Mannings Nomograph

$$V_c = \frac{1}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$$

hydraulic radius $R = \frac{D}{4}$

$$V_c = \frac{1}{n}\left(\frac{D}{4}\right)^{\frac{2}{3}} S^{\frac{1}{2}}$$

$$Q_D = A \cdot V_c = \frac{\pi}{4} D^2 \cdot \frac{1}{n} \cdot \frac{D^{\frac{2}{3}}}{4^{\frac{2}{3}}} S^{\frac{1}{2}}$$

$$\Rightarrow \quad Q_D = \frac{\pi}{4^{\frac{5}{3}} n} \cdot D^{\frac{8}{3}} S^{\frac{1}{2}} \qquad ①$$

$$Q_v = \frac{4\pi n^3 \cdot v^4}{S^{\frac{3}{2}}} \qquad ②$$

① Diameter lines

② Velocity lines

Colebrook White Nomograph

$$V = -2\sqrt{2gDS}\,\log_e\left[\frac{K}{3.7D} + \frac{2.51\nu}{D\sqrt{2gDS}}\right]$$

$$Q_D = V \cdot A \qquad \sim (D, S)$$

$$= -\frac{\pi\sqrt{g}}{\sqrt{2}} D^{\frac{5}{2}} S^{\frac{1}{2}} \cdot \log\left(\frac{K}{3.7} D^{-\frac{1}{2}} + \frac{2.51\nu}{\sqrt{2g}} S^{-\frac{1}{2}} D^{-\frac{3}{2}}\right) \quad ①$$

— Running Full

If partially full pipes $\quad D = 4R_h = 4\frac{Q}{P_{wetted}}$

hydraulic Radius

$$D = \frac{V^2}{8gS_f\left[\log_{10}\left\{\frac{1.558}{(V^2/2gS_f K_s)^{0.8}} + \frac{15.045}{(V^3/2gS_f\nu)^{0.73}}\right\}\right]^2}$$

approximate equation (civilweb-spreadsheet) ②(1)

$$Q_V = V \cdot \frac{\pi}{4} D^2$$

$$\sim (V, S)$$

To confirm $\log_{10}$ or $\log_e$

Inlet control

— conduit shape

$\frac{Y_h}{2} = \frac{A_p}{2T_p}$ $\parallel$ $H_c = d_c + \boxed{\frac{V_c^2}{2g}}$

① unsubmerged

(1) $$\frac{HW_i}{D} = \frac{H_c}{D} + K\left[\frac{K_u Q}{AD^{0.5}}\right]^M + K_s S \quad ☆$$

K_s: -0.5

(2) $$\frac{HW_i}{D} = K\left[\frac{K_u Q}{AD^{0.5}}\right]^M$$

$K_u = 1.811$ SI

Constants: K, M, c, Y

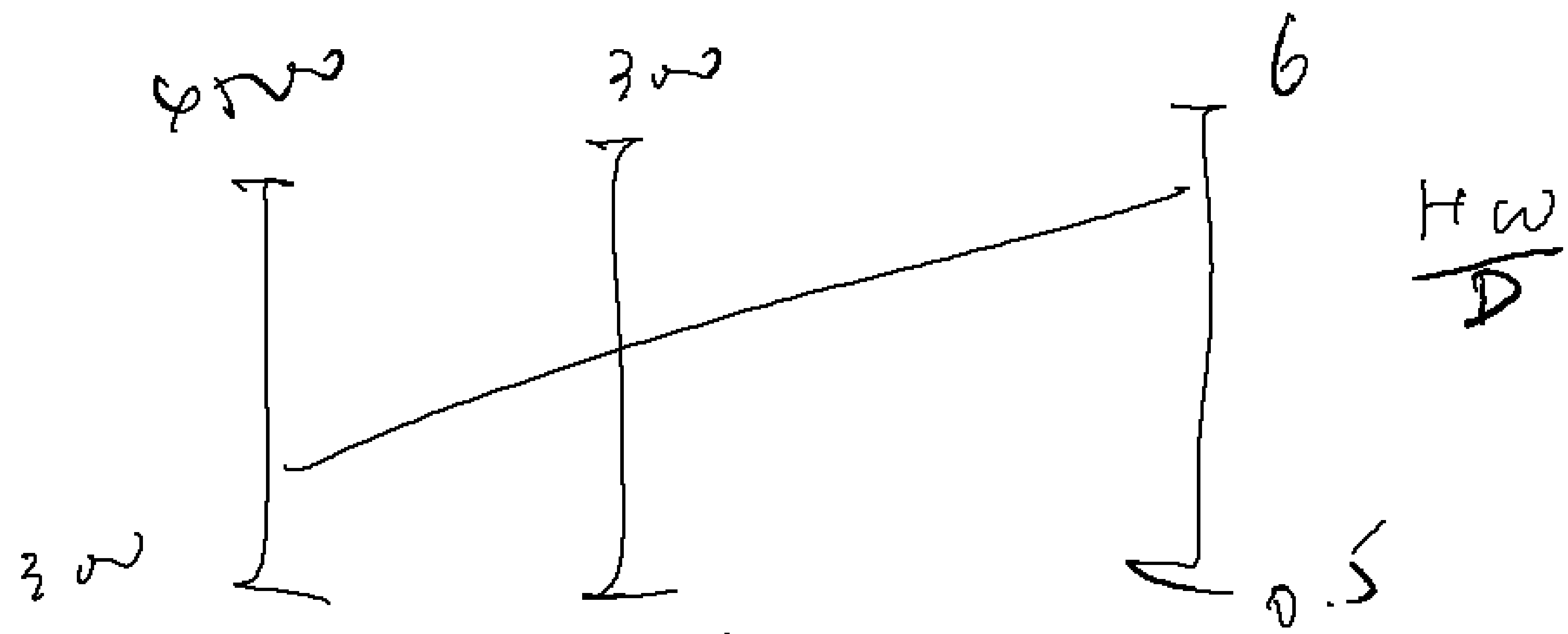
$\frac{Q}{AD^{0.5}} = 3.5$ (1.93 SI)

