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Internal Assessment Test 2 – April 2019

Sub:	Applied Hydraulics				Sub Code:	17CV43	Branch:	CIVIL
Date:	16/04/19	Duration:	90 min's	Max Marks: 50	Sem/Sec:	IV A & B		OBE

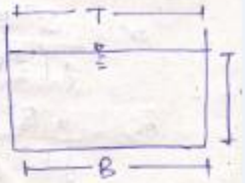
Attempt five full questions

		MARKS	CO	RBT
1	a) Derive expression for critical depth for rectangular section. b) The discharge of water through a rectangular channel of width 8m is 15cumec. When depth of flow of water is 1.2 m, calculate: Specific energy of flowing water, Critical depth and critical velocity, Minimum specific energy.	4 6	CO3	L2
2	Explain type of slope profiles. Write conditions (inequalities) for M2, C1 and S3 water surface profiles. Which water surface profiles do not exist and why?	10	CO4	L3
3	a) What is meant by economical section of a channel? Derive the conditions for the most economical rectangular section. b) Define specific energy and draw specific energy curve.	6 4	CO2, CO3	L1
4	a) For the most economical trapezoidal section show that half of top width is equal to side slope length. b) A trapezoidal channel has side slopes 1H:2V and the slope of bed is 1 in 1500. Area of section is 40 sqm. Find the most economical dimensions of the channel. Also determine discharge of the channel. Take C=50.	5 5	CO2	L1,L2
5	What is gradually varied flow? Derive an expression for gradually varied flow. Also mention the assumptions made for derivation.	10	CO4	L1

CCI CI

Solution:

For Rectangular section:



$$A = By$$
$$T = B$$

critical flow →

$$\frac{Q^2 T}{g A^3} = 1$$

or $\frac{Q^2 \times B}{g (By)^3} = 1$ or $y^3 = \frac{q^2}{g}$

or $\boxed{y_c = \left(\frac{q^2}{g}\right)^{1/3}}$ critical depth for rect. secn.

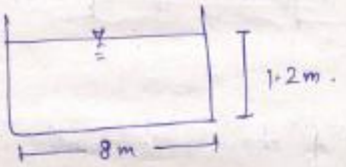
$$E_{min} = y_c + \frac{q^2}{2 g y_c^2}$$
$$= y_c + \left(\frac{q^2}{g}\right) \times \frac{1}{2 y_c^2}$$
$$= y_c + \frac{(y_c)^3}{2 (y_c)^2} = y_c + \frac{y_c}{2}$$

$E_{min} = \frac{3}{2} y_c$ (i.e, $K.E = \frac{1}{2} P.E$)

or $\boxed{y_c = \frac{2}{3} E_{min}}$

1.

soln:



$$q = \frac{Q}{B} = \frac{15}{8} = 1.875 \text{ m}^2/\text{s}$$

i) Specific energy $= y + \frac{q^2}{2 g y^2}$

$$= 1.2 + \frac{(1.875)^2}{2 \times 9.81 \times 1.2^2}$$
$$= 1.324 \text{ m.}$$

(ii) critical depth for rectangular channel:

$$y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{1.875^2}{9.81}\right)^{1/3}$$
$$= 0.71 \text{ m.}$$

critical velocity: $V_c = \sqrt{g D}$

$$= \sqrt{9.81 \times \frac{B y_c}{B}}$$
$$= \sqrt{9.81 \times 0.71}$$
$$= 2.6392 \text{ m/s}$$

(iii) $E_{min} = \frac{3}{2} y_c$ (for rectangular section)

$= \frac{3}{2} \times 0.71$

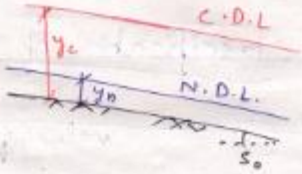
$= 1.065$ m

(1) steep slope

Bed slope is steep when

→ bottom slope S_0 > critical slope S_c

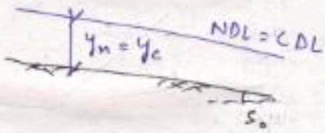
→ $y_n < y_c$ (applying chezy's & manning's)



