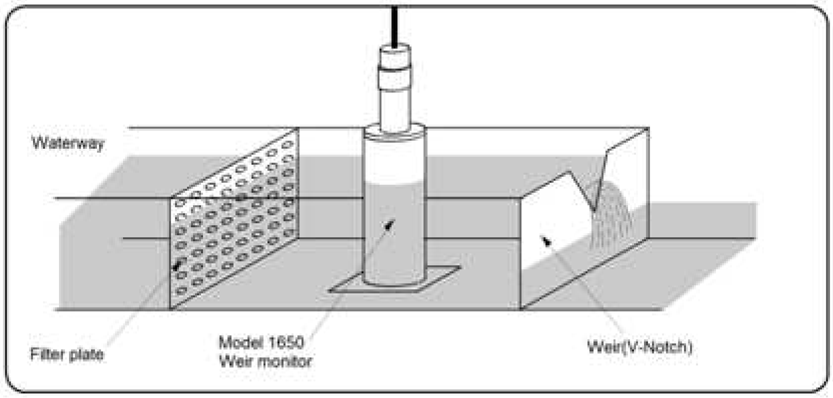
Calculating theory of flow rate by the weir monitor(model 1650)

1. Description of weir and weir monitor

1) Weir : A device that measures the flow rate by blocking a part of the waterway and blurring the water with that part. It is used for purposes such as increasing the water level, distributing and controlling the flow rate. Triangular weir is also called V-notch.

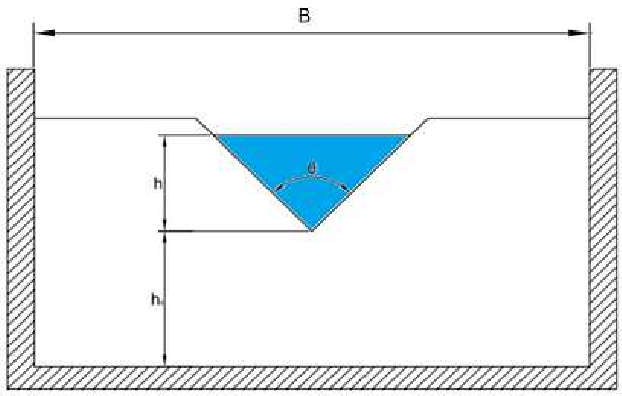
2) Weir monitor: Model 1650 weir monitor is installed inside the waterway to measure the height of water flowing through the waterway.



[Installation overview of weir and weir monitor]

2. Flow rate calculation method for triangular and rectangular weirs

1) Triangular weir
The flow rate of a triangular weir can be calculated in two ways: when the angle of the V-notch is 90° (Numaji formula) and when it is not 90° (Strickland formula).



Symbols	Descriptions	Units
Q	Flow rate	m^3/min
C	Flow coefficient	-
θ	Central angle	Degree
g	Gravitational acceleration	m/s
h	depth of water of head waters	m
h_d	Bottom height	m

① Flow rate formula of triangular weir (Strickland formula)

$$\mathbf{C(Flow\ coefficient) = 0.565 + \frac{0.0087}{\sqrt{h}}}$$

$$\mathbf{Q(Flow\ rate) = 32 \times C \times \sqrt{2g} \times \tan\frac{\theta}{2} \times h^{\frac{5}{2}}\ (m^3/min)}$$

② Flow rate formula of triangular weir (Numaji formula)

$$\mathbf{C(Flow\ coefficient) = 81.2 + \frac{0.24}{h} + \left(8.4 + \frac{12}{\sqrt{h_d}}\right) \times (\frac{h}{B} - 0.09)^2}$$

$$\mathbf{Q(Flow\ rate) = C \times h^{\frac{5}{2}}\ (m^3/\ min)}$$

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For example, if the water level (depth of water of head waters) measured by the model 1650 weir monitor is 0.2m, the bottom height is 0.25m, and the weir width is 0.8m, the flow rate calculation for a right triangle weir is as follows.
(The notch angle of the triangular weir is 90º and is installed in the center of the width of the waterway)

[Strickland Formula]

$$\mathbf{C(Flow\ coefficient)} = 0.565 + \frac{0.0087}{\sqrt{0.2}} = 0.584454$$

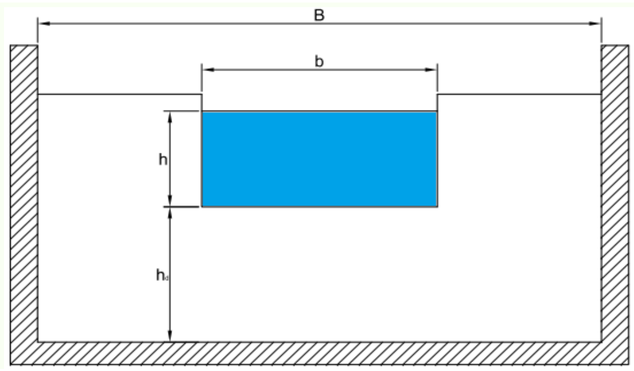
$$\mathbf{Q(Flow\ rate)} = 32 \times 0.584454 \times \sqrt{2 \times 9.8} \times \tan\frac{90}{2} \times 0.2^{\frac{5}{2}} = 1.4814(m^3/\min)$$

[Numaji formula]

$$\mathbf{C(Flow\ coefficient)} = 81.2 + \frac{0.24}{0.2} + \left(8.4 + \frac{12}{\sqrt{0.25}}\right) \times \left(\frac{0.2}{0.8} - 0.09\right)^2 = 83.22944$$

$$\mathbf{Q(Flow\ rate)} = 83.22944 \times 0.2^{\frac{5}{2}} = 1.4888(m^3/\min)$$

2) Rectangular weir
For rectangular weir, the flow rate can be calculated using the Itadani and Dejima formulas.



Symbols	Descriptions	Units
Q	Flow rate	m^3/min
C	Flow coefficient	-
B	Width of weir	m
b	Width of rectangular	m
h	depth of water of head waters	m
h_d	Bottom height	m

① Rectangular weir flow rate formula (Itadani, Dejima formula)

$$\mathbf{C(Flow\ coefficient)} = 1.785 + \frac{0.00295}{h} + 0.237\frac{h}{h_d} - 0.428 \times \sqrt{\frac{(B-b)h}{Bh_d}} + 0.034\sqrt{\frac{B}{h_d}}$$

$$\mathbf{Q(Flow\ rate)} = 60 \times C \times b \times h^{\frac{3}{2}}\ (m^3/\min)$$

For example, if the water level (depth of water of head waters) measured by the model 1650 weir monitor is 0.2m, the bottom height is 0.25m, the width of the weir is 0.8m, and the width of the rectangular notch is 0.4m, the flow rate calculation for a rectangular weir is as follows.

$$\mathbf{C(Flow\ coefficient)} = 1.785 + \frac{0.00295}{0.2} + 0.237 \times \frac{0.2}{0.25} - 0.428 \times \sqrt{\frac{(0.8-0.4)0.2}{0.8 \times 0.25}} + 0.034\sqrt{\frac{0.8}{0.25}} = 1.86395$$

$$\mathbf{Q(Flow\ rate)} = 60 \times 1.86395 \times 0.4 \times 0.2^{\frac{3}{2}}\ (m^3/s) = 4.0012(m^3/\min)$$