1

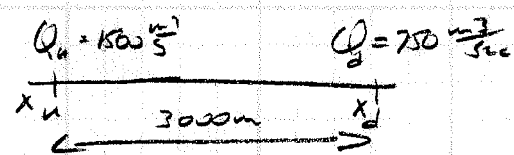
1.4 Given: Riverflow. $Q_u = 1500\,m^3/s$, $Q_d = 750\,m^3/sec$. Uniform channel $b = 300\,m$

$x_d - x_u = 3000\,m$

Find: Find rate of change of water surface elevation in $\frac{m}{hr}$. Rising? Falling?

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = 0$$

$$\frac{\partial A}{\partial t} = -\frac{\partial Q}{\partial x}$$



$$A = by$$

$$\frac{\partial A}{\partial t} = \frac{\partial (by)}{\partial t} = b\frac{\partial y}{\partial t} = -\frac{\partial Q}{\partial x}$$

10

$$\frac{\partial y}{\partial t} = -\frac{1}{b}\frac{\partial Q}{\partial x} = -\frac{1}{b}\,\frac{Q_d - Q_u}{x_d - x_u}$$

$$= -\left(\frac{1}{300\,m}\right)\frac{(750\,m^3/s) - (1500\,m^3/sec)}{3000\,m}\left(\frac{3600\,sec}{hr}\right)$$

$$\boxed{\frac{\partial y}{\partial t} = +3\,\frac{m}{hr}} > 0, \text{ so rising}$$

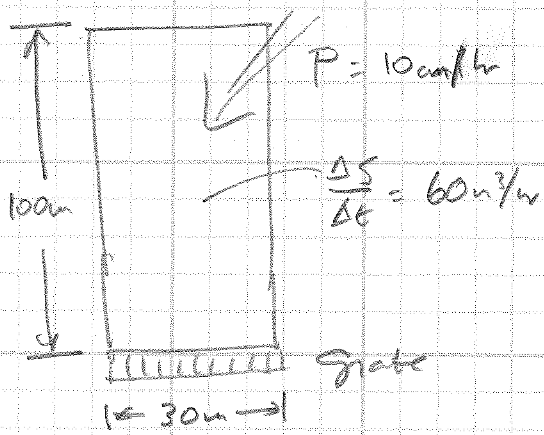
80

0

[1] [1.5] Given: Paved parking lot. Sloped area length of 100m from drainage divide to inlet grate, 30m wide. Rainfall rate P = 10 cm/hr. Detention storage increasing @ 60 m³/hr.

Find: Runoff rate into grate in m³/hr.

10



Water Budget for Lot

$$I - O = \frac{\Delta S}{\Delta t}$$

$$PA - R_{grate} = \frac{\Delta S}{\Delta t}$$

$$R_{grate} = PA - \frac{\Delta S}{\Delta t}$$

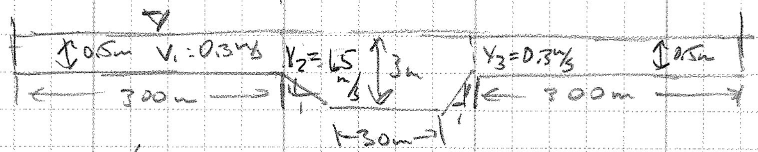
$$= \left(10\frac{cm}{hr}\right)(30m)(100m)\left(\frac{1m}{100cm}\right) - 60\frac{m^3}{hr}$$

$$= 300 - 60\ \frac{m^3}{hr}$$

$$R_{grate} = 240\ \frac{m^3}{hr}$$

$\boxed{4}$ Problem 1.9 **Given:** Symmetric compound channel as shown

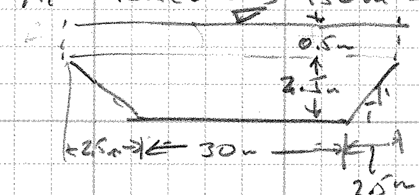
Find: α



$$\alpha = \frac{\int V_s^3 \, dA}{V_s^3 A}$$

$$= \frac{\sum V_{s_i}^3 \, dA_i}{V_s^3 \sum dA_i}$$

$A_1 = 0.5m(300m) = 150m^2 = A_3$



$A_2 = (35m)(0.5m) + \left(\frac{30 + 35m}{2}\right) 2.5m$

$A_2 = 98.75m^2$

$Q_{TOTAL} = \sum V_{s_i} A_i$

$= (0.3 \text{ m/sec})(150m^2) + (1.5 \text{ m/s})(98.75m^2) + (0.3 \text{ m/s})(150m^2)$

