Engineering and Technology Journal e-ISSN: 2456-3358
Volume 09 Issue 01 January-2024, Page No.- 3294-3297
DOI: 10.47191/etj/v9i01.06, I.F. – 7.136

Determination of Flow Patterns Occurring at the Downstream of a Tilting Flume Channel Gate with 3 Variations of Inclination Angles

Djoni Irianto[1], Naufal Dhiya Ulhaq[2]
[1,2]Department of Civil Engineering, Faculty of Engineering, Universitas Negeri Surabaya, Ketintang, Surabaya, 60231, Indonesia.

ABSTRACT: Flow that occurs in the tilting flume channel often changes when observed. This phenomenon is closely related to the variation in the channel's bottom angle as it crosses the open channel, resulting from water input supply or water supply from reservoirs pumped by water researchers. The flow of water through the open channel is influenced by the presence of the channel's bottom surface profile and various angles. When a certain discharge is given, visible flow patterns can be observed on the water surface, while the unseen flow above the water surface is referred to as the Energy Gride Line (EGL).

If the energy that occurs in the channel is not measured, it may lead to water jumping. The structured water jump can be observed to understand the flow patterns that occur. To avoid undetected flow patterns, hydraulic structures are required, one of which is a water gate with an opening below, commonly known as a Sluice Gate. This water gate is easily operable, either manually or with the availability of excess water supply. Calculating the operational water requirements can be challenging due to the influence of the depth and jumps occurring downstream of the gate. Often, the hydraulic jump's differences tend to overlook these measurements, which can become a hindrance when there is an excess water supply during peak flow conditions. To address this issue, it is necessary to conduct a model test using an instrument known as the Sluice Gate, which generates hydraulic jumps. This area of research needs further exploration in the laboratory.

The Sluice Gate model in the equipment is equipped with instruments, various gate openings, and adjustable pressurized water gates with measurable flow rates. To analyze the jump height, flow patterns, and velocity using a flow watch measuring instrument, the researchers conducted tests with three specific gate openings, testing and measuring the depths (Y) at different positions of the channel's bottom slope. The test started with gate openings of 0.5, 0.75, and 1.00, reading the instrument, moving the gate positions from a depth of 2 cm to the highest depth of 5 cm. Graphing the test results of the Sluice Gate apparatus, which is a sliding gate-type apparatus manually operated, the researchers conducted three tests for each gate opening with pumping, recording, and mapping the depth values, jump lengths, and travel times from the instrument on the testing apparatus. The subsequent recommendation of the Sluice Gate test analysis is intended to provide information for water construction planning, indicating that the test results with various slopes under certain conditions have different depth values and jump times (t). Furthermore, the researchers determine the positioning of the model gate, which can be used to determine the water depth (Y) after jumping (cm). This laboratory research involves a channel model.

The objective of this study is to publish a journal article presenting the simulation results determining the flow patterns occurring in the channel with three different bottom slope angles (5°, 15°, 25°). The results will be presented in tables and graphs and then documented in an article submitted to an international journal.

KEYWORD: Channel slope, Door opening, Jump height

1. INTRODUCTION

Water flow that occurs in channels often easily changes when observed. This event is closely related to the magnitude of the slope angle across the open channel, caused by rainwater supply, water supply from reservoirs, or other purposes. The flow of water through an open channel is influenced by the existence of the channel's bed surface profile. When a certain discharge is applied, visible flow forms with the water surface observable, while the part not seen with the naked eye above the water surface is referred to as the Energy Grade Line (EGL).

If the energy occurring in the water channel is not measured, it can lead to damage to the surrounding land and even harm the structure of the channel. To avoid damage to the model area, it is necessary to have water measurement structures, one of which is a water gate in the form of a Sluice Gate. This gate can be easily operated manually. Calculating the water operation requirement with an excess water supply is not an easy task due to factors such as depth, height difference upstream and downstream, and hydraulic jumps, which often overlook this measurement. This can be a problem when there is an excessive water supply during peak flow conditions. Determining the appropriate measurement requires conducting model tests using a tool known as the Sluice Gate, which generates hydraulic jumps. Further research is needed in the laboratory for this purpose.

The tool is equipped with instruments and various treatments for gate openings, which are controlled by pressurized water using a certain incline angle. To analyze the jump height, researchers conduct tests and measure the depth (Y) with different gate openings. They record the data from the instruments and move the gate's position from a depth of 2 cm to a maximum depth of 5 cm. The test results are then graphed for further analysis. The Sluice Gate is a sliding door-shaped tool that can be moved manually to test with different gate openings three times. The depth values and travel times from the instrument on the test tool are recorded and mapped. Additionally, a mesh tool is provided to anticipate any sand entering the channel.

The resulting analysis of the Sluice Gate test is recommended to provide information for the construction of water buildings. The test results with various gate openings in specific conditions show differences in depth values and jump heights with travel times. This information can be applied to water gates and other water-related constructions to determine the depth of the water after a jump of (Y) cm.

