14/09/2020

Design of canal

(Unlined and lined canal)

1) A canal is a course of water (channel) which is well designed and maintained in a 3 degree of freedom, breadth, depth and bed slope

2) Every canal is a channel but every channel is ~~not~~ may not be a canal.

3) The design of an earthen canal was developed by Mr. R.G. Kennedy.

** 4) Mr. kennedy did investigation on upper Bari Doab canal in punjab (now in pakistan)

5) Mr. kennedy developed ~~the~~ his theory called kennedy theory to design an earthen canal which is in regime condition (stable)

6) According to him a canal can be called as regime only when there is neither silting nor scouring in the canal.

** 7) According to Mr. kennedy for regime condition of canal, the velocity of flow of water through canal is called critical velocity which is given by,

$$V_c = 0.55 m D^{0.64}$$

where

V_c = Critical velocity

0.55 = Coefficient

0.64 = Exponent

m = Critical velocity Ratio (CVR) having value

** 0.7 river Indu

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= 1.0 - for North Indian rivers

= 1.3 - for South Indian rivers with boulders.

D = Depth of flow in canal, in 'm'.

Vc = 'm/sec'

8) According to Mr. Kennedy the depth of flow of water should be assumed suitably

9) Mr. kennedy considered only vertical eddies formed due to friction between bed and flow of water, which is only responsible to keep silts in suspension and hence critical velocity is a function of depth only.

10) Mr. kennedy neglected horizontal eddies. Therefore his formula doesnot contain perimeter.

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11) The longitudional bed slope of earthern canal (unlined) is determined by Garrat Diagram, Garrat diagram is based on Mr. Kennedy theory and Mr. kutter theory.

12) Mr. kennedy theory is based on trail and error method which is very tedious.

13) Mr. kennedy took the help of kutters theory to verify his formula to design an earthern canal,

kutter's formula $V_a = C\sqrt{RS}$

and check weather $V_a = V_c$

If not take another trail

14) Mr. Kennedy could not suggest any formula to find longitudinal slope.

15) Mr. Lacy, a brilliant Engineer of uttar pradesh Irrigation department, found draw backs of kennedy theory and he suggested the three types of regime

a) Initial regime
b) Final regime
c) Permanent regime (lined canal Pucca canal)

* 16) Mr. Lacy theory is mainly applicable for final regime only

17) Mr. Lacy theory is not applicable for lined canal (permanent regime, Pucca canal)

* 18) For permanent regime canal, Mr. Manning formula is applicable

**** 19) Mr. Lacy developed * four formulae to design a regime canal as given below.

He made following assumptions.

i) The discharge of water is constant throughout the canal (Q constant)
ii) Silt grade and Silt charge are constant throughout the canal.
iii) The soil is incoherent (alluvial soil)
iv) The silt grade ~~did not~~ need not be of clay size

1) Silt factor

$$f = 1.76\sqrt{d}$$

where d - dia of silt in 'mm'

dimensionless

2) Velocity of flow (unlined canal Earthern canal)

$$V = \left[\frac{Qf^2}{140}\right]^{1/6}$$ m/sec

Q - m^3/sec.

$f = 1.76\sqrt{d}$, d in mm.

$V \propto Q^{1/6}$

$V \propto f^{1/3}$

3) Perimeter:-

$$P = 4.75\sqrt{Q}$$

P - perimeter in m

Q - m^3/sec.

4) Bed Slope:- (unlined canal)