(2) critical slope

→ $y_n = y_c$

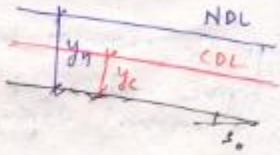
→ $S_0 = S_c$



(3) mild slope

→ $y_n > y_c$

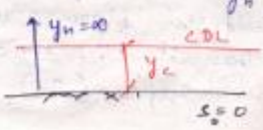
→ $S_0 < S_c$



(4) Horizontal slope

→ $y_n \to \infty$ $\left(\text{as } S_0 = \frac{k}{y_n^x}\right)$

→ $S_0 = 0$



2.

(5) Adverse slope

→ $y_n = -ve$ (imaginary)

→ $S_0 < 0$

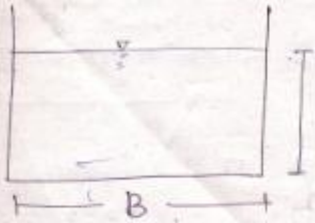
Channel bottom slope instead of falling, rises in direction of flow ⇒ adverse flow.

(∵ zone 2 vanishes in case of critical slope → NDL = CDL)

A_2, A_3 for adverse sloped channel.
H_2, H_3 for horizontal channel.

(∵ for horiz. channels, $y_n = \infty$ &
adverse channels, y_n = imag.)
∴ $y \not> y_c$ & y_n can't be compared.

(*) zone I & zone III are backwater curves &
zone II are drawdown curves.



our aim is to minimiz[e] wetted perime[ter]

ie, $\dfrac{dP}{dy} = 0$

or $\dfrac{d\left(\frac{A}{y}+2y\right)}{dy} =$

$$\left[\begin{aligned} A &= B \cdot y \quad \text{or} \quad B = \frac{A}{y} \\ P &= B + 2y \\ &= \frac{A}{y} + 2y \end{aligned}\right]$$

or $-\dfrac{A}{y^2} + 2 = 0$

or $\dfrac{A}{y^2} = 2$

or $\dfrac{By}{y^2} = 2$

or $B = 2y$

or $\boxed{y = \dfrac{B}{2}}$ condition (1)

Now,

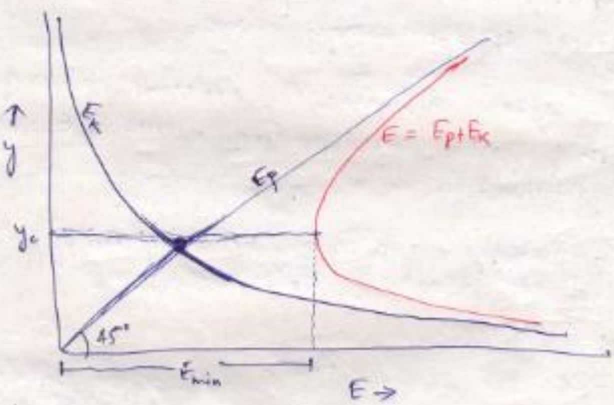
$R = \dfrac{A}{P}$

$= \dfrac{By}{B+2y}$

$= \dfrac{2y^2}{2y+2y}$

or $\boxed{R = \dfrac{y}{2}}$ condition (2)

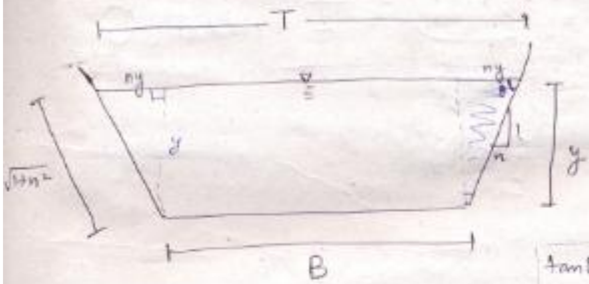
3.



y_c = critical depth of flow
= depth of flow at which specific energy is minimum.

4.

