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CV2015 HYDRAULICS 2013-2014 S1

1. $\delta_v = \frac{14.14\,\nu}{V\sqrt{f}}$

$V = \frac{1}{n} R_h^{2/3} S_0^{1/2}$

$= \frac{1}{0.015}\left[\frac{\frac{1}{2}(5+4+4+5)(2)}{5+2\sqrt{5}(2)}\right]^{2/3} 0.001^{1/2}$

$= 2.4993\ m/s$

$n = R_h^{1/6}\sqrt{\frac{f}{8g}}$

$\frac{n}{R_h^{1/6}}\sqrt{8g} = \sqrt{f}$

$f = \frac{n^2(8g)}{R_h^{1/3}}$

$= \frac{0.015^2(8)(9.81)}{\left[\frac{\frac{1}{2}(18)(2)}{5+4\sqrt{5}}\right]^{1/3}}$

$= 0.01621$

$\delta_v = \frac{14.14(10^{-6})}{2.4993\sqrt{0.01621}}$

$= 4.4436\times10^{-5}\ m$

ii Location $= 0.368(2)$

$= 0.736\,m$

iii $Q = VA$

$= 2.4993\left[\frac{1}{2}(18)(2)\right]$

$= 44.987$

$= 45.0\,m^3/s$

iv $Re_n = \frac{VR_h}{\nu} = \frac{2.4993\times\left[\frac{18}{5+4\sqrt{5}}\right]}{10^{-6}}$

$= 3.226\times10^6$ >500 ∴ Turbulent regime

v $n = \frac{R_h^{1/6}}{2\sqrt{8g}\log_{10}\left(\frac{14.8R_h}{e}\right)}$

$\log_{10}\left(\frac{14.8R_h}{e}\right) = \frac{R_h^{1/6}}{2\sqrt{8g}\,n}$

$\frac{14.8R_h}{e} = 10^{\frac{R_h^{1/6}}{2\sqrt{8g}\,n}}$

$e = \frac{14.8R_h}{10^{\frac{R_h^{1/6}}{2\sqrt{8g}\,n}}}$

$R_h = \frac{18}{5+4\sqrt{5}}$

$= 1.29085$

$e = \frac{14.8(1.29085)}{10^{\frac{1.29085^{1/6}}{2\sqrt{8(9.81)}(0.015)}}}$

$= 0.00226$

b $Q = \frac{1}{n}R_h^{2/3}S_0^{1/2}A$

$30 = \frac{1}{0.015}\left[\frac{\frac{1}{2}(5+5+2y_0(2)y_0)}{5+2\sqrt{5}y_0}\right]^{2/3} 0.001^{1/2}\left[\frac{1}{2}(10+4y_0)y_0\right]$

using GC,

$y_0 = 1.6253\ m$

$= 1.63\,m$

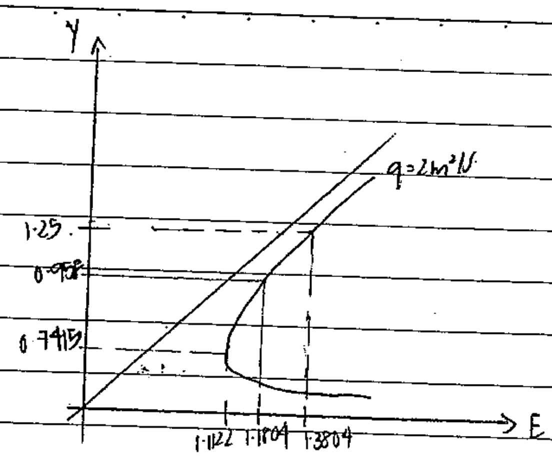
(2)

2a $B = 5m$ $q = 2m^2/s$

$Q = 10m^3/s$

$E_1 = E_2 + \Delta z$

As $\Delta z = 0.2 \neq 0$ $\therefore$ $E_2 < E_1$



b $E_1 = y_1 + \frac{q^2}{2gy_1^2}$

$= 1.25 + \frac{2^2}{2(9.81)(1.25)^2}$

$= 1.3804 m$

$y_c = \sqrt[3]{\frac{q^2}{g}}$

$= \sqrt[3]{\frac{4}{9.81}}$

$= 0.7415 m$

$E_c = 1.5 y_c$

$= 1.1122 m$

$\Delta z_{critical} = 1.3804 - 1.1122$

$= 0.2682 m > 0.2$

$\therefore$ No chocking

$E_2 = E_1 - 0.2$

$= 1.3804 - 0.2$

$= 1.1804 m$

$= y_2 + \frac{q^2}{2gy_2^2}$

$y_2 + \frac{4}{2(9.81)y_2^2} = 1.1804$

$y_2^3 - 1.1804 y_2^2 + 0.20387 = 0$

Using GC,

$y_2 = 0.9584 m$ (take the subcritical flow depth)

c $y_c = 0.7415$ (even though you are asked for y_c in part (c) and not in part (b), you can still proceed to find y_c when doing calculations for part (b). It is always a good practice to do so to find out if chocking occurs or not)

