الفرقة الثالثة

هيدروليكا

Part (8)

ch(3): Flow Resistance

Resistance equations:

→ Manning's eqn.

$$V = \frac{1}{n} R^{2/3} S_o^{1/2}$$

V ↓ m/sec

$$V = \frac{1.49}{n} R^{2/3} S_o^{1/2}$$

V ↓ ft/sec

→ chezy eqn.

$$V = C\sqrt{R \cdot S_o}$$

Relation between Manning's (n) & Chezy's (C):

$$V = \frac{1}{n} R^{2/3} S_o^{1/2} = C R^{1/2} S_o^{1/2} \Rightarrow \boxed{C = \frac{1}{n} R^{1/6}}$$

$$V = \frac{1.49}{n} R^{2/3} S_o^{1/2} = C R^{1/2} S_o^{1/2} \Rightarrow \boxed{C = \frac{1.49}{n} R^{1/6}}$$

Relation between Chezy's (C) & Darcy Weisbach frictim factor (f):

$$\boxed{C = \sqrt{\frac{8g}{f}}}$$

f = Darcy Weisbach friction factor

→ average shear stress

$$\boxed{\tau_o = \gamma R S_o}$$

τ_o	γ
N/m^2	$9810\ N/m^3$
kN/m^2	$9.81\ kN/m^3$
Ib/ft^2	$62.4\ Ib/ft^3$

→ Cowan's equation

$$n = (n_o + n_1 + n_2 + n_3 + n_4)\, m_5$$

↓

Manning's n

→ Cole-Brook White eqn.

$$\frac{C}{\sqrt{8g}} = -2 \, Log\left(\frac{k_s}{12R} + \frac{5.13}{R_e^{0.89}}\right)$$

Where:

C = chezy roughness Coeff.

R = hydraulic radius $= \frac{A}{P}$

R_e = Reynold no. $= \frac{V.R}{\nu}$

الارتفاع المتوسط للخشونة

k_s = average roughness height

ν = kinematic viscosity $= 10^{-6}\ m^2/sec$

$= 10^{-5}\ ft^2/sec$

Values for the computation of the roughness coefficient

Channel conditions		Values	
Material involved	Earth	n_0	0.020
	Rock cut		0.025
	Fine gravel		0.024
	Coarse gravel		0.028
Degree of irregularity (عدم انتظام القطاع)	Smooth	n_1	0.000
	Minor		0.005
	Moderate		0.010
	Severe		0.020
Variations of channel cross section	Gradual	n_2	0.000
	Alternating occasionally		0.005
	Alternating frequently		0.010-0.015
Relative effect of obstructions (العوائق)	Negligible	n_3	0.000
	Minor		0.010-0.015
	Appreciable		0.020-0.030
	Severe		0.040-0.060
(الحشائش) Vegetation	Low	n_4	0.005-0.010
	Medium		0.010-0.025
	High		0.025-0.050
	Very high		0.050-0.100
Degree of meandering (التعرجات)	Minor	m_5	1.000
	Appreciable		1.150
	Severe		1.300

* Factors affecting Manning's roughness coeff. (n):

العوامل التي تؤثر على معامل Manning

1 - size and shape of grain material — شكل وحجم حبيبات التربة

2 - Vegetation — الحشائش

3 - channel irregularity — عدم انتظامية القناه

4 - channel alignment — تخطيط القناه

5 - Silting (الاطماء) & Scouring (النحر)

6 - obstructions — العوائق

7 - size & shape of channel — شكل وحجم القناه

$$\underline{Re} = \frac{V \cdot R}{\nu}$$

< 500 laminar طبقي

$500 \rightarrow 2000$ transitional

> 2000 **turbulent** مضطرب

طبيعة سطح القناة

hydrodynamic nature of surface

$R_f = \frac{V_* \cdot K_s}{\nu} < 4$ (smooth)

$4 \rightarrow 100$ (transitional)

> 100 (rough)

$V_* = \sqrt{g \cdot R \cdot S_o}$

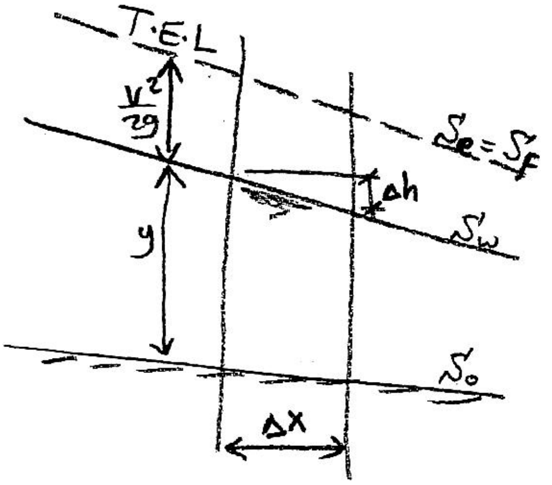
V_* → shear velocity

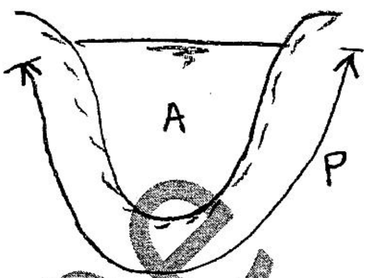
R → $\frac{A}{P}$

$\nu_{water} = 10^{-6}\ m^2/sec$

$= 10^{-5}\ ft^2/sec$

From the first principles, derive Chezy's eqn.