$= 238 \text{ m}^3/\text{sec}$

$V_s = \frac{Q_{TOTAL}}{\sum dA_i} = \frac{238 \text{ m}^3/\text{sec}}{2(150m^2) + 98.75m^2}$

$V_s = 0.597 \text{ m/sec}$

$$\alpha = \frac{2(0.3 \text{ m/s})^3(150m^2) + (1.5 \text{ m/s})^3(98.75m^2)}{(0.597 \text{ m/s})^3(398.75m^2)}$$

$\boxed{\alpha = 4.02}$

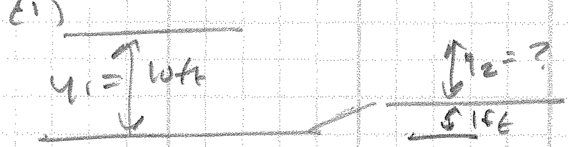
$\boxed{10}$

3) [2.1] Given: Rectangular x-section. $y_1 = 10\,ft$, $V_1 = 10\,fps$. $h_L = 0$

Find: (i) y_2 & Δ(water surface elevation) if $\Delta z = 1\,ft$

(ii) Max Δz_c to prevent choking

(i)



$$y_1 + \frac{V_1^2}{2g} = y_2 + \frac{V_2^2}{2g} + \Delta z$$

$$y_1 + \frac{Q^2}{2g(by_1)^2} = y_2 + \frac{Q^2}{2g(by_2)^2} + \Delta z$$

$$Q = Vby$$

$$q = \frac{Q}{b} = Vy = V_1y_1 = V_2y_2 \quad \text{since } b_1 = b_2$$

$$y_1 + \frac{q^2}{2gy_1^2} = y_2 + \frac{q^2}{2gy_2^2} + \Delta z$$

20 total

$$q = V_1y_1 = (10\,fps)(10\,ft) = 100\,ft^2/s$$

$$(10\,ft) + \frac{(100\,ft^2/s)^2}{2(32.2\,ft/s^2)(10\,ft)^2} = y_2 + \frac{(100\,ft^2/s)^2}{2(32.2\,ft/s^2)y_2^2} + 1\,ft$$

$$10\,ft + 1.55\,ft = y_2 + \frac{155.3}{y_2^2} + 1\,ft$$

$$y_2 + \frac{155.3}{y_2^2} - 10.55 = 0$$

$$y_2^3 - 10.55y_2^2 + 0y_2 + 155.3 = 0$$

Find y_2 by trial-&-error & see if LHS of equation = 0?

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guess y_2	LHS
9.0	29.8
8.0	-7.9
8.5	7.2
8.3	0.30
8.2	-2.7
$\boxed{8.29}$	-0.02 close enough

— 1 root, check others

$y_2 = 8.29$

$$\begin{array}{r} y_2^2 - 2.26y_2 - 18.74 \\ \hline y_2^3 - 10.55y_2^2 + 0y_2 + 155.3 \\ y_2^3 - 8.29y_2^2 \\ \hline -2.26y_2^2 + 0y_2 \\ -2.26y_2^2 + 18.74 \\ \hline -18.74y_2 + 155.3 \\ -18.74y_2 + 155.3 \end{array}$$

quadratic formula

$$y_2 = \frac{+2.26 \pm \sqrt{(2.26)^2 - 4(1)(-18.74)}}{2(1)}$$

$$= +1.13 \pm 4.47$$

$$= 5.60 \text{ or } -3.34$$

$< y_c$ - see next section

$$\boxed{y_2 = 8.29\,ft}$$

$$\Delta \text{ water surface} = y_1 - (y_2 + \Delta z) = 10\,ft - (8.29 + 1\,ft)$$

$$\boxed{\Delta WS = 0.71\,ft}$$

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(ii) Choking begins when $y_2 = y_c$

$$y_c = \left[\frac{q^2}{g}\right]^{1/3} = \left[\frac{(100\,ft^2/s)^2}{32.2\,ft/s^2}\right]^{1/3}$$

