

Faculty of engineering

Mechanical engineering department

Fluid mechanics Laboratory

ENME312

Section NO.1

Experiment NO.7

**“WATER CHANNEL APPLICATIONS**

**DISCHARGE BENEATH A SLUICE GATE”**

Prepared by:

 Said Jamjoum No.1152783

**Instructor:**

Dr. Mohammad Al Karaeen

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**Abstract:**

Our experiment is "The water channel applications". The open water channel is very essential in fluid mechanics, it has a lot of applications for example it is used for dams and many hydraulic structures. This experiment consists of two parts. At the first part the discharge must be measured beneath a sluice gate, and at the second the flow over a "V" Notch weir must be studied. At both parts, the water channel is represented by a glass sided tilting flume. At the first part, the bottom edge of the sluice gate (Yg) is adjusted to 20mm, and then the pump is switched on to supply water. The value of the total head at discharge point is recorded from the pitot- tube and the total depth of fluid before and after the gate is recorded. The sluice gate bottom edge is raised by 5mm increment with constant flow rate, and the steps are repeated. The hydraulic jump in the water channel is obviously seen during the experiment.

At the second part, the "V-notch weir" is positioned and water is introduced until it discharges over the weir plate. The flow of water in the flume is adjusted to obtain heads increasing in about 10mm steps, and for each step, the discharge (Q) and the head above the bottom of the V-notch is measured.

**Objectives**

This experiment is very important, and has a lot of applications, the main objectives are:

* To study the characteristics of an open water channel and its applications.
* To study the hydraulic jump phenomenon, this is obviously recognized during the experiment.
* To determine the discharge and the coefficient of discharge beneath a sluice gate.
* To determine the resultant gate thrust and the resultant hydraulic thrust and compare between them. These values are important for the design of hydraulic structures and dams.
* To study the characteristics of the flow over a "V-Notch Weir" and to determine the discharge coefficient of the flow experimentally and from the graph.

**Sample Calculation:**

**Part 1: For run 1 »**

Coefficient of contraction (Cc) calculated using below equation:

Cc = $\frac{Y\_{1}}{Y\_{g}}$

Where:

Cc: Coefficient of contraction

$Y\_{1}$: Total depth of fluid after the gate

$Y\_{g}$: Height of sluice gate opening

Cc =$\frac{Y\_{1}}{Y\_{g}}$ =$\frac{19}{20}$ = 0.95

Velocity Coefficient(Cv) calculated using below equation:

Cv= $\sqrt{\frac{H\_{c}}{Y\_{0}}}$

Where

Cv: Velocity Coefficient.

$H\_{c}$: Total head of discharge point.

$Y\_{0}$: Total depth of fluid before the gate.

Cv= $\sqrt{\frac{H\_{c}}{Y\_{0}}}$ = $\sqrt{\frac{220}{243}}$ = 0.95

Discharge coefficient(Cd) calculated using below equation:

 Cd=Cc\*Cv

Where:

Cd: Discharge coefficient

Cc: Coefficient of contraction

Cv: Velocity Coefficient

Cd=Cc\*Cv = 0.95\*0.95 =0.9025

Discharge beneath a sluice gate (Q) calculated using below equation:

 Q= Cd \*$Y\_{g}$\*b$\sqrt{2\*g\*Y\_{0}}$

Where:

Q: Discharge beneath a sluice gate

Cd: Discharge coefficient

$Y\_{g}$: Height of sluice gate opening

b: Width of channel(30cm)

$Y\_{0}$: Total depth of fluid before the gate.

g : Gravity(9.81 m^2/sec)

Q= Cd \*$Y\_{g}$\*b$\sqrt{2\*g\*Y\_{0}}$ = 0.9025\*0.02\*0.3\*$\sqrt{2\*9.81\*0.243}$= 0.012 m3/sec

The resultant gate thrust ($F\_{g}$)calculated using below equation:

$F\_{g}$ = 0.5 ρ g 𝑌12 ($\frac{Y\_{o}^{2}}{Y\_{1}^{2}}$ - 1) - $\frac{ρ Q^{2} }{b^{2}Y\_{1}}$ (1 – $\frac{Y\_{1}}{Y\_{0}} $)

 = 212.27 N

Where:

Fg: the resultant gate thrust

$Y\_{0}$: Total depth of fluid before the gate.

$Y\_{1}$: Total depth of fluid after the gate.

g : Gravity(9.81 m^2/sec)

Q: Discharge beneath a sluice gate

b: Width of channel(30cm)

𝜌: Water density (1000kg/m^3)

The resultant hydrostatic thrust ($F\_{h}$)calculated using below equation:

 Fh= 0.5 ρ g (Y0-Yg)2

= 243.92

Where:

Fh:the resultant hydrostatic thrust

$Y\_{0}$: Total depth of fluid before the gate.

