THE EFFECTIVENESS NUMBER OF *BAFFLE BLOCKS* TO REDUCE ENERGY IN TUKUTAHA TRANSITION CHANNELS

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Abstract: *One of the causes of damage to the weir structure is scouring that can accur along the weir channel. Scouring occurs due to the high flow velocity and high specific energy. One of the methods used to reduce specific velocity and energy is by installing baffle blocks in parts that have high velocity and energy. The addition of baffle blocks is carried out at a place that has a high velocity, namely the transition channel. To see the effect of baffle block variation on velocity and energy, a study was conducted. The study was conducted with four baffle block models type. Model type 0 is a model with the same assumptions as of the existing one. model type 1 is designed based on the planning of The Colorado State University (CSU) rigid boundary basin. Model type 2 is designed by reducing the number of baffle blocks from the initial design of 102 baffles to as many as 75 baffles. while the 3 channel model type transitions without baffle blocks. Based on the percentage of energy loss analysis in the transition channel, Model type 0 can reduce energy greater than others models. At maximum discharge, the model type 0 has an energy loss of 10.821% greater than the model type 1, 14,889% greater than the model type 2, and 33.02% greater than the model type 3.*

Keywords*: Velocity, specific energy, baffle block, scouring*

INTRODUCTION

The phenomenon that occurs in the morning glory weir is that there is a high-velocity in the weir channel. This is because the morning glory weir has a very large elevation difference [6]. The Tukutaha Weir is a morning glory weir. At the Tukutaha weir, there is a high-velocity. High-velocity produces high specific energy. With high specific energy, it will cause scouring [7][8].

Scouring is very dangerous on weir structures. This problem can often be seen in cases where flow is transferred from a high energi point to a downstream [9][10]. According to the weir planning manual, energy can be reduced by adding *baffle blocks*[3]. The *baffle block* is expected to reduce velocity so that it can reduce energy in the flow.

In this study, several variations of baffle block installation were given. From the *baffle block* variation, it can be determined which variation is more effective to reduce velocity and specific energy. In this study, the shape, distance, and size of the *baffle blocks* were determined to be the same in all models type. *The baffles* are hexagon-shaped, with a radius of 2 cm and a distance between the axles of 8 cm. The difference in *baffle block* model variations is the number of *baffle blocks.*

Adhia, in 2016 on the results of his research on testing the physical model of the baffle chute to increase energy in the Riam Kiwa dam spillway stated that the use of baffles can reduce overall velocity. This allows the scour that occurs downstream of the spillway to be less. Akmal (2014) has conducted a study on the modification of the transition channel on the Bener dam model. Akmal mentioned that the addition of baffle blocks upstream of the channel can reduce the Velocity [5]. Akmal revealed that with reduced flow velocity, the flow was evenly distributed. So reducing velocity will reduce energy. The results of this study are used as the basis for the research theory that the installation of baffle blocks affects energy dissipation.

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THE IMPORTANCE OF RESEARCH

By this research, a more efficient serial model can be determined to reduce velocity and energy in terms of the number of *baffle blocks* installed.

METHODOLOGY

This research methodology consists of 4 stages. The first stage is literature study. In the literature study, researchers conducted previous research related to energy reduction and velocity in weirs. Then the data was recorded, both technical data and discharge plan data. Planned discharge data is the flow data used in planning. The planned flow used as the research flow has been scaled Meanwhile, technical data is the size data in the physical model.

The second stage is the preparation stage. This stage includes the preparation of the physical model and the tools used. In the preparation of the physical model, flow is carried out on the model to determine leaks or building damage. Further improvements were made. While the preparation of the tools includes the preparation of a current meter, a Thomson discharge measuring device, and a ruler as a measuring tool for flow depth. The third stage is the physical model test stage. The third stage includes testing the physical model, recording data, and treating *baffle blocks.* Physical model testing and treatment of *baffle blocks* includes 4 models type.