$$S = \frac{f^{5/3}}{3340\, Q^{1/6}}$$

15/09/2010 ~~Numericals~~:-

20 Mr. Lacy Suggested Side slope of earthern canal as 0.5H : 1V

21) Mr. Lacy developed bed slope (Longitudional Slope

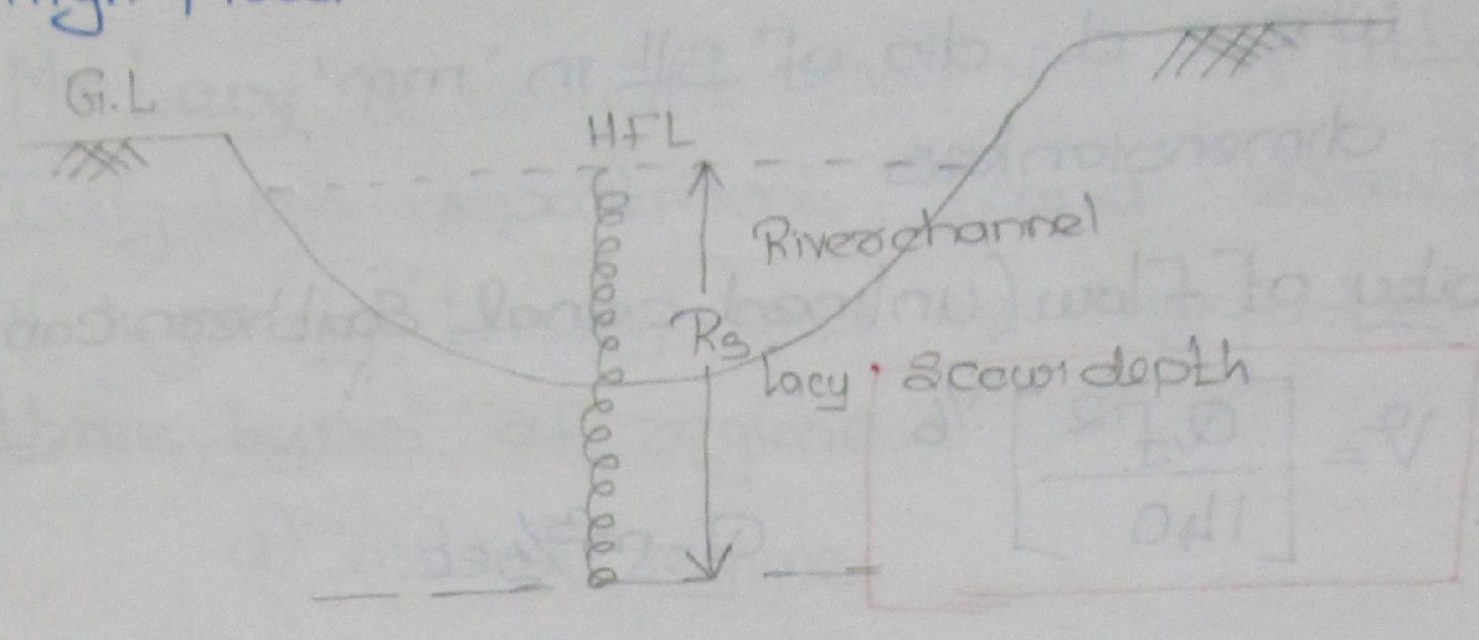
$$V = 10.8 R^{2/3} S^{1/3}$$

$\Rightarrow S = ?$

$V \propto S^{1/3}$ $\Rightarrow$ lacy velocity

$U \propto S^{1/2}$ $\Rightarrow$ Mannings velocity

22) Lacy developed a formula to determine the scour depth in a channel like rivers during high flood below HFL



HFL - high flood Level - River

FSL - Full supply Level - Cannal

$$R_{s(lacy)} = 1.35\left[\frac{q^2}{f}\right]^{1/3}$$

where q - discharge per unit width of channel,

$$q = \frac{Q_{river}}{L.w.w}$$

L.w.w ⇒ Linear water way

$$= 4.75\sqrt{Q}$$

Note:-

In India the Economical span of bridge is equal to Linear waterway given by Mr. Lacy

$$L.W.W = 4.75\sqrt{Q}$$

f = Silt factor $= 1.76\sqrt{d}$ d in mm

23) Mr. Lacy considered vertical eddy as well as horizontal eddy to keep silt in suspension and hence he developed formula for velocity in terms of hydraulic Mean Depth (HMD)

$$HMD = \frac{Area}{Wetted\ perimeter}$$

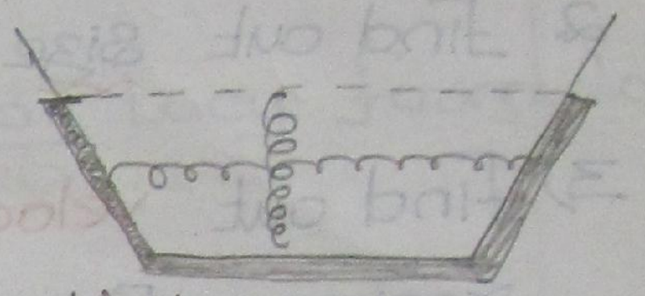
hydraulic depth = $\frac{\text{Area}}{\text{Top width,}}$

$$V = \sqrt{\frac{2}{5} f \times R}$$

where f - Silt factor $= 1.76\sqrt{d}$

R - hydraulic mean depth.