$Y\_{g}$: Height of sluice gate opening

g: Gravity (9.81 m^2/sec)

**Part (2): For run 1 »**

Discharge coefficient (Cd) calculated using below equation:

Q= Cd\* $\frac{8}{15}$ $\sqrt{2g}$ \* tan($\frac{ɵ}{2}$) \* $H^{2.5}$

Where :

Cd: Discharge coefficient

𝛳/2: half the enclose angle of the V-notch ($45^{0}$)

H: head above bottom of the V-notch.

g: Gravity (9.81 m^2/sec)

Q= Cd\* $\frac{8}{15}$ $\sqrt{2g}$ \* tan($\frac{ɵ}{2}$) \* $H^{2.5}$

0.000167= Cd\* $\frac{8}{15}$ $\sqrt{2\*9.81}$ \* tan(45) \* $0.018^{2.5}$ , Cd= 1.62

**Results:**

For part 1:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Yg** | **Yo** | **Y1** | **Hc** | **Cv** | **Cc** | **Cd** | **Q** | **Fg** | **Fh** | **Fg/Fh** | **Yg/Yo** |
| 20 | 243 | 19 | 220 | 0.951499 | 0.95 | 0.903924 | 0.011842 | 212.2655 | 243.92075 | 0.870223 | 0.082305 |
| 25 | 188 | 20 | 161 | 0.92541 | 0.8 | 0.740328 | 0.010664 | 114.9448 | 130.32095 | 0.882013 | 0.132979 |
| 30 | 134 | 22 | 119 | 0.942369 | 0.73333333 | 0.691071 | 0.010085 | 42.76809 | 53.05248 | 0.806147 | 0.223881 |
| 35 | 104 | 25 | 97 | 0.96576 | 0.71428571 | 0.689829 | 0.010347 | 13.84549 | 23.352705 | 0.592886 | 0.336538 |
| 40 | 85 | 28 | 82 | 0.982194 | 0.7 | 0.687536 | 0.010655 | 1.384768 | 9.932625 | 0.139416 | 0.470588 |
| 45 | 71 | 40 | 64 | 0.949425 | 0.88888889 | 0.843934 | 0.013447 | -5.05208 | 3.31578 | -1.52365 | 0.633803 |

Table (1): Yg, Yo&Y1 in mm, Hc in cm, Q in m^3/sec and V in m/sec

For part 2:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Q(m3/hr) | Q(m3/s) | Hmm | Hm | Cd | Q^(2/5) |
| 0.6 | 0.000167 | 18 | 0.018 | 1.623258 | 0.03081339 |
| 0.9 | 0.00025 | 23 | 0.023 | 1.319291 | 0.03623898 |
| 1.02 | 0.000283 | 26 | 0.026 | 1.100486 | 0.03809948 |
| 1.86 | 0.000517 | 41 | 0.041 | 0.642645 | 0.04844893 |
| 4.2 | 0.001167 | 58 | 0.058 | 0.609673 | 0.06710868 |
| 12.3 | 0.003417 | 92 | 0.092 | 0.563447 | 0.10314331 |

Table (2): Q in m^3/sec,h in mm and H in mm

Graph (1): (Fg/Fh) Vs (Yg/Yo)

Graph (2): Q^ (2/5) Vs H

Graph (3): Cd Vs Q

**Discussion of Results**

For part 1, it is noticed many things:

* The gate thrust and hydrostatic thrust decrease with the increase in the height of sluice gate opening, and this is due to increase of the area under the gate for the gate thrust Fg, and decrease in total depth of fluid before gate for hydrostatic thrust FH.
* The velocity decreases when the height of the sluice gate increases due to increase of the area under the gate
* FHis larger than Fg and this can be shown from table 1 that the ratio of $\frac{F\_{g}}{F\_{H}}$ decreases with the increase of $\frac{Y\_{g}}{Y\_{0}}$ and the relationship between them is not linear

For part 2, it is shown that the relationship between Q 2/5 and H is linear with slope= 0.9688, and its close to our values, and the relationship between Cd and Q is not linear ,moreover , the coefficient of discharge is decreasing when the height of water above the bottom of v- notch increases.

 However, many resources of errors can be considered in this experiment:

* Reading the depth of water before and after the gate due to vibration of water since it is wavy.
* The height of the gate may not be exact, and it is due to human ability to be more accurate.
* The reading of the total head in pitot tube may be more than it taken since it is a very thin tube and the head take time to became constant.
* The reading of H above V notch is not accurate since taking the readings was a rapid process.

**Conclusion:**

This experiment can be considered as a simple theoretical approach to predict conditions for the occurrence of hydrostatic forces on a sluice gate. Also, it was important to study some application of water channel. The main result of this experiment was calculating these forces and the discharge coefficient to improve the experiment its suggested to use more accurate tools for reading the height of water to get more exact results.