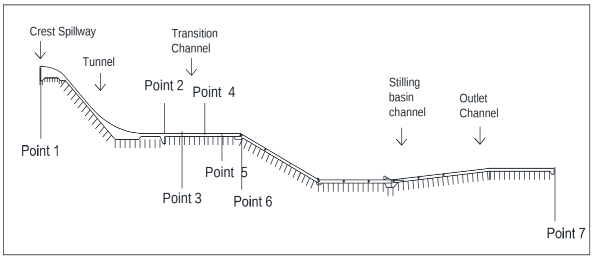

Figure 1 Measurement points for flow velocity and depth

Models type 0 (initial design) Models type 1, Models type 2, and Models type 3. In the initial design, 102 *baffle blocks* were installed in the transitional channel design. The data

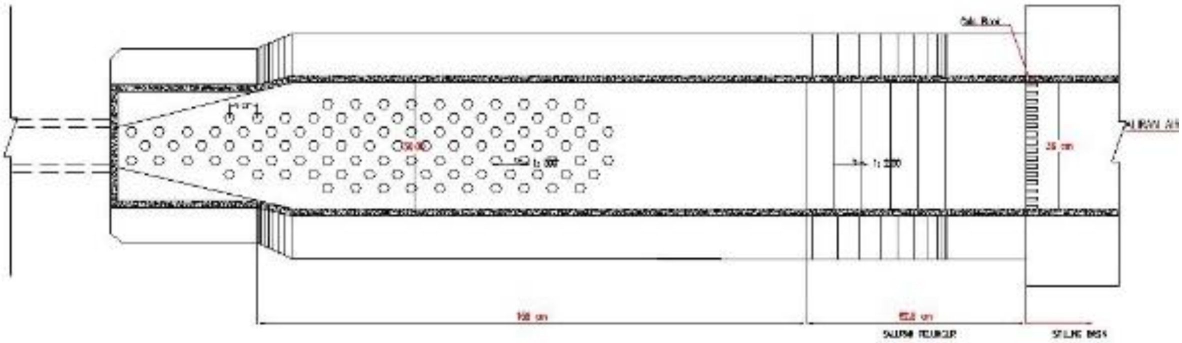

Figure 2 Model type 0

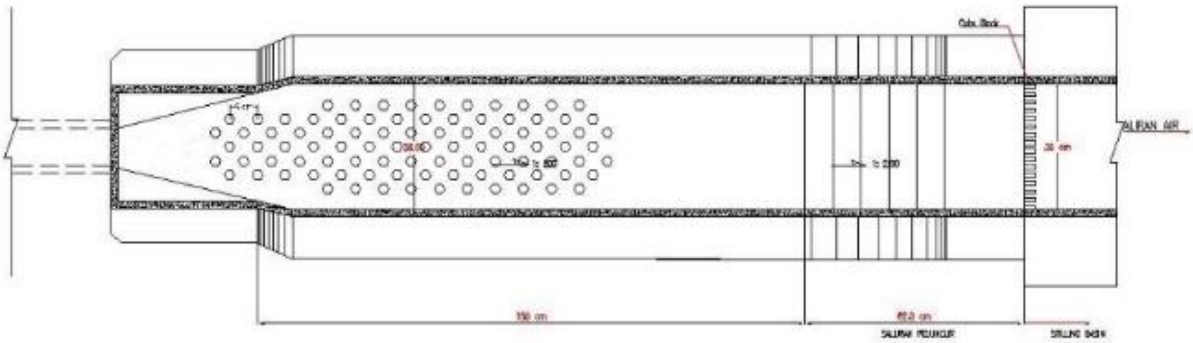

Figure 3 Model type 1

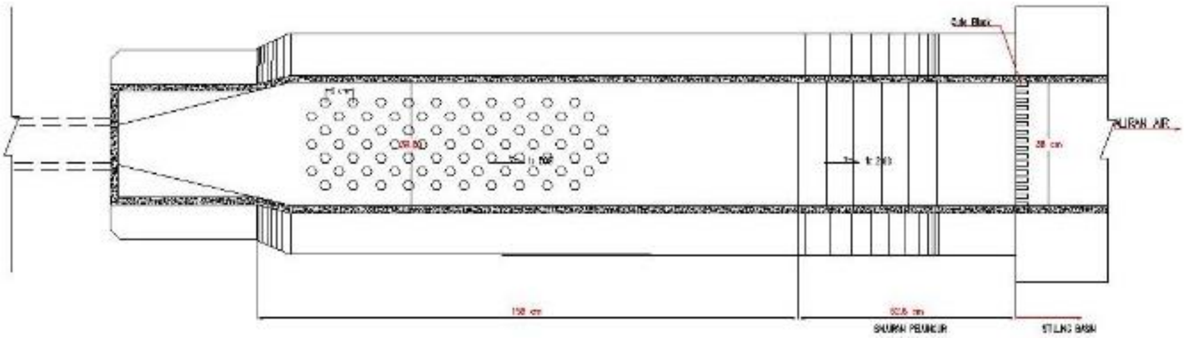

Figure 4 Type 2 model

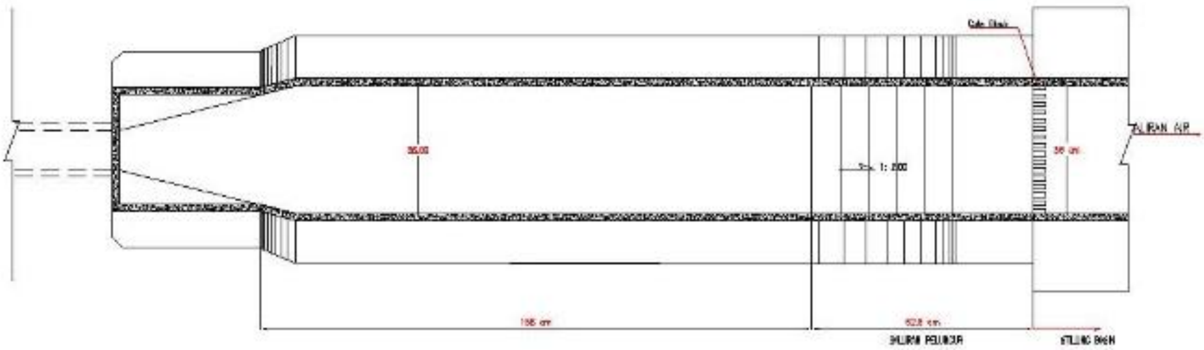

Figure 5 Model type 3

recorded were flowed depth data at 7, the velocity at 7 measurement points, and discharge on the Thomson gauge. The measurement position can be seen in Figure 1. The last stage is data processing. Data processing is done to determine the Models type which is more efficient with specific velocity and energy.

A. MODEL

Tukutaha dam is designed with the type of morning glory spillway, with a width of 70 cm and a radius of 50 cm. The transitional channel has a channel length of 196 cm, an upstream width of 16 cm, a downstream width of 36 cm, and a slope of 1: 500. *Baffle blocks* are used to reduce energy. The following are variations of the *baffle block* variations in this experiment:

1. Model Type 0
   Model type 0 is a *baffle block* installation pattern based on the initial design. In the model type 0, there are 102 *baffle blocks* with a hexagon shape. The image of model type 0 can be seen in Figure 2.
2. Model Type 1
   Models Type 1 do not change the initial shape of the *baffle block*. In the model type 1 the installation is based on CSU (Colorado State University) [4]. According to CSU, the *baffle block* design is determined to be a distance of 2 x width of the upstream channel or 2 x 11 cm = 22 cm from the upstream channel. In the model type 1, 9 *baffles* or 6 rows of *baffles* are removed. Figure model type 1 can be seen in Figure 3
3. Model Type 2
   In the model type 2 the *baffle block* is reduced to 75 *baffles*. The image of the model type 2 can be seen in Figure 4.
4. Model Type 3
   In the model type 3, there are no *baffle blocks* at all. Figure model type 3 can be seen in Figure 5.