$$= \frac{\text{Wetted Area}}{\text{Wetted perimeter}}$$



24) Mr. Lacy developed a relation between area and velocity,

$$Af^2 = 140v^5$$

$$v \times Af^2 = 140 v^5 . v$$

$$Qf^2 = 140v^6$$

$$V = \left(\frac{Qf^2}{140}\right)^{1/6}$$

25) The relation between perimeter p and discharge is given as below.

$$V = \sqrt{\frac{2}{5} f R}$$

$$V^2 = \frac{2}{5} f R \Rightarrow f = \frac{5}{2}\frac{V^2}{R}$$

$$Af^2 = 140v^5 \qquad R = \frac{A}{P}$$

$$A \times \left(\frac{5}{2}\frac{V^2}{R}\right)^2 = 140v^5 \qquad P = \frac{A}{R}$$

$$\frac{A}{R^2}\left(\frac{5}{2}\right)^2 V^4 = 140v^5$$

$$\frac{A^2}{R^2} \times \frac{25}{4} = 140\, V \times A$$

$$P^2 = \frac{4 \times 140}{25} V \times A \Rightarrow P = \sqrt{22.4Q} = 4.75\sqrt{Q}$$

(4.7328 → 4.75)

$$P = 4.75\sqrt{Q}$$

26) Design steps to design an earthen canal

① Find out design discharge of a canal based on crop requirement and combination of crops

2. Find out size of silt (sediments) in 'mm'

3) Find out velocity of flow of water for final regime of canal.

$$V = \left[\frac{Q f^2}{140}\right]^{1/6}$$

f - Silt factor = $1.76\sqrt{d}$; d in 'mm'

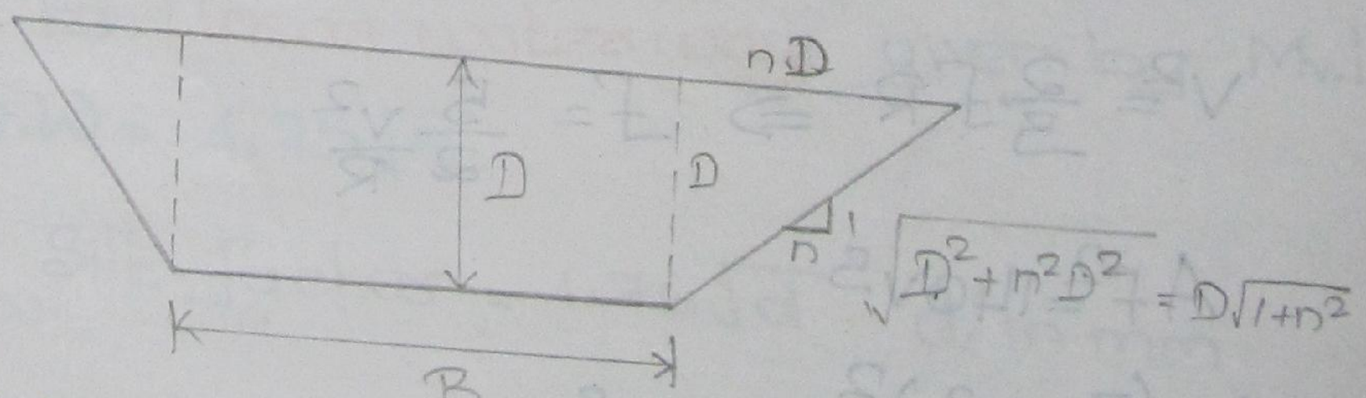
Q - discharge Cumec

V - m/sec

4) Find out c/s area of unlined canal by the relation $A = Q/V$

5) Provide side slope of canal as 0.5H to 1V (as per Lacy)

6) Find out cross sectional area of canal in terms of breadth and depth.