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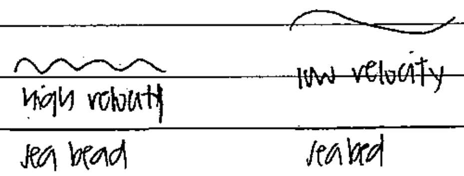
d. $\Delta z_{critical} = 0.2682\,m$

e. No. By increasing Δz, the flow depth will continue to decrease. However when $\Delta z > \Delta z_{critical}$, flow would be critical at station 2 and flow depth continue to remain at y_c when $\Delta z \gg \Delta z_{crit}$. By decreasing Δz such that a depression occurs at section 2, the flow depth will simply continue to increase more and more.

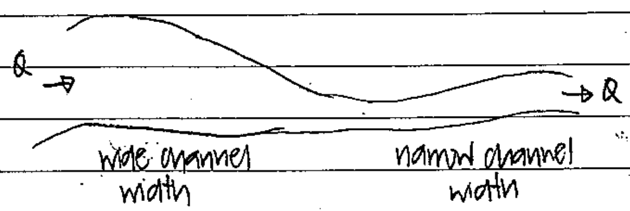
3a) i Local acceleration is how velocity of the particle is changing with respect to time. It refers to the steadiness of the flow

Convective acceleration is how velocity of the particle is changing with distance. It refers to the uniformity of the flow.

ii Local acceleration eg ocean waves

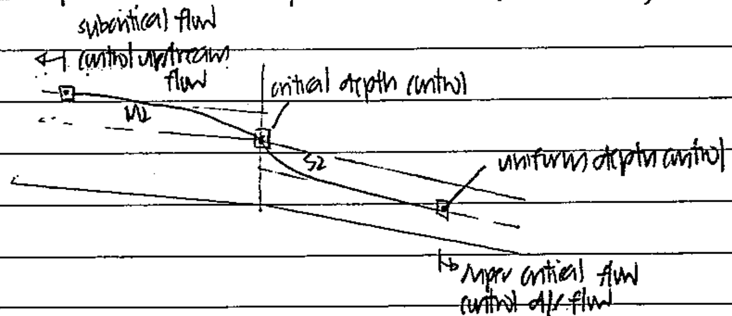


convective acceleration



b) i A control point is defined as any channel feature, whether natural or manmade, that fixes the relationship between flow depth and discharge in its neighbourhood

ii



The critical control point is located at the point where there is a change from subcritical to supercritical flow regime.

(4)

c $F_1 - F_2 - P_f = \rho Q(V_2 - V_1)$

$F_1 + \rho Q V_1 = F_2 + \rho Q V_2$

$\left(\rho g A h_c + \frac{\rho Q^2}{A}\right)_1 = \left(\rho g A h_c + \frac{\rho Q^2}{A}\right)_2$

$(9.81)\left(\frac{1}{2}(4y_1)(y_1)\right)\left(\frac{1}{3}y_1\right) + \frac{28^2}{2y_1^2} = 9.81\left(\frac{1}{2}(12)(3)\right)\left(\frac{1}{3}(3)\right) + \frac{28^2}{18}$

$6.54y_1^3 + \frac{392}{y_1^2} = 220.1355$

$6.54y_1^5 - 220.1355y_1^2 + 392 = 0$

using GC,

$y_1 = 1.3912\,m$

$E_1 = y_1 + \frac{V^2}{2g}$

$= y_1 + \frac{Q^2}{2gA^2}$

$= 1.3912 + \frac{28^2}{2(9.81)\left[\frac{1}{2}(4(1.3912))(1.3912)\right]^2}$

$= 4.058\ m$

$E_2 = 3 + \frac{28^2}{2(9.81)\left[\frac{1}{2}(12)(3)\right]^2}$

$= 3.123$

Power (W) $= \rho g Q \Delta E$

$= (9.81)(10^3)(28)(4.0581 - 3.123)$

$= 256.8\ kW$

$= 257\ kW$

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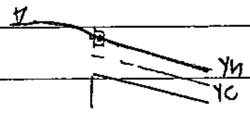
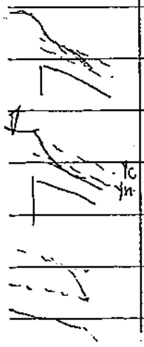
4a) $B = 4m$

$S_0 = 1.5\times10^{-5}$

$n = 0.025$





$V = \frac{1}{n} R_h^{2/3} S_0^{1/2}$

$= \frac{1}{0.025}\left[\frac{3.5(4)}{(3.5)2+4}\right]^{2/3}(1.5\times10^{-5})^{1/2}$

