20 total

4.12) Given: Trapezoidal channel $Q = 3.75\ m^3/sec$ Lined w/grass
Class C Retardance $S = 0.004$, $b = 2.0\ m$, $m = 3$
Find: Depth of design flow. Is channel stable?

① $VRC = C \rightarrow$ Table 4.4 $\rightarrow \tau_p = 1.00\ psf = 48\ N/m^2$ $\boxed{1}$

② Estimate flow depth $b = 2.0\ m$, $m = 3$

Guess $y_{0_1} = 1.0\ m$

$A_1 = y_{0_1}(b + m y_{0_1}) = 1m(2m + 3(1m)) = 5.0\ m^2$ $\boxed{3}$

$P_1 = b + 2y_{0_1}\sqrt{1+m^2} = 2m + 2(1m)\sqrt{1+3^2} = 8.32\ m$

$R_1 = \frac{A_1}{P_1} = \frac{5.0\ m^2}{8.32\ m} = 0.60\ m$

③ Table 4.4 $\rightarrow MEI = 0.5\ N m^2$, $h_s = 0.2\ m$

$\tau_0 = \gamma R S = (9810\ N/m^3)(0.60\ m)(0.004) = 24\ N/m^2$

$\frac{k}{h_s} = 0.14\left[\frac{(MEI/\tau_0)^{0.25}}{h_s}\right]^{1.59} = 0.14\left[\frac{(0.5\ Nm^2/24\ N/m^2)^{0.25}}{0.2\ m}\right]^{1.59}$

$= 0.39 \Rightarrow k = 0.39(0.2\ m) = 0.078\ m$

$u_* = (gRS)^{1/2} = [(9.81\ m/s^2)(0.60\ m)(0.004)]^{1/2} = 0.15\ m/s$

$u_{*c} = \min[0.028 + 6.33\ MEI^2,\ 0.23\ MEI^{0.106}]$ $\boxed{12}$

$= \min[0.028 + 6.33(0.5\ Nm^2)^2,\ 0.23(0.5\ Nm^2)^{0.106}]$

$= \min[1.61,\ 0.21] = 0.21\ m/s$

$\frac{u_*}{u_{*c}} = \frac{0.15\ m/sec}{0.21\ m/sec} = 0.71 \rightarrow$ Table 4.3 $a = 0.15$, $b = 1.85$

$\frac{n}{k^{1/6}} = \frac{K_n}{\sqrt{8g}}\frac{(R/k)^{1/6}}{(a + b\log R/k)} = \frac{1}{[8(9.81\ m/s^2)]^{1/2}}\frac{(0.60\ m/0.078)^{1/6}}{\left(0.15 + 1.85\log\left(\frac{0.6\ m}{0.078\ m}\right)\right)}$

$= 0.089$

$n = 0.089(0.078)^{1/6} = 0.058$

④ $Q = \frac{K_n}{n} A_1 R_1^{2/3} S_0^{1/2} = \frac{1}{0.058}\frac{A_2^{5/3}}{P_2^{2/3}} S_0^{1/2}$

$3.75\ m^3/s = \frac{1}{0.058}\frac{(y_{0_2}[2m + 3y_0])^{5/3}}{(2m + 2y_{0_2}\sqrt{10})^{2/3}}(0.004)^{1/2}$ $\boxed{3}$

Goal Seek $y_{0_2} = 0.984\ m$

See spreadsheet for next iterations

$\boxed{y_0 = 0.987\ m}$ $\boxed{n = 0.058}$

⑤ $\tau_{max} = \gamma y_0 S = (9810\ N/m^3)(0.987\ m)(0.004) = 38.8\ N/m^2 < \tau_p = 48\ N/m^2$ ✓

$\boxed{\text{Stable}}$ $\boxed{1}$

First trial from first yo guess

b =	2	m	MEI =	0.5	N m
m =	3		h_s =	0.2	m
S_o =	0.004		γ =	9810	N/m^3
n =	0.058		g =	9.81	m/s^2

Q (m^3/s)	y_o (m)	A (m^2)	P (m)	RHS (m^3/s)
3.75	0.984	4.87	8.22	3.75

by Goal Seek

Next trial

y_o (m)	A (m^2)	P (m)	R (m)	τ_o (N/m^2)	k/h_s	k (m)	u_* (m/s)	u_{*c} (m/s)	u_*/u_{*c}	a	b	$n/k^{1/6}$	n	Q (m^3/s)
0.984	4.87	8.22	0.593	23.3	0.393	0.08	0.1525	0.214	0.714	0.15	1.85	0.0892	0.0584	3.73
0.987	4.89	8.24	0.594	23.3	0.393	0.08	0.1527	0.214	0.714	0.15	1.85	0.0891	0.0583	3.75