B. SPECIFIC ENERGY

The specific energy is the amount of water depth with a high-velocity. Velocity is obtained by using a current meter measuring instrument. In general the amount of energy on channel cross-section is stated by:

$$E = d\cos\theta + \frac{\alpha V_A^2}{2g} \quad (1)$$

For a channel with a small slope of α = 1 the equation becomes

$$E = h + \frac{V_A^2}{2g} \quad (2)$$

(Anggrahini, 1997)

C. ENERGY LOSS

From equation (2) above, it can be calculated energy loss (ΔE)

$$\Delta E = E_1 - E_1 \quad (3)$$

So,

$$\Delta E = \left[h_1 + \frac{V_1^2}{2g}\right] - \left[h_2 + \frac{V_2^2}{2g}\right] \quad (4)$$

ANALYSIS AND DISCUSSION

Experiments were carried out on the physical model of the Tukutaha weir at the ITS Civil Engineering hydraulics and coastal laboratory. The data recorded and processed are flow velocity, flow rate, and flow rate. The velocity is obtained by processing the data on the number of turns obtained with a current meter. Flow depth is obtained by taking direct measurements using a ruler. Discharge is obtained by using a Thomson measuring instrument. Experiments were carried out with each of 5 variations of the water level above the lighthouse for each model type.

The following are the results of the calculation of velocity in the model type 0.

A. THE RELATIONSHIP BETWEEN FLOW VELOCITY AND DISCHARGE

The Relationship Between Velocity And Discharge In The 0 Model Type Is Shown In Figure 6.

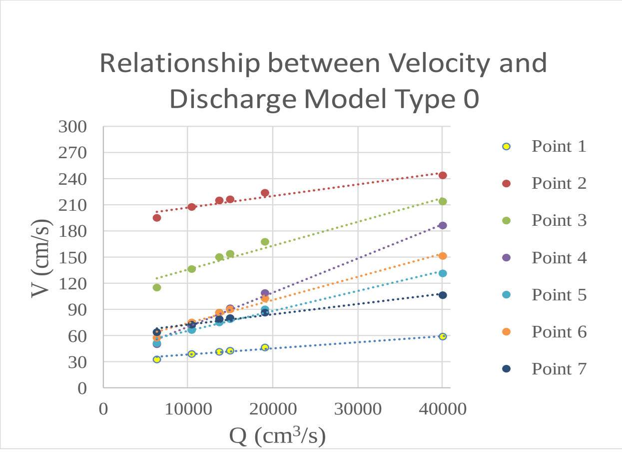

Figure 6 Graph of the relationship between velocity and discharge in model type 0

Based on Figure 6, it can be seen that the velocity of point 1 is more stable, namely at the upstream weir than the other measurement points or at the transition and downstream channels. Based on the Figure 6, it can be seen that the highest velocity is at point 2 and the lowest is at point 1. This is because the cross-sectional area is larger at point 1 and smaller at point 2. Based on the Figure 6, it can be seen that the greater the discharge value. then the velocity is getting bigger. Velocity at different discharges at each discharge can be seen in the following Figure:

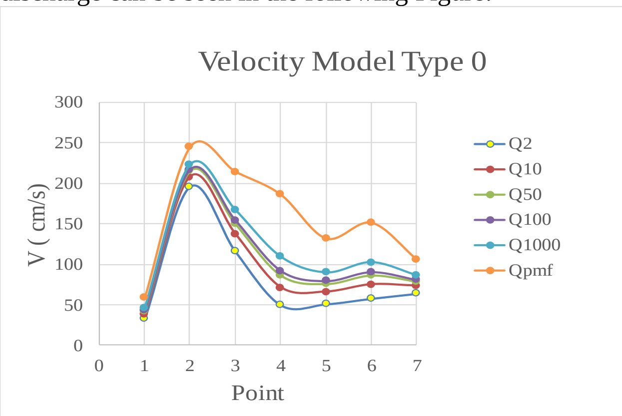

Figure 7 Graph of velocity in model type 0

From the Figure 7 it can be seen that the greater the discharge , the greater the velocity . The largest velocity is at Qpmf while the smallest speed is at Q2. From the Figure 7 it can be seen that the greatest velocity is at point 2 while the smallest velocity is at point 1. this is due to the greater depth at point 1, while the lowest depth is at point 2.

