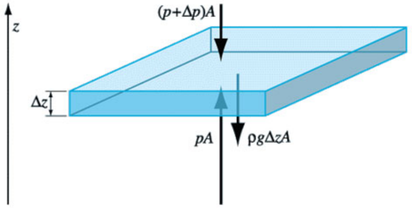
静水圧



$$\Delta p = -\rho g \Delta z$$

$$\frac{dp}{dz} = -\rho g$$

$$\int_{p}^{p_s} dp = -\rho g \int_{-d}^{0} dz$$

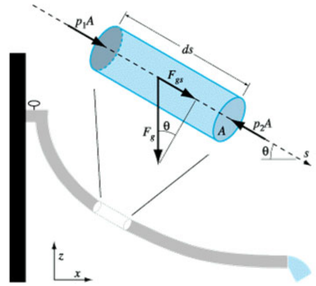
$$p = \rho g d$$

1

ベルヌイの定理

(1) $ma = (\rho ds A)a = \rho ds A u \dfrac{du}{ds}$

$$a = \frac{du}{dt} = \frac{\partial u}{\partial t} + \frac{\partial u}{\partial s}\frac{ds}{dt} = u\frac{du}{ds}$$



(2) $F_p = -\dfrac{dp}{ds} ds A$

(3) $F_{gs} = -\dfrac{dz}{ds} \rho g ds A$

(1)＝(2)＋(3)

$$u\frac{du}{ds} + g\frac{dz}{ds} + \frac{1}{\rho}\frac{dp}{ds} = 0$$

2

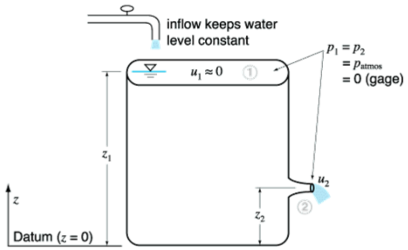
$$\frac{d}{ds}\left(\frac{u^2}{2g} + z + \frac{p}{\rho g}\right) = 0$$

$$u\frac{du}{ds} = \frac{1}{2}\frac{d(u^2)}{ds}$$

$$\boxed{\frac{u^2}{2g} + z + \frac{p}{\rho g} = const.}$$

$\times mg$

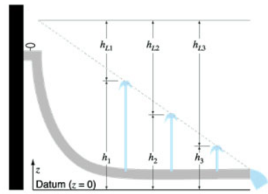
$$\frac{1}{2}mu^2 + mgz + pV = const.$$

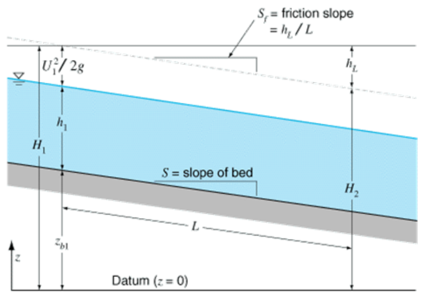


3

ベルヌイの定理の応用

渓流流速





エネルギー損失

$$h_L \equiv f\frac{L}{D}\frac{U^2}{2g}$$

$$U = \sqrt{\frac{h_L}{L}\frac{2gD}{f}} \quad (1)$$

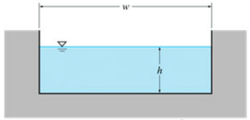
$$\frac{p_1}{\rho g} + z_1 + \frac{u_1^2}{2g} = \frac{p_2}{\rho g} + z_2 + \frac{u_2^2}{2g} + h_L$$

$$\frac{h_L}{L} = \frac{1}{\rho g}\frac{p_1 - p_2}{L} = -\frac{1}{\rho g}\frac{dp}{dx} \quad (2)$$

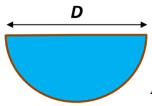
(1)と(2)より $\quad U = \sqrt{-\dfrac{2D}{\rho f}\dfrac{dp}{dx}} \quad (3)$

4

径深R_Hの定義



$R_H \equiv \frac{A}{W} = \frac{wh}{2h+w}$



$R_H = \frac{D}{4}$ (4)

$\frac{h_L}{L} \equiv S$ (5)

:損失エネルギー勾配を河床勾配と等しいと仮定

(3)、(4)、(5)より

$U = \sqrt{S\frac{8gR_H}{f}} = \sqrt{\frac{8g}{f}}\sqrt{SR_H} = C\sqrt{SR_H}$ (6)

:Chézy式

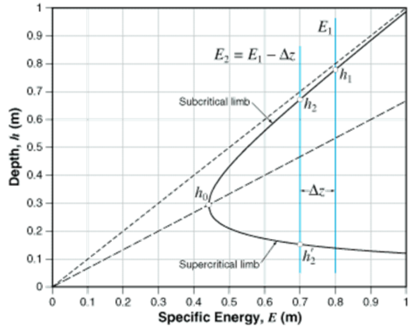
Flamantの提案 $C = \frac{R_H^{\frac{1}{6}}}{n}$ を(6)に代入

n:粗度の関数（自然渓流で0.024～0.075）

$U = \frac{R_H^{\frac{1}{6}}}{n} S^{\frac{1}{2}} R_H^{\frac{1}{2}} = \frac{1}{n} R_H^{\frac{2}{3}} S^{\frac{1}{2}}$ (7) :Manning式

水位－流量関係

$E = h + \frac{u^2}{2g}$ を考える



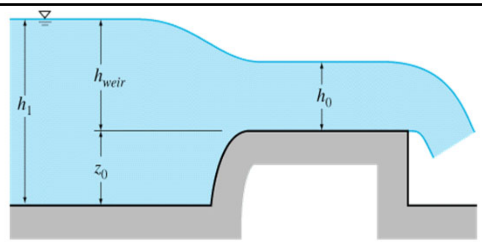
$q = uh$ として $E = h + \frac{q^2}{2gh^2}$

$\left.\frac{dE}{dh}\right|_{h=h_0} = 1 - \frac{q^2}{gh_0^3} = 1 - \frac{u^2}{gh_0} = 0$

$\frac{u}{\sqrt{gh_0}} = F$:フルード数 を考える

$F > 1$ **射流**

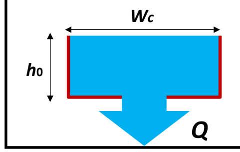
$F < 1$ **常流**



$h_1 + \frac{u_1^2}{2g} = z_0 + h_0 + \frac{u_0^2}{2g}$

$F = 1$ 射流-常流転換点なら流速が水位の関数になる

$z_0 + h_w + \frac{u_1^2}{2g} = z_0 + h_0 + \frac{u_0^2}{2g}$、 $h_0 = \frac{u_0^2}{g}$ より $h_w = \frac{3u_0^2}{2g}$



$h_0 = \frac{2}{3}h_w$ であるから

$Q = u_0 h_0 w_c = \left(\frac{8}{27}g\right)^{\frac{1}{2}} h_w^{\frac{3}{2}} w_c$