TEXAS TECH UNIVERSITY
J. H. MURDOUGH
ASCE STUDENT CHAPTER

NAME ______ DATE ______

COURSE ______ SHEET ____ OF ____

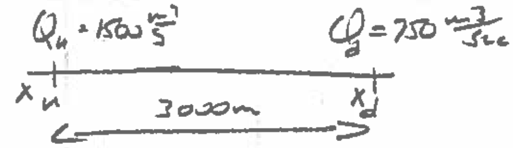
1 1.4 Given: Riverflow. $Q_u = 1500\,m^3/s$, $Q_d = 750\,m^3/sec$. Uniform channel $b = 300\,m$

$x_d - x_u = 3000\,m$

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

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

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

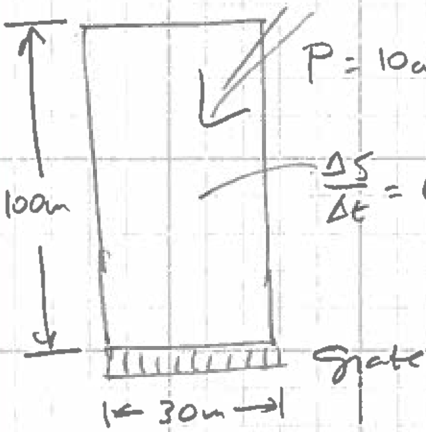
$$\boxed{\frac{\partial y}{\partial t} = +3\,\frac{m}{hr}}$$ > 0, so rising

10

10

1 [1.5] Given: Paved parking lot. Sloped over 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.



Water Budget for Lot

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

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

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

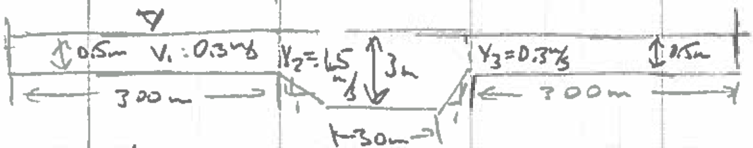
$$= \left(10\frac{cm}{hr}\right)(30m)(100m)\left(\frac{1m}{100cm}\right) - 60\frac{m^3}{hr}$$

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

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

4 Problem 1.9 Given: Symmetric compound channel as shown

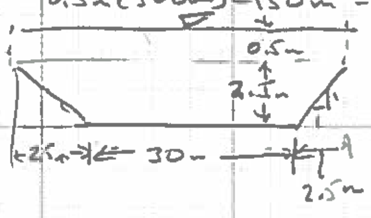
Find: α



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

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

$A_1 = 0.5\text{m}(300\text{m}) = 150\text{m}^2 = A_3$



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

$A_2 = 98.75\text{m}^2$

10

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

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

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

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

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

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

$$\boxed{\alpha = 4.02}$$

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

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

(ii) Max Δz_c to prevent choking

(i)

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

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

$$Q = Vby$$

$$q = \frac{Q}{b} = Vy = V_1 y_1 = V_2 y_2 \quad \text{since } b_1 = b_2$$

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

20 total

$$q = V_1 y_1 = (10\text{ fps})(10\text{ ft}) = 100\text{ ft}^2/\text{s}$$

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

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

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

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

Used Goal Seek in Excel roots 8.29ft, 5.60ft, −3.34ft

14

Check y_1 vs. y_{c_1}

$$y_{c_1} = \left[\frac{q^2}{g}\right]^{1/3} = \left[\frac{(100\text{ ft}^2/\text{sec})^2}{32.2\text{ ft/sec}^2}\right]^{1/3}$$

$y_{c_1} = 6.77$ ft $< y_1$ so y_1 is subcritical

→ y_2 also subcritical

→ $\boxed{y_2 = 8.29\text{ ft}}$

$$\Delta WS = y_1 - (y_2 + \Delta z)$$

$$= 10\text{ft} - (8.29\text{ft} + 1\text{ft})$$

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

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(ii) Choking begins when $y_2 = y_{c_2} = y_{c_1}$ for rect, b = constant

$$y_1 + \frac{q^2}{2g y_1^2} = y_{c_2} + \frac{q^2}{2g y_{c_2}^2} + \Delta z_c$$

b

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

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

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

4 [2.2] Given: Rectangular x-section. $y_1 = 10$ ft, $V = 10$ 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

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

$$Q = V_1 b_1 y_1 = (10 \text{ fps})(10\text{ft})(10\text{ft}) = 1000 \text{ cfs}$$

20 total

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

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

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

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

Check to see if subcritical or supercritical @ y_1

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

12

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

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

$y_1 > y_{c_1}$, so subcritical

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

$$\Delta ws = y_1 - y_2 = 10\text{ft} - 9.36\text{ft}$$

$$\boxed{\Delta ws = 0.64 \text{ ft}}$$

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

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

$E_1 = E_2 = E_c$ 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

$E_1 = 11.55\text{ ft}$ 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 $E_c = E_2$

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

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

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

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

18