



1.4 Given: River flow. $Q_u = 1500 \text{ m}^3/\text{s}$, $Q_d = 750 \text{ m}^3/\text{sec}$. Un. frim channel $b = 300 \text{ m}$
 $x_d - x_u = 300 \text{ m}$

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

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

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

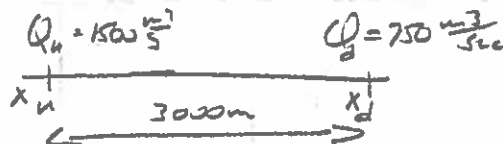
$$A = by$$

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

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

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

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

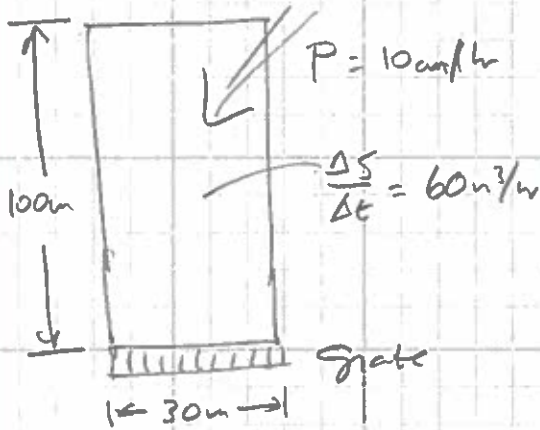


110

0.00



1. [1.5] Given: Paved parking lot. Sloped from length of 100m from drainage divide to inlet grate, 30m wide. Rain-fall rate $P = 10 \text{ cm/hr}$. Detention storage increasing @ $60 \text{ m}^3/\text{hr}$.
Find: Runoff rate into grate in m^3/hr .



Water Budget for Lot

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

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

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

$$= \left(\frac{100\text{m}}{\text{m}} \right) (30\text{m}) \left(\frac{10\text{m}}{1000\text{m}} \right) - 60 \frac{\text{m}^3}{\text{hr}}$$

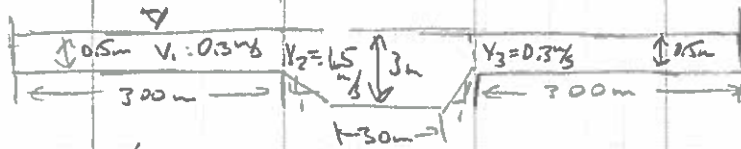
$$= 300 - 60 \frac{\text{m}^3}{\text{hr}}$$

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



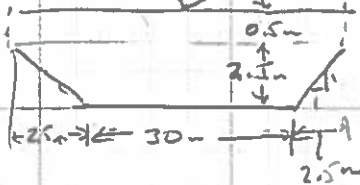
4 Problem 1.9 Given: Symmetric compound channel as shown

Find: α



$$\alpha = \frac{\int V^3 dA}{V_s^3 A} = \frac{\sum V_{si}^3 dA_i}{V_s^3 \sum dA_i}$$

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



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

$$A_2 = 98.75m^2$$

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

$$= (0.3m/s)(150m^2) + (1.5m/s)(98.75m^2) + (0.3m/s)(150m^2)$$
$$= 238m^3/sec$$

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

$$V_s = 0.597m/sec$$

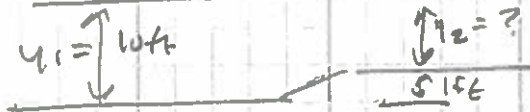
$$\alpha = \frac{2(0.3m/s)^3(150m^2) + (1.5m/s)^3(98.75m^2)}{(0.597m/s)^3(398.75m^2)}$$

$$\alpha = 4.02$$



3 [2.1] Given: Rectangular x-section. $y_1 = 10 \text{ ft}$, $V_1 = 10 \text{ fps}$. $h_L = 0$
Find: (i) Δz & Δ (water surface elevation) if $\Delta z = 1 \text{ ft}$
(ii) Max Δz_c to prevent choking

(i)