$$\underline{y_c = 6.77\,ft} = y_2$$

$$y_1 + \frac{q^2}{2gy_1^2} = y_2 + \frac{q^2}{2gy_2^2} + \Delta z_c$$

$$\Delta z_c = \underset{\text{from (i)}}{11.55\,ft} - \left[(6.77\,ft) + \frac{(100\,ft^2/s)^2}{2(32.2\,ft/s^2)(6.77\,ft)^2}\right]$$

$$= 11.55\,ft - [10.16\,ft]$$

$$\boxed{\Delta z = 1.39\,ft}$$

8

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4 [2.27] Given: Rectangular x-section. $y_1 = 10\,ft$, $V_1 = 10\,fps$, $h_L = 0$
Smooth contraction $b_1 = 10\,ft$, $b_2 = 9\,ft$

Find: (i) y_2 & ΔWS from 1 to 2
(ii) b_2 to prevent choking

20 total

(i)
$$y_1 + \frac{Q^2}{2g(b_1 y_1)^2} = y_2 + \frac{Q^2}{2g(b_2 y_2)^2}$$

$$Q = V_1 b_1 y_1 = (10\,fps)(10\,ft)(10\,ft) = 1000\,cfs$$

$$10\,ft + \frac{(1000\,cfs)^2}{2(32.2\,ft/s^2)[(10\,ft)(10\,ft)]^2} = y_2 + \frac{(1000\,cfs)^2}{2(32.2\,ft/s^2)[(9\,ft)\,y_2]^2}$$

$$11.55\,ft = y_2 + \frac{191.7}{y_2^2}$$

$$y_2^3 - 11.55 y_2^2 + 191.7 = 0$$

Roots - by trial & error or solver in calculator
$+9.36\,ft$, $+5.75\,ft$, $\cancel{-3.57\,ft}$

Check to see if subcritical or supercritical @ y_1

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$$y_{c_1} = \left(\frac{q^2}{g}\right)^{1/3}$$

$$q_1 = \frac{Q}{b_1} = \frac{V_1 b_1 y_1}{b_1} = V_1 y_1$$
$$= (10\,fps)(10\,ft) = 100\,ft^2/sec$$

$$y_{c_1} = \left[\frac{(100\,ft^2/s)^2}{32.2\,ft/s^2}\right]^{1/3} = 6.77\,ft$$

$y_1 > y_{c_1}$, so subcritical

$\rightarrow \boxed{y_2 = 9.36\,ft}$

$$\Delta WS = y_1 - y_2 = 10\,ft - 9.36\,ft$$

$\boxed{\Delta WS = 0.64\,ft}$

(ii) $y_2 = y_c$ at start of choking

$$y_c = \left[\frac{q_2^2}{g}\right]^{1/3} \quad q_2 = \frac{Q}{b_2}, \quad b_2 \text{ unknown}$$

$$E_1 = E_2 = E_c \text{ at choking}$$

$$y_1 + \frac{Q^2}{2g b_1^2 y_1^2} = y_2 + \frac{Q^2}{2g b_2^2 y_2^2} = y_c + \frac{Q^2}{2g b_2^2 y_c^2}$$

This was in the text also

$$E_c = E_{min} = y_c + \frac{Q^2}{2g b_2^2 y_c^2} = y_c + \frac{q_2^2}{2g y_c^2}$$

$$y_c = \left[\frac{q_2^2}{g}\right]^{1/3}$$

$$y_c^3 = \frac{q_2^2}{g} \Rightarrow E_c = y_c + \frac{y_c^3}{2y_c^2} = \frac{3}{2} y_c$$

so $y_c = \frac{2}{3} E_c = \frac{2}{3} E_1$ at choking, no head loss

8

$E_1 = 11.55$ ft from part (i)

$$11.55\text{ft} = E_c = \frac{3}{2} y_c$$

$$y_c = 7.70\text{ft}$$

Now solve for b_2 in $E_c = E_2$

$$11.55\text{ft} = 7.70\text{ft} + \frac{(1000 \text{ cfs})^2}{2(32.2 \text{ ft/s}^2)(b_2^2)(7.70\text{ft})^2}$$

$$3.85\text{ft} = \frac{261.9}{b_2^2}$$

$$b_2 = \left[\frac{261.9}{3.85}\right]^{1/2}$$

$$\boxed{b_2 = 8.25\text{ ft}}$$