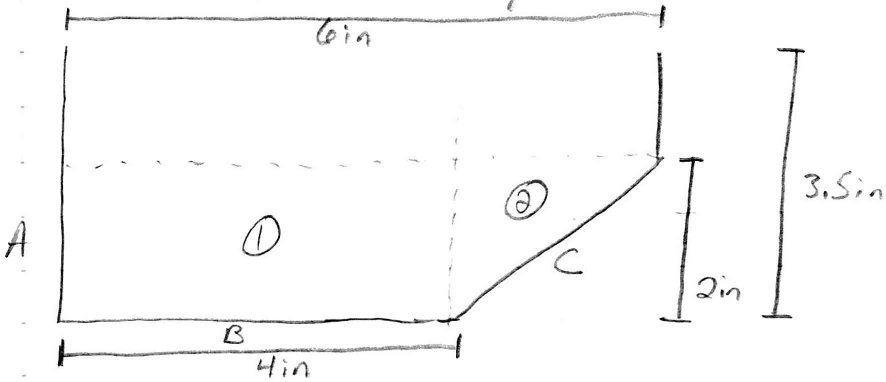
Homework 1.5 Chapter 14 Giant Falcon

14.6. Compute the hydraulic radius for the section shown in figure if water flows at a depth of 2.0in. This is a rain gutter.



We know that $R = \frac{A}{WP}$

So $A = A_1 + A_2 = (2in)(4in) + \frac{1}{2}(2in)(2in)$

$\rightarrow A = 10in^2$

Then $WP = A + B + C$ where $C = \sqrt{2^2 + 2^2} = 2.828in$

$\rightarrow WP = 2in + 4in + 2.828in$

$\rightarrow WP = 8.828in$

Then $R = \frac{10in^2}{8.828in} = \boxed{1.133in}$

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14.21 The flow from two of the troughs described in 14.20 passes into a sump, from which a round common clay drainage tile carries it to a storm sewer. Determine the size of tile required to carry the flow (500 gal/min) when running half full. The slope is 0.1 %.

We know $Q = \frac{1.49}{n} \cdot A S^{1/2} R^{2/3}$ & $R = \frac{A}{WP}$

So A = area of drain $= \frac{\pi D^2}{8}$ & $WP = \frac{\pi D}{2}$

So $R = \frac{\cancel{\pi} D^{\cancel{2}}/8}{\cancel{\pi}\cancel{D}/2} = \frac{D}{4}$

Then $Q = \frac{1.49}{n} A S^{1/2} R^{2/3} \rightarrow AR^{2/3} = \frac{Qn}{1.49 \cdot S^{1/2}}$

So $AR^{2/3} = \frac{\pi D^2}{8}\left(\frac{D}{4}\right)^{2/3} = \frac{\pi D^{8/3}}{20.159} = 0.1558 \cdot D^{8/3}$

From Table 14.1, $n = 0.013$ for common clay drainage tile

So $0.1558 \cdot D^{8/3} = \frac{(500\ \text{gal/min})\left(\frac{35.315\ \text{ft}^3/\text{s}}{15850\ \text{gal/min}}\right)(0.013)}{1.49(0.001)^{1/2}}$

$\rightarrow 0.1558 \cdot D^{8/3} = 0.3074\ \text{ft}^3$

$\rightarrow D^{8/3} = 1.9728\ \text{ft}^3$

$\rightarrow D = 1.290\ \text{ft}$

The common clay drainage tile would need to be $\boxed{1.290\ \text{ft}}$ in diameter.

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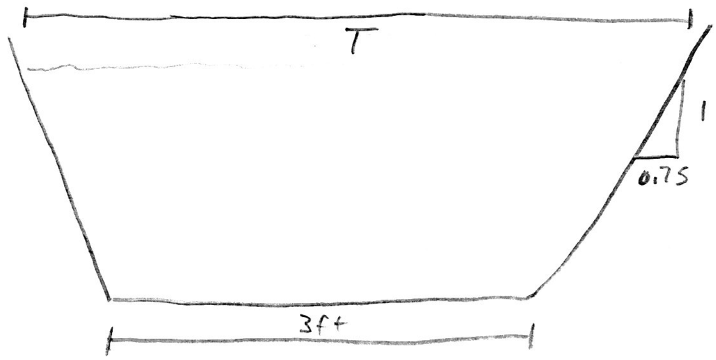
14.42. A trapezoidal channel with a bottom width of 3.0 ft and side slopes having a ratio of 1:0.75 carries 0.80 ft^3/s of water and is made from trowel-finished concrete. a) Calculate the critical depth. b) Calculate the minimum specific energy. c) Plot the specific energy curve. d) Determine the specific energy when $y = 0.05$ ft and the alternate depth for this energy. e) Determine the velocity of flow and the Froude number for each depth in (d). f) Calculate the required slopes of the channel if the depths from (d) are to be normal depths for the given flow rate.