$= 0.1819 \, m/s$

$q = Vy$

$= 0.1819(3.5)$

$= 0.63665 \, m^2/s$

$E = y + \frac{V^2}{2g} - 0.5\frac{V^2}{2g}$

$= y + 0.5\frac{V^2}{2g}$

$= 3.5 + 0.5\frac{(0.1819)^2}{2(9.81)}$

$= 3.50084$

$E = y_n + \frac{q^2}{2gy_n^2}$

$= y_n + \frac{0.63665^2}{2(9.81)y_n^2} = 3.50084$

$y_n^3 - 3.50084y_n^2 + 0.020658 = 0$

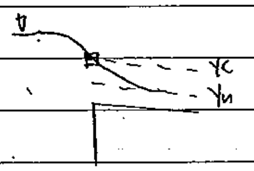
$y_n = 3.499 m$

$= 3.5m$

$Q = 8.91 m^3/s$

ii) when channel slope is mild $y_n > y_c$

iii)



$y_c = 3.5$

$q = \sqrt{gy_c^3}$

$= \sqrt{9.81(3.5^3)}$

$= 20.508 \, m^2/s$

$E = y_c + \frac{V^2}{2g} - 0.5\frac{V^2}{2g}$

$= y_c + 0.5\frac{V^2}{2g}$

$= y_c + 0.5\frac{q^2}{2gy_c^2}$

$E = 3.5 + 0.5\frac{(20.508)^2}{2(9.81)(3.5)^2}$

$= 4.374$

$E = 4.374 = y_n + \frac{20.508^2}{2gy_n^2}$

$y_n^3 - 4.374y_n^2 + 21.436 = 0$

using GC,

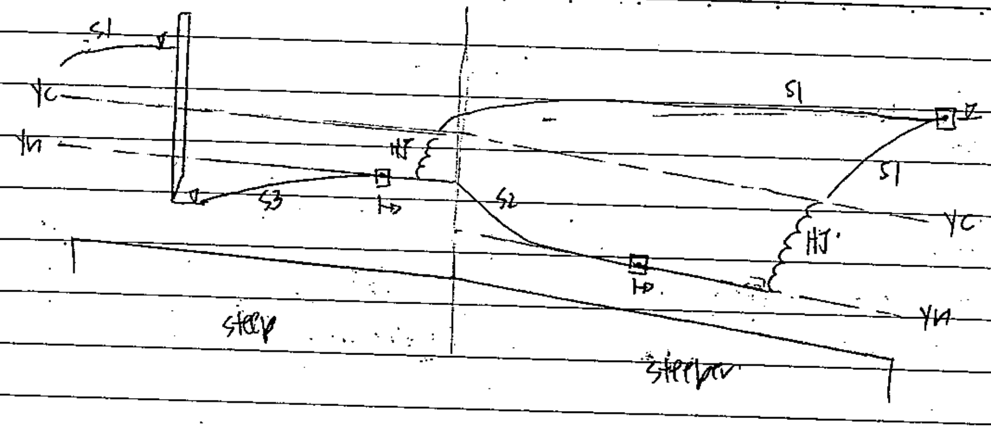
$y_n = -1.855$

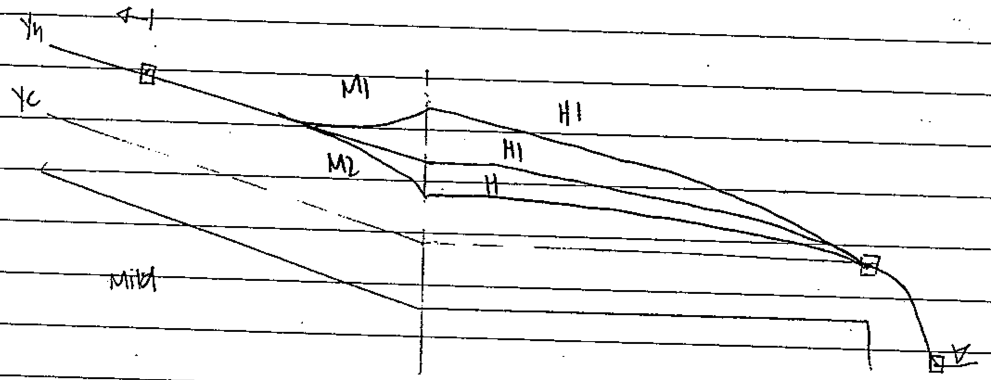
As a negative y_n is not possible

∴ the assumption that the slope is steep is erroneous.

⑥

b.


S1
Yc
Yn
S3
HJ
S2
S1
S1
Yc
HJ'
Yn
steep
steeper


Yn
Yc
M1
M2
H1
H1
H
Mild