$\sqrt{D^2 + n^2D^2} = D\sqrt{1+n^2}$

V = 1 H = n

V = D H = nD

$$A = B \times D + 2\left[\frac{1}{2} \times nD \times D\right]$$

$$A = BD + nD^2$$

7) Equate both areas,

$$A = BD + nD^2$$

$$\frac{Q}{V} = BD + nD^2$$

$$\frac{Q}{V} = BD + nD^2 \text{ ------ (1)}$$

8) Find out wetted perimeter by Lacy formula

$$P = 4.75\sqrt{Q}$$

9) Find out wetted perimeter interms of breadth and depth.

$$P = D\sqrt{1+n^2} + B + D\sqrt{1+n^2}$$

$$P = B + 2D\sqrt{1+n^2}$$

10) Equate both wetted perimeter,

$$P = B + 2D\sqrt{1+n^2}$$

$$4.75\sqrt{Q} = B + 2D\sqrt{1+n^2} \text{ ------ (2)}$$

11) With the help of above two equations, the width and depth of canal can be determined

12) Findout Longitudinal bed slope of earthern canal by relation

$$S = \frac{f^{5/3}}{3340\, Q^{1/6}} \quad \text{or} \quad V = 10.8\, R^{2/3} S^{1/3}$$

$R = A/P$. $S = ?$

1) Numericals

Determine discharge carrying capacity of an earthern canal having base width 10m and depth of flow 1.5m.

$$P = B + 2D\sqrt{1+n^2}$$

$$4.75\sqrt{Q} = B + 2D\sqrt{1+n^2}$$

$$4.75\sqrt{Q} = 10 + 2\times1.5\sqrt{1+0.5^2}$$

$$Q = 7.9 \text{ Cumec}$$

2) If rate of flow in canal is 100 cumec then what will be the perimeter.

$$P = 4.75\sqrt{Q}$$
$$= 4.75\sqrt{100}$$
$$= 47.5m$$

3) If scour depth of channel carrying discharge 20cumec/m is is 8.5m then what will be the scour depth if discharge 30cumec

$$R_{S_1} = 1.35\left[\frac{Q_1^2}{f}\right]^{1/3}$$

$$8.5 = 1.35\left[\frac{20^2}{f}\right]^{1/3}$$

$$x = 1.35\left[\frac{30^2}{f}\right]^{1/3}$$

$$\frac{8.5}{x} = \left[\frac{20^2}{30^2}\right]^{1/3}$$

$$x = 11.138m$$

4) Determine the size of silt where kennedy C.V.R is 0.9 which is analogous lacy silt factor

$$m = f = 0.9$$
$$f = 1.76\sqrt{d}$$
$$0.9 = 1.76\sqrt{d}$$
$$d = 0.261mm$$

5) Design an earthern canal to irrigate 1×10^5 ha land where I.I is 40% for rice and 80% for rabi. Take outlet factor for rice 7775 hec/cumec. & for rabi 1500 hec/cumec Take capacity factor 0.8, Time factor 10/12

and conveyance losses 15%. Take size of silt 0.03cm

$$Q_{rice} = \frac{\text{Area under rice}}{\text{duty}}$$

$$= \frac{1\times10^5\times0.4}{775}$$

$$= 51.613 \text{ cumec}$$

$$Q_{rubi} = \frac{1\times10^5\times0.8}{1500}$$

$$= 53.33 \text{ cumec}$$

$$Q_{design} = \frac{51.613\times140}{0.8\times\frac{10}{12}\times(1-0.15} \quad \frac{53.33}{0.8\times\frac{10}{12}\times(1-0.15} = 94.11 \text{ cumec}$$