Last by Goal Seek

4.17 Given: Riprap-lined channel $Q = 1000$ cfs $S_0 = 0.0005$
Crushed rock $b \leq 15$ ft

Find: Riprap size, m, y_0 design depth

20 total

(1) Choose $d_{50} = 100\text{mm} = 10\text{cm}\left(\frac{1\text{ft}}{30.5\text{cm}}\right) = 0.33\text{ft}$

[5] Fig 4.13 $\phi = 41.8°$, $\theta = 23°$, $m = 2.3$

(2) Critical bed & wall shear stresses

$\tau_{0c}(\text{psf}) = 4 d_{50}(\text{ft}) = 4(0.33\text{ft}) = 1.32$ psf

[5] $$K_r = \frac{\tau_{0c}^{w}}{\tau_{0c}} = \left[1 - \frac{\sin^2\theta}{\sin^2\phi}\right]^{1/2} = \left[1 - \frac{\sin^2(23°)}{\sin^2(41.8°)}\right]^{1/2} = 0.81$$

$$\tau_{0c}^{w} = K_r \tau_{0c} = 0.81(1.32\text{psf}) = 1.07\text{psf}$$

[2] (3) $n = 0.04\, d_{50}^{1/6} = 0.04\,(0.33\text{ft})^{1/6} = 0.033$

(4) Find y_0 for given b, Q, S I'll choose $\boxed{b = 12\text{ft},\ m = 2.3}$

$$Q = \frac{K_n}{n} A R^{2/3} S_0^{1/2}$$

[4] $$A R^{2/3} = \frac{A^{5/3}}{P^{2/3}} = \frac{Qn}{K_n S_0^{1/2}}$$

$$\frac{[y_0(b+my_0)]^{5/3}}{[b+2y_0(1+m^2)^{1/2}]^{2/3}} = \frac{[y_0(12\text{ft}+2.3y_0)]^{5/3}}{[12\text{ft}+2y_0(1+2.3^2)^{1/2}]^{2/3}} = \frac{(1000\text{cfs})(0.033)}{(1.49)(0.0005)^{1/2}} = 990$$

using Goal Seek $\boxed{y_0 = 9.5\text{ ft}}$ $R = 5.4$ ft

(5) $(\tau_0)_{max} = 1.5\,\gamma R S = 1.5\,(62.4\,\text{lb/ft}^3)(5.4\text{ft})(0.0005) = 0.25$ psf

$(\tau_0^{w})_{max} = 1.2\,\gamma R S = 1.2\,(62.4\,\text{lb/ft}^3)(5.4\text{ft})(0.0005) = 0.20$ psf

[4] $(\tau_0)_{max} = 0.25\text{psf} < \tau_{0c} = 1.32$ psf ✓

$(\tau_0^{w})_{max} = 0.20\text{psf} < \tau_{0c}^{w} = 1.07$ psf ✓

Channel is stable so ok

Your answers may vary, but procedure should agree

4.19 Given: Rectangular channel. $b = 10\text{ft}$ $n = 0.020$

Find: Slope such that uniform flow will always have $Fr \leq 0.5$

(10)

Limit Slope $S_L = \frac{2.67g}{K_n^2} \frac{n^2}{b^{1/3}}$

$$S_L = \frac{2.67(32.2\text{ft/s}^2)}{1.49^2} \frac{(0.020)^2}{(10\text{ft})^{1/3}}$$

$$S_L = 0.0072$$

$$Fr_{max} = \left[\frac{S_o}{S_L}\right]^{1/2}$$

$$Fr_{max}^2 = \frac{S_o}{S_L}$$

$$S_o = Fr_{max}^2 \, S_L = (0.5)^2(0.0072)$$

$$\boxed{S_o = 0.0018}$$

30 total

4.13 Given: Compound channel shown below

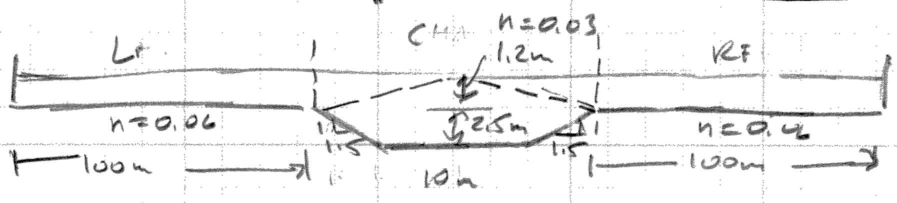
$S_0 = 0.001$, $y_0 = 3.7$ m

Find: Q for uniform flow

(i) vertical interface w/ & w/o P for main channel

(ii) diagonal interface " " " " " " "