→ total thurst (force) on whole sec. = $\gamma A \Delta h$

→ resisting shear force = $\tau_o . P . \Delta x$

$$- \gamma A \Delta h - \tau_o . P . \Delta x = 0.0$$

$$- \gamma A \Delta h = \tau_o . P . \Delta x$$

$$\tau_o = \frac{- \gamma A \Delta h}{P . \Delta x} \qquad \text{but } \frac{\Delta h}{\Delta x} = - S_w$$

$$\therefore \tau_o = \gamma R S_w$$

For steady uniform flow $S_o = S_w = S_e$

$$\boxed{\tau_o = \gamma R S_o}$$

From Dimensional analysis $\tau_o = a . \rho V^2$ (a → dimensionless no.)

$$\tau_o = a \rho V^2 = \gamma R S_o$$

$$V^2 = \frac{\gamma R S_o}{a \rho} = \frac{g}{a} R S_o$$

$$V = \sqrt{\frac{g}{a}} \sqrt{R S_o} \qquad \text{take } C = \sqrt{\frac{g}{a}}$$

$$\therefore \boxed{V = C \sqrt{R . S_o}}$$

Ex: A rectangular channel 4m wide carries water of 20°c at a depth of 1.5 m is laid on slope 0.0004 Find the hydrodynamic nature of the surface if $K_s = 0.6$ mm Estimate the discharge by using chezy's eqn. with Cole-brook white eqn.

Sol.

$S_o = 0.0004$

$K_s = 0.6$ mm

$y = 1.5$ m

$b = 4$ m

$$R = \frac{A}{P} = \frac{4 \times 1.5}{4 + 2 \times 1.5} = 0.857 \text{ m}$$

$$V_* = \sqrt{g R S_o} = \sqrt{9.81 * 0.857 * 0.0004} = 0.058 \text{ m/sec}$$

$$R_f = \frac{V_* \cdot K_s}{\nu} = \frac{0.058 * \frac{0.6}{1000}}{10^{-6}} = 34.8 \quad > 4, \; < 100$$

(transitional turbulent flow)

$$\# \quad \frac{C}{\sqrt{8g}} = -2 \log \left(\frac{K_s}{12R} + \frac{5.13}{R_e^{0.89}} \right)$$

$$\frac{C}{\sqrt{8 \times 9.81}} = -2 \log \left(\frac{\frac{0.6}{1000}}{12 \times 0.857} \right) \rightarrow C = 75.017$$

$$V = C\sqrt{R \cdot S_o} = 75.017 * \sqrt{0.875 \times 0.0004} = 1.389 \text{ m/sec}$$

$$R_e = \frac{V \cdot R}{\nu} = \frac{1.389 * 0.857}{10^{-6}} = 1.1903 * 10^6$$

$$\frac{C}{\sqrt{8g}} = -2\log\left(\frac{\frac{0.6}{1000}}{12 \times 0.857} + \frac{5.13}{(1.1903 \times 10^{6})^{0.89}}\right)$$

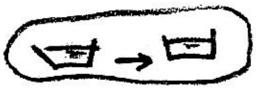
$C = 72.75 \longrightarrow V = 1.347$ m/sec $\qquad Re = 1.1544 \times 10^{6}$

$$\frac{C}{\sqrt{8g}} = -2\log\left(\frac{\frac{0.6}{1000}}{12 \times 0.857} + \frac{5.13}{(1.1544 \times 10^{6})^{0.89}}\right)$$

$C = 72.7 \longrightarrow V = 72.7\sqrt{0.857 \times 0.0004} = 1.346$ m/sec

$Q = A \cdot V = 6 \times 1.346 = \underline{8.076}$ m³/sec

* أفكار مسائل الـ Transition *

← حل مسألة (hump) أو (Contraction) أو تغير في الشكل 

بالمطاليب الآتيه :

- عدم حدوث chocking
- وجود chocking
- تلاشي تأثير الـ Transition على تغير سطح الماء
- توصيل السرعة للـ critical

← عند الحل لتلاشي (eliminate) تأثير الـ Transition على تغير سطح الماء

نلاحظ عند رسم المنحنيات لكل من التغيرات الرأسيه (hump / depression)

والتغيرات الأفقية (contraction / expansion)

نرى أن تأثير الـ hump على تغير سطح الماء هو نفس تأثير الـ contraction

وتأثير الـ depression على تغير سطح الماء هو نفس تأثير الـ expansion ولكنه عكس تأثير الـ hump والـ contraction

ولذا عند وجود أحد الجمل التالية في المسأله

- water level unchanged through the channel
- " " remains constant
- " " " the same