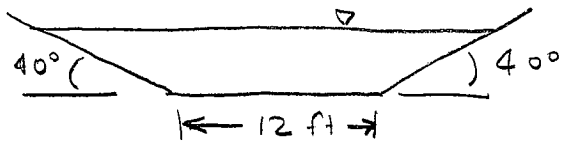
EXAMPLE 10.3

GIVEN: $Q = 10\ m^3/s$
Weedy canal lining, $S_o = 0.0014$

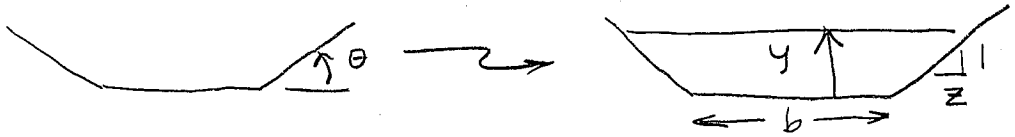


FIND: UNIFORM FLOW DEPTH

SOLUTION:

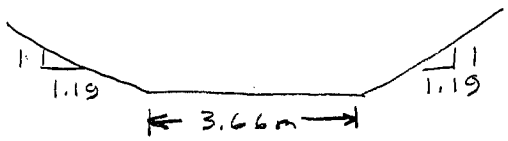
1. use meters: $12\ ft \times \frac{1\ m}{3.28\ ft} = 3.66\ m$

2. convert cross section to standard engineering nomenclature:



from above, $\tan\theta = \frac{1}{z}$ or $z = \cot\theta$

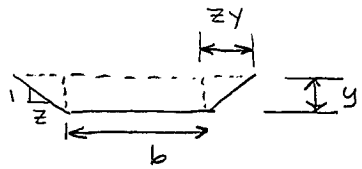
in our problem, $\theta = 40° \Rightarrow z = 1.19$



3. write Manning Equation as a $f(y)$ only:

$$Q = \frac{K}{n} A R^{2/3} S_o^{1/2} \qquad \text{but} \quad R = \frac{A}{P} \quad \text{so}$$

$$Q = \frac{1K}{n} A^{5/3} P^{-2/3} S_o^{1/2} \qquad \text{where}$$



$$A = by + 2\left(\tfrac{1}{2} zy \cdot y\right)$$
$$= y(b + zy)$$
$$P = b + 2\sqrt{y^2 + (zy)^2}$$
$$= b + 2y\sqrt{1 + z^2}$$

$$\Rightarrow \quad Q = \frac{K}{n}\left[y(b+zy)\right]^{5/3}\left[b + 2y\sqrt{1+z^2}\right]^{-2/3} S_o^{1/2}$$

4. use all known values and simplify as much as possible:

$Q = 10\ m^3/s$
$K = 1.0$ (SI)
$n = 0.03$ (Table 10.1)
$b = 3.66\ m$
$z = 1.19$
$S_0 = 0.0014$

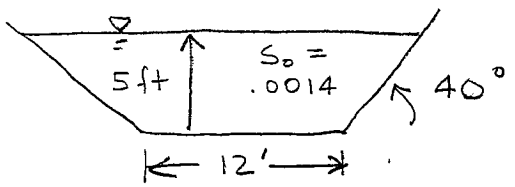
$$\Rightarrow \quad 10 = \frac{1}{0.03}\left[y(3.66 + 1.19y)\right]^{5/3}\left[3.66 + 2y\sqrt{1+(1.19)^2}\right]^{-2/3}(0.0014)^{1/2}$$

$$8.02 = \left[y(3.66 + 1.19y)\right]^{5/3}\left[3.66 + 3.10y\right]^{-2/3}$$

5. solve by trial-and-error or some solver:

y, m	1	2	1.5	1.49
right-hand side	3.88	13.83	8.07	7.97
			↑ OK	

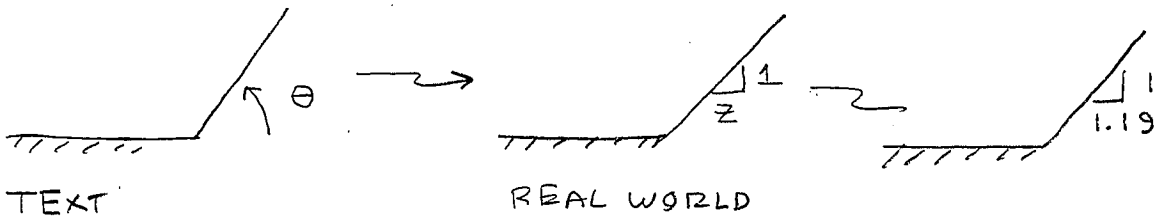
EXAMPLE 10.2 and more



GIVEN: canal as shown with
(a) smooth concrete
(b) weeds
on perimeter

FIND: Q and F_r for each case

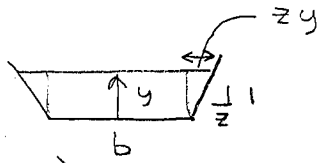
SOLUTION:



$\tan\theta = \frac{1}{z} \Rightarrow \tan^{-1}\frac{1}{z} = \theta \Rightarrow z = \frac{1}{\tan\theta} = 1.19$

Table 10.1: $n_{con} = 0.012$; $n_{weeds} = 0.030$

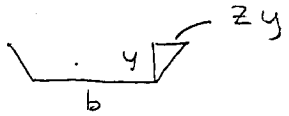
$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$ where



$A = by + \frac{1}{2}(2zy^2)$

$= y(b + zy) = 5(12 + 1.19 \cdot 5)$

$= 89.8\ ft^2$



$P = b + 2\sqrt{y^2 + (zy)^2}$

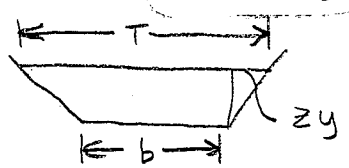
$= b + 2y\sqrt{1 + z^2}$

$= 12 + 2(5)\sqrt{1 + 1.19^2} = 27.5\ ft.$

$R = A/P = 89.8\ ft^2 / 27.5\ ft = 3.26\ ft$

$Q_{conc} = \frac{1.49}{0.012}(89.8\ ft^2)(3.26\ ft)^{2/3}(0.0014)^{1/2} =$ 917 cfs

$Q_{weed} = 917\ cfs \times \left(\frac{0.012}{0.03}\right) =$ 367 cfs



$F_r = \frac{V}{\sqrt{gD}}$ where $D = A/T$,

$T = b + 2zy$

$= 12\ ft + (2)(1.19)(5\ ft)$

$= 23.9\ ft$

$D = 89.8\ ft^2 / 23.9\ ft = 3.75\ ft$

note: text incorrectly uses y

$$V_{concrete} = \frac{Q_{concrete}}{A} = \frac{917\ ft^3/s}{89.8\ ft^2} = 10.2\ ft/s$$

$$V_{weed} = \frac{Q_{weed}}{A} = \frac{367\ ft^3/s}{89.8\ ft^2} = 4.09\ ft/s$$

$$Fr_{concrete} = \frac{V_{concrete}}{\sqrt{gD}} = \frac{10.2\ ft/s}{\sqrt{32.2\ \frac{ft}{s^2} \times 3.75\ ft}} = 0.93$$

$$Fr_{weeds} = \frac{V_{weeds}}{\sqrt{gD}} = \frac{4.09\ ft/s}{\sqrt{32.2\ \frac{ft}{s^2} \times 3.75\ ft}} = 0.37$$