MOST EFFICIENT CROSSECTION/BEST

HYDRAULIC SECTION OF AN OPEN CHANNEL

Definition: Maximum rate of discharge for a given crossection.

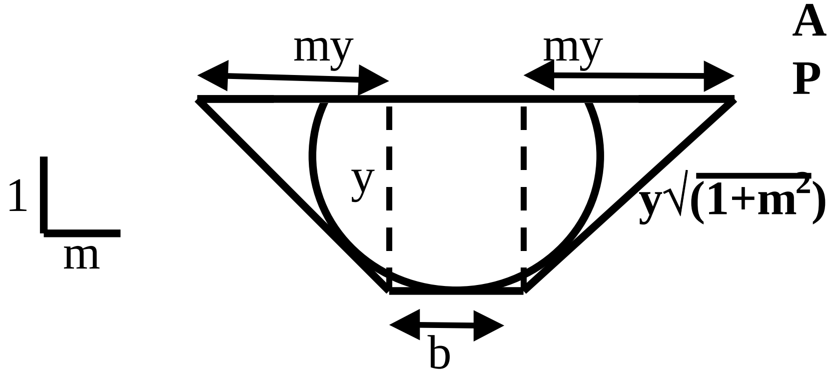
Note: best or Maximum discharge occurs when frictional resistance is lowest, or wetted perimeter 'P' is lowest. Or R_h is Maximum

Why is this important for design?

- **Reducing P reduces channel construction costs.**
- **Cost of deep excavation less than shallow excavation**
- **If Right-of-way costs are high: No choice but to dig deeper.**

A semicircular open channel is the most efficient crossection for a given area, slope and surface roughness. (circle has least perimeter for given area). So why are all open channels not circular?

MOST EFFICIENT TRAPEZOIDAL CHANNEL



A = 2(my/2)y + yb=(my+b)y
P = b + 2 y√(1+m²)

$$R_h = \frac{A}{P} = \frac{(my+b)y}{b + 2y\sqrt{1+m^2}} = \frac{A}{\frac{A}{y} + y\left(2\sqrt{1+m^2} - m\right)}$$

For, a constant A and m, maximum R_h is found by setting $dR_h/dy = 0$

$$\frac{A}{y} = y\left(2\sqrt{1+m^2} - m\right)$$

Solving for R_{hmax}

$R_{hmax} = y/2$

Hydraulically best trapezoid is given by

$$R_h = \frac{y}{2} = \frac{1}{2}\sqrt{\frac{A}{\left(2\sqrt{1+m^2} - m\right)}}$$

for $dR_h/dm = 0$, when $m = \infty$

$$\frac{2m}{\sqrt{1+m^2}} - 1 = 0$$

or, $m=1/\sqrt{3}$ or side slopes are 60° to horizontal and trapezoid is half hexagon

Also, optimum trapezoid always envelops a semicircle whose center is water surface.

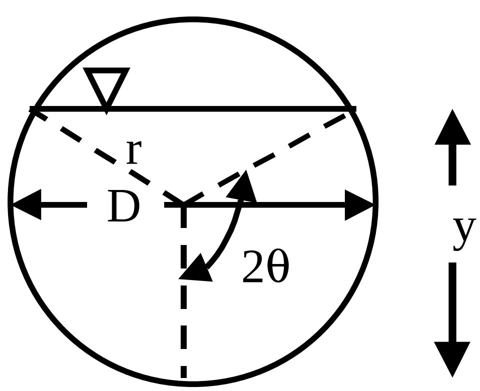
MOST EFFICIENT TRIANGULAR CROSSECTION

Total vertex angle = 90°

MOST EFFICIENT RECTANGULAR CROSSECTION

R_{hmax} = y/2, y=b/2(depth=half of width)

CIRCULAR SECTION NOT FLOWING FULL



$$R_h = \frac{A}{P} = \frac{D}{4}\left(1 - \frac{\sin\theta\cos\theta}{\theta}\right) = \frac{D}{4}\left(1 - \frac{\sin 2\theta}{2\theta}\right)$$

For maximum rate of discharge, Mannings formula

indicates that $AR_h^{2/3}$ must be maximum

Setting $d\,AR_h^{2/3}/d\theta = 0$,

$\theta = 152.2°$ or y =0.938 D

Maximum velocity Occurs at: $dR_h^{2/3}/d\theta = 0$
or y=0.813D