$$V = \left[\frac{Qf^2}{140}\right]^{1/6}$$

$$f = 1.76\sqrt{d} = 1.76\sqrt{\frac{0.03\times10}{100}} = 0.896$$

$$V = \left[\frac{94.11\times0.896^2}{140}\right]^{1/6} = 0.923 \text{ m/sec}$$

$$A = \frac{Q}{V} = \frac{94.11}{0.923} = 101.93 \text{ m}^2$$

$$A = BD + nD^2$$

$$101.93 = BD + 0.5D^2 \text{ ----(1)}$$

$$P = 4.75\sqrt{Q} = 46.08$$

$$P = B + 2D\sqrt{1+n^2}$$

$$46.08 = B + 2D\sqrt{1+0.5^2}$$

$$46.08 = B + \sqrt{5}D \text{ ----(2)}$$

$$101.93 = (46.08 - \sqrt{5}D)D + 0.5D^2$$

$$D = 2.435 \text{ m}$$

$$B = 40.64 \text{ m}$$

Bed slope

$$S = \frac{f^{5/3}}{3340\,Q^{1/6}}$$

$$= \frac{(0.964)^{5/3}}{3340\times(94.11)^{1/6}}$$

$$= 1 \text{ in } 7572$$

Design an earthen canal having longitudional slope 1 in 6000 take $f = 1.0$

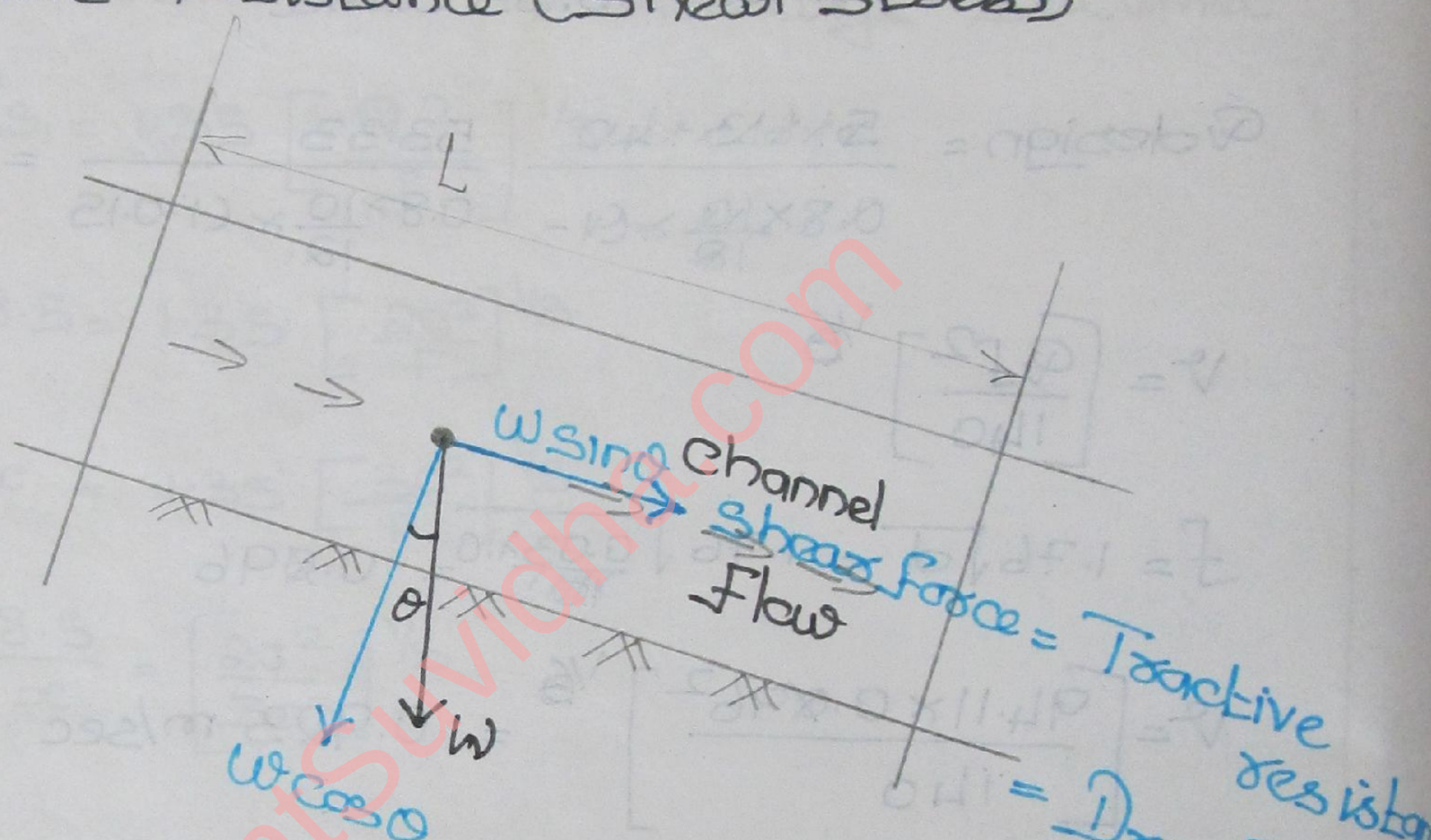
$$S = \frac{f^{5/3}}{3340\, Q^{1/6}}$$

$$\frac{1}{6000} = \frac{(1.0)^{5/3}}{3340\, Q^{1/6}}$$

$Q = 33.606$ cumec

21/09/2010

Tractive Resistance (Shear Stress)



