LFOM weir design documentation

Linear Flow Orifice Meter Sutro Weir Design Documentation

Mathcad Code

the mathcad code can be found here. You will need to have mathcad installed on your computer in order to open the file.

Sutro Weir Design Documentation

This program creates a sutro weir design and is used to calulcate the optimal LFOM diameter.
Note : The values used in this documentation are not static the user can change the inputs.

Inputs

Inputs are the data that must be entereed by the user in order to design the sutro weir for the specific application.
Inputs

Symbol	Definition	Sample Value
Q_{max}	maximum flow through sutro wier, L/min	400 L/min
H_{dmax}	the set height of the curved portion of the wier, cm	20 cm
$\Pi_{Sutro} = \frac{Q_{min}}{Q_{max}}$	the ratio of the minimum over the maximumflow given that the linear region doesn't include the rectabgular base	0.01
C_d	proportionality constant	0.62

Linear Proportionality

$$C_{linear} := \frac{Q_{max}}{H_{dmax}} = 20 \cdot \frac{L}{min \cdot cm}$$

C_{linear} = linear proportionality, L/min/cm

Rectangular Base Width

$$W(Q_{max}, H_{dmax}) := \frac{Q_{max}}{H_{dmax}^{\frac{3}{2}} \cdot C_d \cdot \sqrt{2g \cdot \Pi_{Sutro}}}$$

W = rectangular base width, cm
g = gravity, 9.8 m/s^2

Rectangular Base Height

$$s_{base} := \Pi_{Sutro} \cdot H_{dmax} = 2 \cdot cm$$

s_base = rectangular base height, cm

Profile of curved portion of weir

$$y(x, Q_{max}, H_{dmax}) := \begin{cases} \dfrac{W(Q_{max}, H_{dmax})}{2} \cdot \left(1 - \dfrac{2}{\pi} \cdot \operatorname{atan}\left(\sqrt{\dfrac{x}{s_{base}}}\right)\right) & \text{if } x > 0 \\ \dfrac{W(Q_{max}, H_{dmax})}{2} & \text{otherwise} \end{cases}$$

y = the profile of the curved portion of the weir, cm

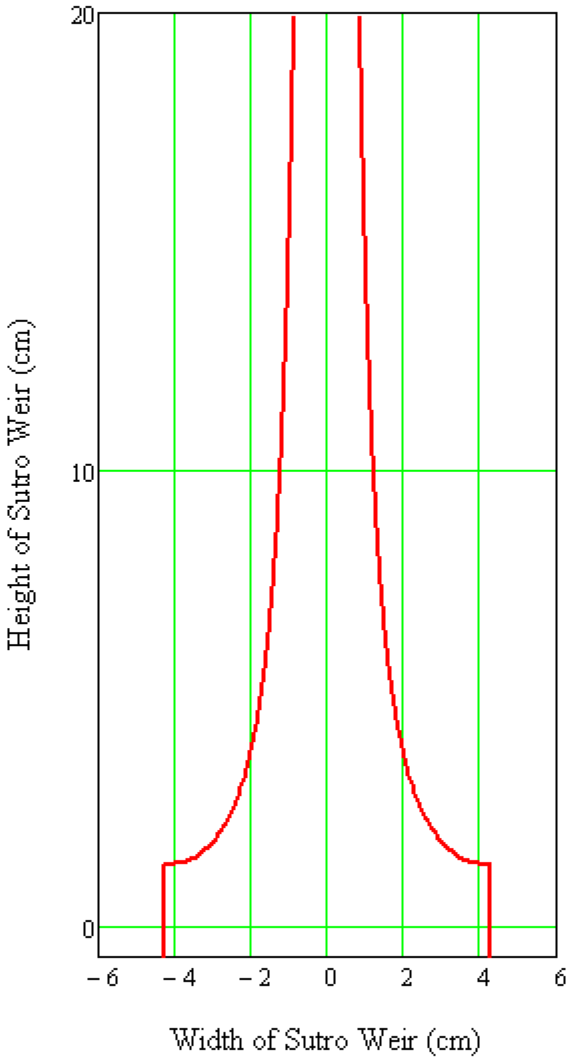
x = corresponds to the the vertical height of weir from -s_base to $H_{dmax} - \frac{2}{3} s_{base}$, cm

Y-axis of the graph

$$H_d(x) := x + \frac{2}{3} s_{base}$$

H_d = this is the vairable that corresponds to the height of the entire weir from the bottom of the rectangular base to the top of the curved portion of the weir, cm

Sutro Weir Graph: Illustrates the shape of the weir.



Y-axis = H_d
X-axis = y

The height of the rectangular base

$$s_{base} := \Pi_{Sutro} \cdot H_{dmax} = 2 \cdot cm$$

s_base = rectangular base height, cm

The flow through the rectangular base

$$Q_{base} := \frac{2}{3} C_d \cdot W(Q_{max}, H_{dmax}) \cdot \sqrt{2g} \cdot \left[\left(H_{dmax} + \frac{1}{3} s_{base} \right)^{\frac{3}{2}} - \left(H_{dmax} - \frac{2}{3} s_{base} \right)^{\frac{3}{2}} \right]$$

Q_{base} = The flow through the rectangular base, L/min

Initial Momemtum of Water Entering Riser Pipe

If the riser pipe diameter is too small for the flow rate then the water will back up in the bottom of the pipe and the water entering the weir won't experience free fall anymore. Balance of momentum in and out helps us achieve these values.Background for the development of the minimum cross sectional area equation are the equations below:

- vertical velocity of the water from any height when it reaches the bottom of the weir $V_z = \sqrt{2g(x + s_{base})}$
- velocity through the weir in the vena contracta (point in a fluid stream where the diameter of the stream is the least) $V_{vc} = \sqrt{2g(h - x)}$
- Effective area of a differential weir element as a function of height given the effect of the vena contracta - $A = C_d 2y$, y is the width of the cruved portion of the weir and it is dependent on H_{dmax} , Q_{max} and, x (the incremental height up the weir)

$$M_{in}(Q_{max}) := 2g \cdot \rho \left[\int_{-s_{base}}^{h} \sqrt{(x + s_{base}) \cdot (h - x)} \cdot C_d \cdot 2 \cdot y(x, Q_{max}, H_{dmax}) \, dx \right]$$

M_{in} = momentum into the sutro weir, N
ρ = the density of water, 1,000 kg/m^3
g = gravity 9.81 m/s^2

Exit Velocity of the Sutro Weir

$$V_{out}(Q_{max}) := \frac{M_{in}(Q_{max})}{\rho \cdot Q_{max} \cdot \Pi_{SutroSafety}}$$

V_{out} = exit velocity of water from sutro weir, m/s
$\Pi_{SutroSafety}$ = A safety factor, so there is no risk of flooding the pipe. Set equal to 2.

Minimum Area of Riser Pipe

$$A_{pipemin}(Q_{max}) := \frac{Q_{max}}{V_{out}(Q_{max})}$$

$A_{pipemin}$ = the minimum area of the riser pipe

The Diameter of the Riser Pipe

$$d_{pipemin}(Q_{max}) := \sqrt{\frac{4 \cdot A_{pipemin}(Q_{max})}{\pi}}$$

$d_{pipemin}$ = the minimum diameter of the riser pipe

Graph of the Riser Pipe Diameter as a Function of Flow Rate

$$d_{pipemin}(Q_{max}) := \sqrt{\frac{4 \cdot A_{pipemin}(Q_{max})}{\pi}}$$