Manual data collection during observations is done to facilitate researchers in reading the data. On the outside of the tool, there are two tanks for reading the downstream water depth and the downstream water jump length, both measured in centimeters. The urgency of this research is expected to provide recommendations for the flow that occurs in rivers, drainage ponds, and irrigation channels. This will make it easier for field workers to determine the flow patterns that may pose risks to residents near the channels and implement warning systems accordingly.

2. LITERATURE REVIEW

1. Water Gate.

A Water Gate is a device used to alter the flow pattern in a channel by harnessing the energy of gate opening to create a water jump. This means that the faster the gate is opened, the higher the resulting water jump, allowing the water to be distributed to another location at a higher, faster, and more controlled rate (Ven Tee Chow, 2015).

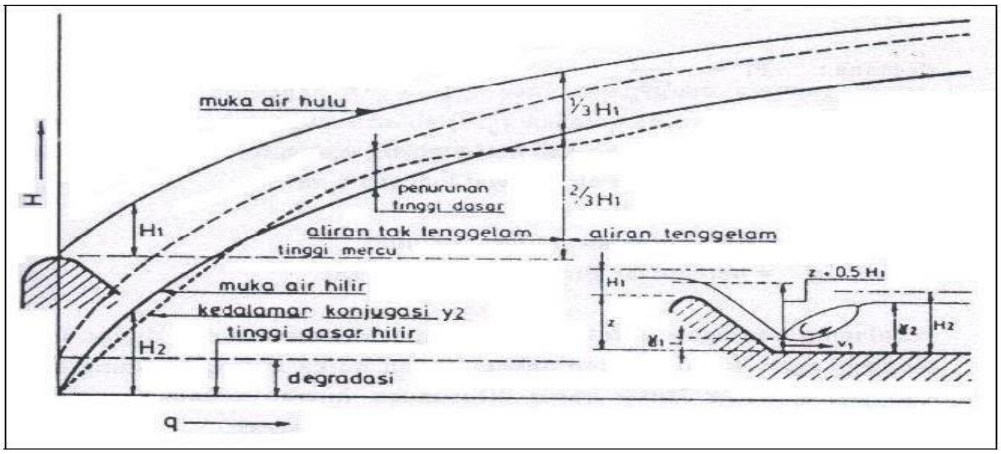
The Water Gate is a mechanism designed to convert kinetic energy into a water jump. A Sluice Gate is employed to dam and elevate the water surface using the kinetic energy from the subcritical fluid flow, transforming it into a supercritical jump (Subramanya, 2016).

The operation of this device involves creating a difference in height between the inlet and outlet sections. In other words, it converts mechanical energy from a source (the driver) into kinetic energy (Froude number), wherein the force overcomes the existing jumps along the channel.

Water jumps occur due to the transition of flow from supercritical to critical. Generally, water jumps happen when the gate opening is below the critical depth of a flow or when water flows over a spillway. During a water jump, significant turbulence is observed, accompanied by a substantial energy reduction. Consequently, after the water jump, the flow becomes tranquil as the velocity decreases abruptly, and the flow depth rapidly increases. Applications of water jumps include energy dissipation in water structures to prevent erosion downstream, increasing pressure on protective layers to reduce uplift pressure on gate structures by increasing the water depth on the protective layer, eliminating air pockets from water supply networks to prevent air locking (compressible flow).

The momentum equation for forces per unit width can be

$$\frac{y2}{y1} = \frac{1}{2}(\sqrt{1 + 8\,Fr^2}\text{-}1 \qquad \text{FR = FROUDE}$$



Sumber: KP - 02

Gambar 3.2. Metode Perencanaan Kolam Loncat Air

The planning of a diving pool is illustrated in the above picture. From the graph depicting the relationship between q and H1, and the falling height z, the initial diving velocity (v1) can be determined using the following equation:

$$v1\sqrt{2g(\frac{1}{2H1}+z)}$$

v1 = initial velocity of the jump, m/s
g = acceleration due to gravity, m/s^2 (≈ 9.81)
H1 = height of energy above the threshold, m
z = falling height, m
2.Model Iteration.
The iteration of river flood wave after a disaster occurred in Korea, modeled in the laboratory using the 1D routing method, resulted in the inference of unsteady flow velocities in open channels (Ven Tee Chow, 2015).
The propagation of flood waves for the dam break case and calibration with 1D experiments in the laboratory at the University of Mississippi, America, for head loss using various valve opening weights, can be simulated and data obtained (Xinya Ying, 2013).
Comparing physical flow experiment modeling with finite element method for propagating wave break with laboratory experiments, it was found that the compressible flow method is capable of simulating the propagation of head loss (A. Kaceniauskas, 2016).