Total weight of water,

$W = \gamma_w \times$ Volume of water

$= \gamma_w \times$ C/S area $\times$ length

$= \gamma_w A \times L$

Drag force / Tractive resistance / shear force

$= W \sin\theta$

$$\text{Shear Stress} = \frac{\text{Drag Force (Shear force)}}{\text{Contact Area}}$$

$$= \frac{W \sin\theta}{(P \times L)}$$

ongitudional

$$\tau = \frac{w \sin\theta}{PL}$$

$$= \frac{\gamma_w A L \sin\theta}{PL}$$

$$= \gamma_w \frac{A}{P} \sin\theta$$

$$= \gamma_w \times R \sin\theta$$

$$= \gamma_w \times R \times \text{bed slope}$$

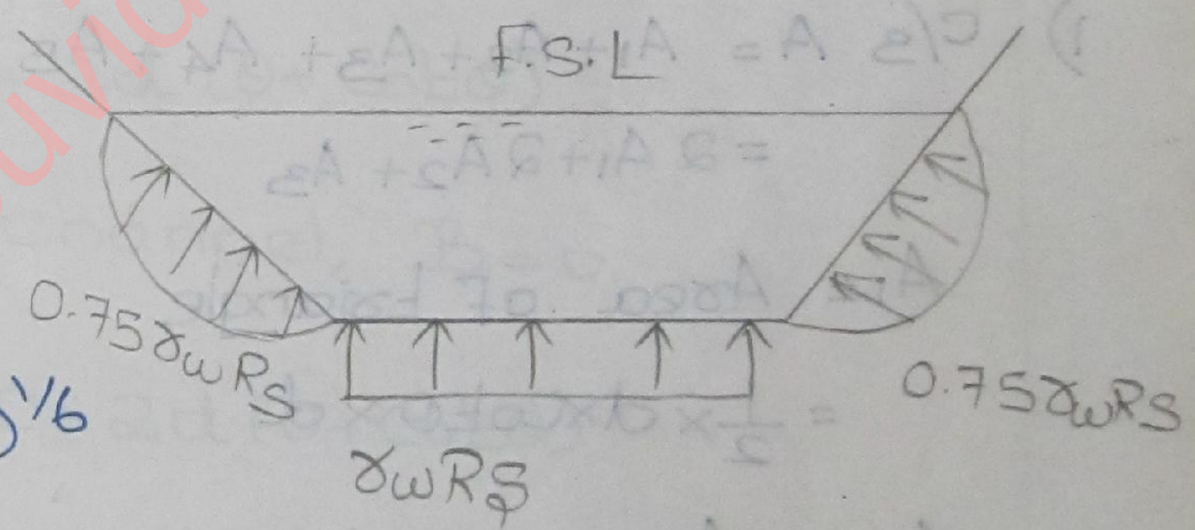
$\tau = \gamma_w R S$
pascal
S - Bed Slope longitudional slope

7) Determine the shear stress on the bed and on the side of a canal carrying discharge 30 cumecs. Take Silt factor 1.

$$Q = \frac{f^{5/3}}{3340 Q^{1/6}}$$

$$= \frac{1^{5/3}}{3340 \times (30)^{1/6}}$$

$$= 1 \text{ in } 5887.5$$



$$V = \left[\frac{Qf^2}{140}\right]^{1/6} = \left[\frac{30 \times 1}{140}\right]^{1/6} = 0.7735$$

$$A = Q/V = \frac{30}{0.7735} = 38.78 m^2$$

$$P = 4.75\sqrt{Q} = 4.75 \times \sqrt{30} = 26.016 m^2$$

$$R = A/P = \frac{38.78}{26.01} = 1.49$$

$$\tau = \gamma_w R S = 1.49 \times 9810 \times \frac{1}{5887.5} = 2.48 Pa$$

bed slope

= Tractive resistance
= Drag force
$w \sin\theta$

/shear force

ss force)