Most efficient trapezoidal section :



$$\tan\theta = \frac{y}{ny} = \frac{1}{n}$$

$$A = \frac{1}{2} \times \left[B + (B+2ny)\right] \times y$$

$$= (B+ny)\,y$$

$$P = B + 2y\sqrt{1+n^2} = \left(\frac{A}{y} - ny\right) + 2y\sqrt{1+n^2}$$

Assuming n = constant : & minimizing perimeter.

$$\frac{dP}{dy} = 0$$

$$-\frac{A}{y^2} - n + 2\sqrt{1+n^2} = 0$$

or $2\sqrt{1+n^2} = \frac{A}{y^2} + n$

or $2\sqrt{1+n^2} = \frac{(B+ny)\,y}{y^2} + n$

or $2y\sqrt{1+n^2} = B + ny + ny$

or $y\sqrt{1+n^2} = \frac{(B+2ny)}{2}$

or $\boxed{\underbrace{y\sqrt{1+n^2}}_{\text{length of sloping side}} = \frac{T}{2}}$ $T \rightarrow$ top width. condition 1

5.

Gradually varied flow:

derivation of dynamic eqn of GVF :-

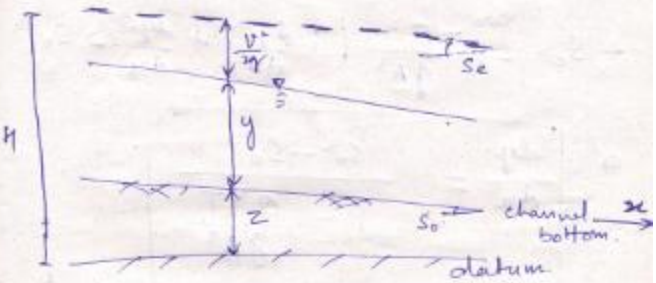
Assumptions:

1. Bed slope of channel is small.
2. steady flow, hence $Q =$ const.
3. channel is prismatic ⇒ channel having same shape of various sections along its length & is laid on constant bottom slope
4. Chezy's & Manning's eqn may be used to calculate slope of energy line.
5. roughness coefficient is independent of depth of flow and is constant throughout channel reach considered.
6. Energy correction factor $\alpha = 1$ ⇒ ideal fluid flow (when $\alpha \neq 1$ ⇒ real flow)
7. pressure distribution in any vertical is hydrostatic.

Energy eq^n at any section :-

$$H = \frac{v^2}{2g} + y + z$$

or $$H = \frac{Q^2}{2gA^2} + y + z \quad \text{--- (1)} \quad \left(v = \frac{Q}{A}\right)$$



differentiating each term of eq(1) w.r.t. x, when x is measured along channel bottom,

$$\frac{dH}{dx} = \frac{d}{dx}\left(\frac{Q^2}{2gA^2}\right) + \frac{dy}{dx} + \frac{dz}{dx}$$

or $$\frac{dH}{dx} = -\frac{Q^2}{gA^3}\frac{dA}{dx} + \frac{dy}{dx} + \frac{dz}{dx} \quad \text{--- (2)}$$

In eq^n (2) : $\frac{dH}{dx}$ = slope of energy line $= -S_e$

$\frac{dy}{dx}$ = slope of water surface w.r.t. channel bottom.

$\frac{dz}{dx}$ = slope of channel bed $= -S_0$

(negative sign ⇒ as x ↑ses, H & z ↓ses)

also, $$\frac{dA}{dx} = \frac{dA}{dy} \times \frac{dy}{dx} = T\frac{dy}{dx}$$

(surface width T)

thus, eq^n (2) becomes :-

$$-S_e = -\frac{Q^2}{gA^3}\left(T\frac{dy}{dx}\right) + \frac{dy}{dx} - S_0$$

or $$\boxed{\frac{dy}{dx} = \frac{S_0 - S_e}{1 - \frac{Q^2 T}{gA^3}}}$$

DYNAMIC EQ^N of GVF

or $$\boxed{\frac{dy}{dx} = \frac{S_0 - S_e}{1 - (F_r)^2}}$$

$\left(\because \frac{Q}{A} = V \;\&\; \frac{A}{T} = D \;\text{so}\; \frac{V^2}{gD} = F_r^2 = \frac{Q^2 T}{gA^3}\right)$