.0100
BC	600	500	499	0.0017
CD	300	499	485	0.0467
CD	500	485	481	0.008

$$\text{col.}(5) = \frac{\text{col.}(3) - \text{col.}(4)}{\text{col.}(2)}$$

Table 15.1.7-1. Computation of the ground slopes.

The computations of the storm sewer system are arranged in Table 15.1.7-2. For example, for pipe AC, the drainage area is A = 4.2 ac, with runoff coefficient C = 0.6. The time of concentration t_c is equal to the inlet time t_e = 14 min. The rainfall intensity is then, using Eq. (15.1.7-1) with $T_d = t_c$ = 14 min., i = 179.55/(14+27) = 4.38 in/hr as shown in Col. (9) of Table 15.1.7-2. The discharge is given by Eq. (15.1.2) of the textbook, Q = 0.6 x 4.38 x 4.2 in ac/hr = 11.04 cfs. The slope of the sewer is taken equal to the ground slope S_o = 0.01. Then, the pipe diameter is given by Eq. (15.1.6) of the textbook, with n = 0.013:

$$D\ (2.16Qn/\sqrt{S_o})^{3/8} = (2.16 \times 11.04 \times 0.013/\sqrt{0.01})^{3/8}$$

$$= 1.53 \text{ ft} = 18.4 \text{ in.}$$

as shown in Col. (12) of Table 15.1.7-2. The minimum commercial diameter acceptable is D = 21 in. We will use D = 24 in = 2 ft. The velocity in the pipe is $V = 4Q/(\pi D^2) = 4 \times 11.04/(\pi 2^2) = 3.51$ fps which falls in the acceptable range $2 \le v \le 8$ fps. The diameters of the remaining pipes are similarly computed.

(1) Pipe	(2) Length (ft)	(3) Area (acre)	(4) C	(5) CA	(6) ΣCA	(7) t_o (min)	(8) t_c (min)	(9) i (in/h)	(10) Q (cfs)	(11) Slope (ft/ft)	(12) D (ft)	(13) D selected (ft)	(14) V (fps)	(15) t_f (min)
AC	500	4.2	0.6	2.52	2.52	14	14	4.38	11.04	0.01	1.53	2.0	3.51	2.37
BC	600	3.0	0.7	2.10	2.10	10	10	4.85	10.19	0.0017	2.07	2.50	4.91	2.04
CD	300	2.2	0.7	1.54	6.16	12	16.37	4.14	25.50	0.0467	1.57	2.50	5.19	0.96
DE	500	2.2	0.5	1.1	9.96	8	17.33	4.05	40.34	0.008	2.59	3.0	5.71	1.46
		4.5	0.6	2.7		14								

col.(3) = the catchment areas correspond to the upstream inlet of the pipe
col.(6) = Σ col.(5) + Σ (upstream col.(6))
col.(7) = the inlet time corresponds to the upstream inlet of the pipe
col.(8) = max[col.(7), upstream(col.(8) + col.(16))]
col.(9) = 179.5/[col.(8) + 27]
col.(10) = col.(6) x col.(9)
col.(11) = selected slope for pipe

$$\text{col.(12)} = \left(\frac{2.16 \times 0.013 \times \text{col.(10)}}{\sqrt{\text{col.(12)}}}\right)^{3/8}$$

col.(13) = round col.(13) and check $D_{downstream} \geq D_{upstream}$

col.(14) = col.(10)/[π/4 (col.(14))^2] and check $2 \leq$ col.(15) ≤ 8

$$\text{col.(15)} = \frac{\text{col.(2)}}{60 \times \text{col.(15)}}$$

Table 15.1.7-2. Storm Sewer System Design