② Submerged

(3) $$\frac{HW_i}{D} = c\left[\frac{K_u Q}{AD^{0.5}}\right]^2 + Y + K_s S$$

K_s: 0.02

dimensionless $\frac{Q}{AD^{0.5}g^{0.5}}$



D (mm) 0.03 Q (m^3/s)

A2. equ. & Table A.1 constants.

A 2.1 → unsubmerged & submerged equ.

un

$$\frac{HW_i}{D} = \frac{H_c}{D} + 0.0348\left(\frac{Q}{AD^{0.5}}\right)^{1.5} - 0.01.$$

sub

$$\frac{HW_i}{D} = 0.0496 \times \left(\frac{Q}{A \cdot D^{0.5}}\right)^{2} + 0.53 - 0.01$$

$$\frac{H_c}{D} = \frac{d_c}{D} + \frac{Y_h}{2D}$$

Y_h → hydraulic depth

$$\frac{Q_c}{A \cdot D^{0.5}} = \frac{A_p}{A \cdot g^{0.5}\left(\frac{Y_h}{D}\right)^{0.5}}.$$

$$\frac{HW}{D} = c\left(\frac{1.811\,Q}{AD^{0.5}}\right)^{2} + Y - 0.01.$$

$$C_1 x_1^{-5} x_2^{2} - x_3 + C_2 = 0$$

C_1 ↓, x_1 ↓ D, x_2 ↓ Q, x_3 ↓ $\frac{HW}{D}$, C_2 ↓ $Y - 0.01$

5.317c

$$5\log D - 2\log Q + \log\left(\frac{HW}{D} - C_2\right) - \log C_1 = 0$$

$\frac{HW}{D}$ conversion btw 3 types

$$\frac{x_3 - Y + 0.01}{c} = \frac{x_3' - Y' + 0.01}{c'}$$

$$\underline{x_3}' = \frac{c'}{c} (\underline{x_3} - Y + 0.01) + Y' - 0.01$$

$$c (x_3' - Y' + 0.01) = c' (x_3 - Y + 0.01)$$

$$x_3 = \frac{c}{c'} (x_3' - c_2') + c_2$$

Outlet submerged

Flow full

$$H = \left(1 + K_e + \frac{19.63 \cdot n^2 \cdot L}{R^{1.33}}\right) \cdot \left(\frac{V^2}{2g}\right)$$

$$v = \frac{Q}{A}, \quad R = \frac{D}{4} \text{ (full)}$$

$$\Rightarrow \quad H = \left(C_1 + C_2 \frac{L}{D^{1.33}}\right) \frac{4Q^2}{2g\pi D^2}$$

$$\begin{cases} C_1 = 1 + K_e \\ C_2 = 19.63 \times 4^{1.33} \times n^2 \end{cases}$$

$$\Rightarrow$$

$$\log H = \log\left(C_1 + C_2 \frac{L}{D^{1.33}}\right) + 2\log Q - 2\log D + C_3 \quad \left(\log \frac{2}{g\pi}\right) \quad ☆$$