this one



(i) With vertical interface included

10

$$\sum Q = Q_L + Q_c + Q_R = 2Q_L + Q_c \quad \text{since } Q_L = Q_R$$

$$Q_{LF} = \frac{1}{0.06} A_L R_L^{2/3} S_0^{1/2}$$

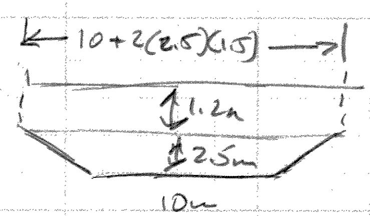
$$A_L = (100m)(1.2m) = 120m^2$$

$$P_L = 100m + 2(1.2m) = 102.4m$$

$$R_L = \frac{120m^2}{102.4m} = 1.17m$$

$$Q_L = \frac{1}{0.06}(120m^2)(1.17m)^{2/3}(0.001)^{1/2}$$

$$Q_L = 70.2\ m^3/sec = Q_R$$



$$B_c = 10m + 2(2.5m)(1.5) = 17.5m$$

$$A_c = (1.2m)(17.5m) + \frac{10m + 17.5m}{2}(2.5m)$$

$$= 21m^2 + 34.4m^2 = 55.4m^2$$

$$P_c = 10m + 2(2.5m)(1+1.5^2)^{1/2} + 2(1.2m) = 19.0m + 2.4m = 21.4m$$

$$R_c = \frac{A_c}{P_c} = \frac{55.4m^2}{21.4m} = 2.59m$$

$$Q_c = \frac{1}{0.03}(55.4m^2)(2.59m)^{2/3}(0.001)^{1/2}$$

$$= 110\ m^3/sec$$

$$\sum Q = 2(70.2m^3/sec) + 110m^3/sec$$

$$\boxed{\sum Q = 250\ m^3/sec}$$

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ASCE STUDENT CHAPTER

NAME ________ DATE ________

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• w/o channel interface P included

A stays same, P changes

$P_L = 100m + 1.2m = 101.2m$

$R_L = \frac{A_L}{P_L} = \frac{120m^2}{101.2m} = 1.19m$

$Q_L = \frac{1}{0.06}(120m^2)(1.19m)^{2/3}(0.001)^{1/2}$

$Q_L = 71\ m^3/sec$

10

$P_c = 21.4m - 2(1.2m) = 19.0m$

$R_c = \frac{A_c}{P_c} = \frac{55.4m^2}{19.0m} = 2.92m$

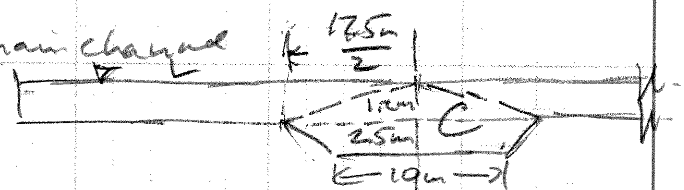
$Q_c = \frac{1}{0.03}(55.4m^2)(2.92m)^{2/3}(0.001)^{1/2}$

$= 119\ m^3/sec$

$\Sigma Q = 2(71\ m^3/sec) + 119\ m^3/sec$

$\boxed{\Sigma Q = 261\ m^3/sec}$

(ii) Diagonal interfaces w/o P for main channel



$A_L = (100m)(1.2m) + \frac{1}{2}(\frac{17.5m}{2})(1.2m)$

$= 125.3m^2$

$P_L = 1.2m + 100m = 101.2m$

$R_L = \frac{A_L}{P_L} = \frac{125.3m^2}{101.2m} = 1.24m$

$Q_L = \frac{1}{0.06}(125.3m^2)(1.24m)^{2/3}(0.001)^{1/2}$

$\boxed{Q_L = 76.2m^3/sec}$

$A_c = 34.4m^2 + \frac{1}{2}(17.5m)(1.2m) = 34.4m^2 + 10.5m^2$

$= 44.9m^2$

$P_c = 19.0m$ as in (i) w/o channel interface P

10

$R_c = \frac{44.9m^2}{19.0m} = 2.36m$

$Q_c = \frac{1}{0.03}(44.9m^2)(2.36m)^{2/3}(0.001)^{1/2}$

$Q_c = 83.9\ m^3/sec$

$\Sigma Q = 2(76.2m^3/sec) + 83.9m^3/sec$

$\boxed{\Sigma Q = 236\ m^3/sec}$