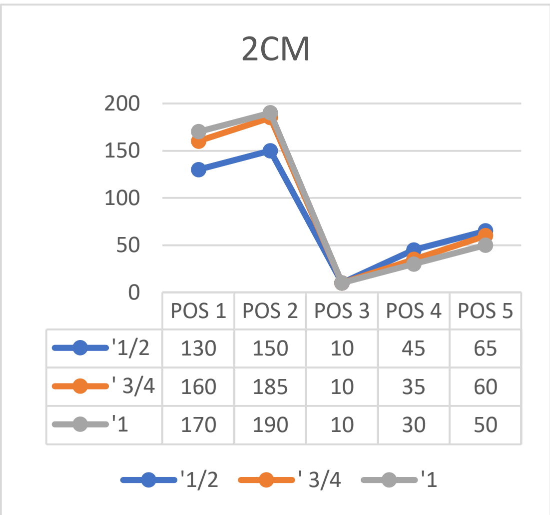
3. RESEARCH METHODS

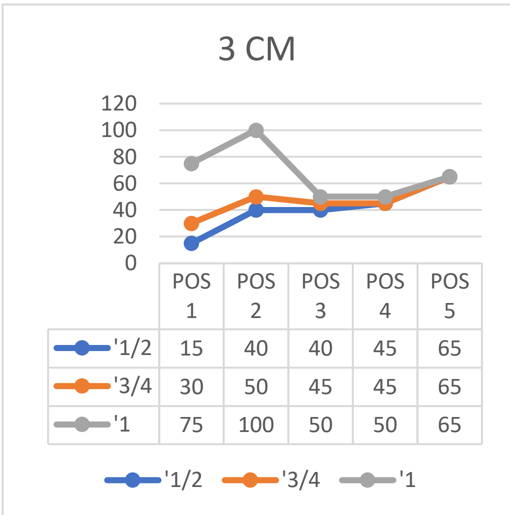
1.Setting and Research Characteristics: The research was conducted at the Water Laboratory of Unesa.
2.Research Procedure: a. Research Simulation involves conducting flow experiments using the apparatus with 3 different angles of channel bed slope. The research was carried out from June to November 2023. b. The target points of the apparatus and the research steps are as follows:
Equipment used:
• Model of a water gate, pump, tilting flume
• Flow watch
• Tank to hold the test water
• Measuring ruler for height measurement
• Writing tools for recording data.
Working steps:
• Prepare the above-mentioned equipment.
• Set up the model gate for observation during the research.
• Measure the width and height of the channel to calculate the volume.
• Treat each gate with a combination of slope angles.
• Conduct treatments with a combination of depth positions at 2 cm and 5 cm

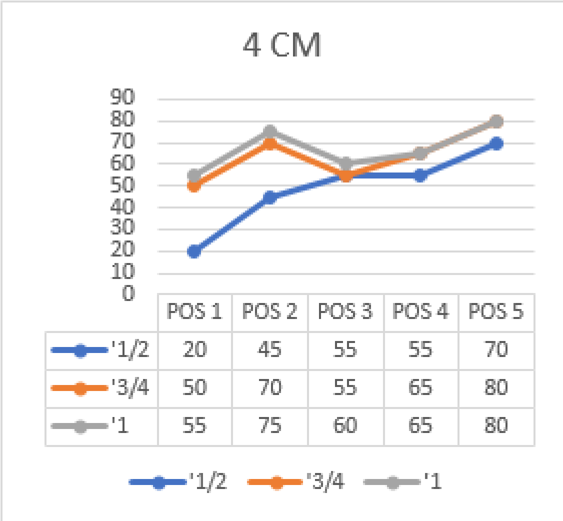
4. RESULTS AND DISCUSSION

- There is a significant hydraulic jump at the bottom opening with a width of 2 cm. Occurs at channel bed slopes of 5, 15, and 25 degrees.
- The wider the bottom opening of the gate, the weaker the hydraulic jump becomes.
- Backwater occurs downstream near the water gate for a channel bed slope of 5 degrees.
- Backwater occurs downstream far from the water gate for a channel bed slope of 25 degrees.
- For channel bed slopes greater than 25 degrees, further observation is required

DATA GRAPH OF 5° SLOPE ELEVATION -40 (CHANNEL HEIGHT 2CM, 3CM, 4CM)







REFERENCES

Journals

1. Paguler, Andrew. 1988. "Mississippi River Flood Simulation," Journal.
2. Kris, Darmadi. 2014. "Steady Flow," Journal.
3. Kaceniauskas, A. 2005. "Simulation of Physical Experiment of Flow," Journal.
4. Ying, Xinya. 2004. "Simulation of Flood Propagation Prediction," Journal.

Books

1. Mawardi, Imam. 2012. "Permanent Dam," Jakarta.
2. Irianto. 2012. "Hydraulics 2," Unipress Unesa.
3. Irianto. 2012. "Water Structures," JTS Unesa.
4. Irianto. 2013. "River Engineering," JTS Unesa.
5. Irianto. 2018. "Hydraulic Modeling," JTS Unesa.
6. Indiah, Kustini. 2013. "Irrigation and Water Structures," JTS Unesa.
7. Soedradjat, A. 1983. "Fluid Mechanics and Hydraulics," Nova, Bandung.
8. Subramanya. 2015. "Open Channel Flow," Mc.Graw Hill.
9. Chow, Ven Te. 2005. "Open Channel Hydraulics," Mc Graw Hill.