$$A = (b + zy)y$$
$$A = (3ft + (0.75)y_c)y_c$$
$$A = 0.3989 ft^2$$

a) We know critical flow: $\frac{A^3}{T} = \frac{Q^2}{g}$

Table 14.2 gives $T = b + 2zy = 3ft + 2(0.75)y_c$

$A = (b + zy)y = (3ft + (0.75)y_c)y_c$

Then $\frac{(3ft \cdot y_c + 0.75 \cdot y_c^2)^3}{3ft + 1.5ft \cdot y_c} = \frac{(0.80\ ft^3/s)^2}{32.2\ ft/s^2} = 0.019876\ ft^5$

Using Excel to interpolate $\boxed{y_c = 0.12882\ ft}$ (within 0.01%)

b) We know $E_{min} = y_c + \frac{Q^2}{2gA^2} = 0.12882 ft + \frac{(0.80 ft^3/s)^2}{2(32.2 ft/s^2)(0.3989 ft^2)^2}$

$\boxed{E_{min} = 0.1913 ft}$

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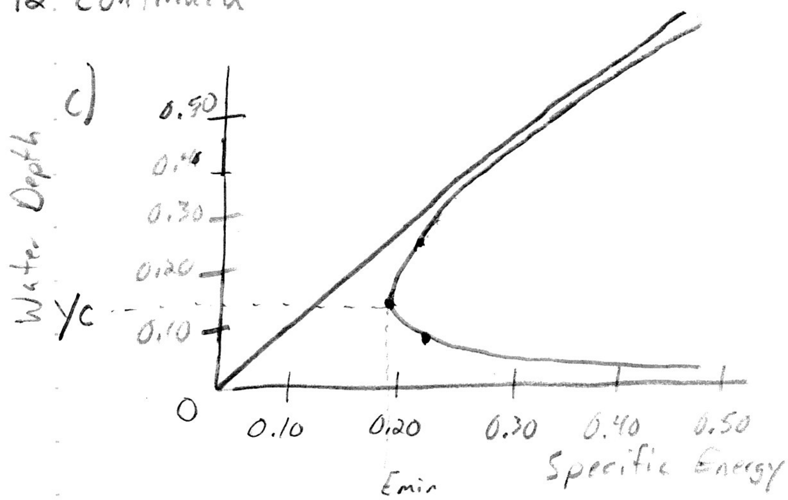
14.42 continued

c)



$y_{h1} = \frac{A}{T} = \frac{0.1519\,ft^2}{3.075\,ft}$

$y_{h1} = 0.0494\,ft$

$y_{h2} = \frac{A}{T} = \frac{0.8694\,ft^2}{3.4071\,ft}$

$y_{h2} = 0.2552\,ft$

d) We know $E = y + \frac{Q^2}{2gA^2} = 0.05\,ft + \frac{(0.80\,ft^3/s)^2}{2(32.2\,ft/s^2)(0.3989\,ft^2)^2}$

$\boxed{E = 0.11245\,ft}$

Alternate depth: $y_2 = \frac{y_1}{2}\left(\sqrt{1+8\cdot N_{F}^2} - 1\right)$

$\rightarrow y_2 = \frac{0.05\,ft}{2}\left(\sqrt{1+8(4.177)^2} - 1\right)$

$\rightarrow \boxed{y_2 = 0.2714\,ft}$

$N_{F1} = \frac{Q/A}{\sqrt{g y_{h1}}} = \frac{(0.80\,ft^3/s)/(3ft + 0.75(0.05ft))(0.05ft)}{\sqrt{(32.2\,ft/s^2)\cdot 0.0494}} = \frac{5.2675\,ft/s}{1.2612} = 4.177$

e) $\boxed{N_{F1} = 4.177}$ $(y_1 = 0.05ft)$ $N_{F2} = \frac{0.9202}{2.86666} = \boxed{0.3210}$

Then $V_1 = \frac{Q}{A_1} = \frac{0.80\,ft^3/s}{(3ft + (0.75)(0.05ft))0.05ft} = \boxed{5.267\,ft/s}$

Then $V_2 = \frac{Q}{A_2} = \frac{0.80\,ft^3/s}{(3ft + (0.75)(0.2714))(0.2714)} = \boxed{0.9202\,ft/s}$

f) We know $R_1 = \frac{A_1}{WP} = \frac{0.1519\,ft^2}{3.125\,ft} = 0.0486\,ft$

$R_2 = \frac{A_2}{WP} = \frac{0.8694\,ft^2}{3.6785} = 0.2363\,ft$

We know $S_1^{1/2} = \frac{Qn}{1.49\cdot A_1 R_1^{2/3}} = \frac{(0.80\,ft^3/s)(0.013)}{(1.49)(0.1519\,ft^2)(0.0486\,ft)^{2/3}} = 0.3450$

$\rightarrow S_1 = (0.3450)^2 = 0.1191 = \boxed{11.91\%}$

$S_2^{1/2} = \frac{(0.80\,ft^3/s)(0.013)}{(1.49)(0.8694\,ft^2)(0.2363\,ft)^{2/3}} = 0.0210 \boxed{= 2.10\%}$