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

$$y_1 + \frac{Q^2}{2g(b y_1)^3} = y_2 + \frac{Q^2}{2g(b y_2)^3} + \Delta z$$

$$Q = V b y$$

$$q = \frac{Q}{b} = V y \Rightarrow V_1 y_1 = V_2 y_2 \quad \text{Since } b_1 = b_2$$

$$y_1 + \frac{q^2}{2g y_1^3} = y_2 + \frac{q^2}{2g y_2^3} + \Delta z$$

$$Q = V_1 y_1 = (10 \text{ fps})(10 \text{ ft}) = 100 \text{ ft}^3/\text{s}$$

$$(10 \text{ ft}) + \frac{(100 \text{ ft}^3/\text{s})^2}{2(32.2 \text{ ft}/\text{s}^2)(10 \text{ ft})^3} = y_2 + \frac{(100 \text{ ft}^3/\text{s})^2}{2(32.2 \text{ ft}/\text{s}^2)y_2^3} + 1 \text{ ft}$$

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

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

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

Used Goal Seek in Excel roots 8.24 ft, 5.60 ft, -3.34 ft

Check y_1 vs. y_{c1}

$$y_{c1} = \left[\frac{q^2}{g} \right]^{1/3} = \left[\frac{(100 \text{ ft}^3/\text{s})^2}{32.2 \text{ ft}/\text{s}^2} \right]^{1/3}$$

$$y_{c1} = 6.77 \text{ ft} < y_1, \text{ so } y_1 \text{ is subcritical}$$

$\rightarrow y_2$ also subcritical

$$\rightarrow y_2 = 8.24 \text{ ft}$$

$$\Delta W S = y_1 - (y_2 + \Delta z)$$

$$= 10 \text{ ft} - (8.24 \text{ ft} + 1 \text{ ft})$$

$$\Delta W S = 0.71 \text{ ft}$$

20 total

14



(ii) Choking begins when $y_2 = y_{c2} = y_{c1}$ for rect, $b = \text{constant}$

$$y_1 + \frac{q^2}{2gy_1^2} = y_{c2} + \frac{q^2}{2gy_{c2}} + \Delta z_c$$

$$\Delta z_c = \underset{(i)}{11.55 \text{ ft}} - \left[6.77 \text{ ft} + \frac{(100 \text{ ft}^2/\text{sec})^2}{2(32.2 \text{ ft}/\text{sec}^2) 6.77 \text{ ft}} \right]$$
$$= 11.55 \text{ ft} - 10.16 \text{ ft}$$

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



4[2.2] Given: Rectangular x-section. $y_1 = 10\text{ ft}$, $V = 10\text{ ft/s}$, $h_L = 0$
Smooth contraction $b_1 = 10\text{ ft}$, $b_2 = 9\text{ ft}$

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

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

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

$$10\text{ ft} + \frac{(1000\text{ cfs})^2}{2(32.2\text{ ft/s}^2)(10\text{ ft})^3} = y_2 + \frac{(1000\text{ cfs})^2}{2(32.2\text{ ft/s}^2)(9\text{ ft})^3 y_2^2}$$

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

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

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

$$y_{c1} = \left(\frac{Q^2}{g}\right)^{1/3}$$

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

$$y_{c1} = \left[\frac{(100\text{ ft}^2/\text{s})^2}{32.2\text{ ft/s}^2}\right]^{1/3} = 6.77\text{ ft}$$

$y_1 > y_{c1}$, so subcritical

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

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

$$\Delta W_S = 0.64\text{ ft}$$

20
total

12



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

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

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

$$y_1 + \frac{Q^2}{2gb_1^3 y_1^3} = y_2 + \frac{Q^2}{2gb_2^3 y_2^3} = y_c + \frac{Q^2}{2gb_2^3 y_c^3}$$

This was
in the
text
also

$$E_c = E_{min} = y_c + \frac{Q^2}{2gb_2^3 y_c^3} = y_c + \frac{q^2}{2gy_c^2}$$

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

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

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

$$E_1 = 11.55 \text{ ft from part (i)}$$

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

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

Now solve for b_2 in $E_c = E_2$

$$11.55 \text{ ft} = 7.70 \text{ ft} + \frac{(1000 \text{ cfs})^2}{2(32.2 \text{ ft/s}^2)(b_2^3)(7.70 \text{ ft})^2}$$

$$3.85 \text{ ft} = \frac{261.9}{b_2^3}$$

$$b_2 = \left[\frac{261.9}{3.85} \right]^{1/3}$$

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