B. RELATIONSHIP BETWEEN SPECIFIC ENERGY AND DISCHARGE

The relationship between the specific energy and the discharge of the model type 0 is shown in Figure 7.

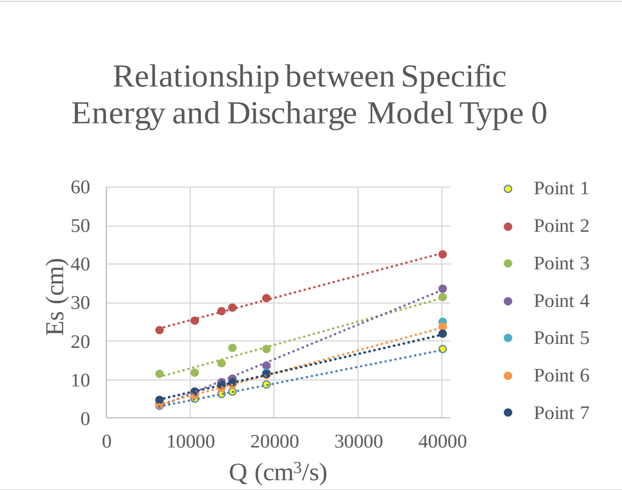

Figure 8 Graph of the relationship between specific energy and discharge in type 0

The Figure 8 shows that the largest specific energy is at point 2 while the smallest is at point 1. The Figure 8 shows that the greater the discharge value, the greater the specific energy. This is due to the increasing velocity and depth of the water level. Specific energy at different discharges at each discharge can be seen in the following figure:

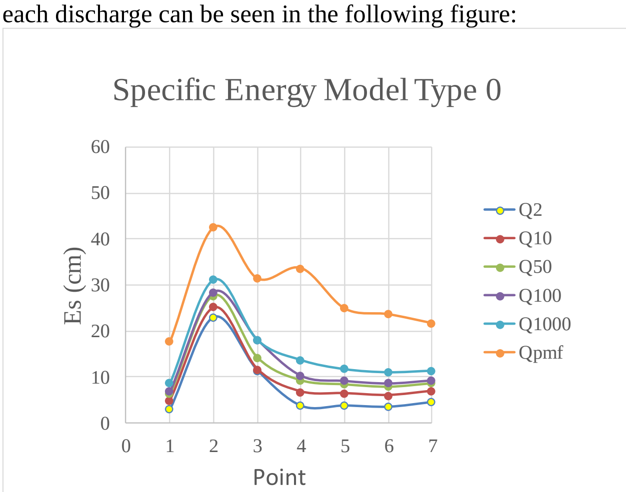

Figure 9 Graph of specific energy in model type 0

From the Figure 9 it can be seen that the greater the discharge, the greater the specific energy. The largest specific energy is at Qpmf while the smallest speed is at Q2. From the Figure 9 it can be seen that the greatest specific energy is at point 2 while the smallest specific energy is at point 1. this is due to the greater velocity at point 1, while the lowest velocity is at point 2

C. ALL MODELS TYPE VELOCITY ANALYSIS

Based on the calculation of hydraulic parameters in chapter A, velocity analysis is carried out by comparing the velocity model type 0, model type 1, model type 2, and model type 3. To see the most effective model type, an analysis is carried out on all models type.

In the Figure 10, each Velocity is the average of *froude numbers* of all points (point 1 to point 7). Based on the Figure 10, it is shown that the maximum velocity of the largest discharge is in model type 1. While the minimum velocity is in the model type 0. This is because at the discharge of 40164.79 cm3/s, the flow depth in model type 1 is smaller than the flow depth in model type 0. In the Figure 10 model type 0 is able to lower the velocity more than the other models. At maximum discharge, the tyoe 0 model has a lower velocity of 42,539 cm/s than the model type 1, 17,316 cm/s smaller than the model type 2 and 31,776 cm/s smaller than the model type 3.

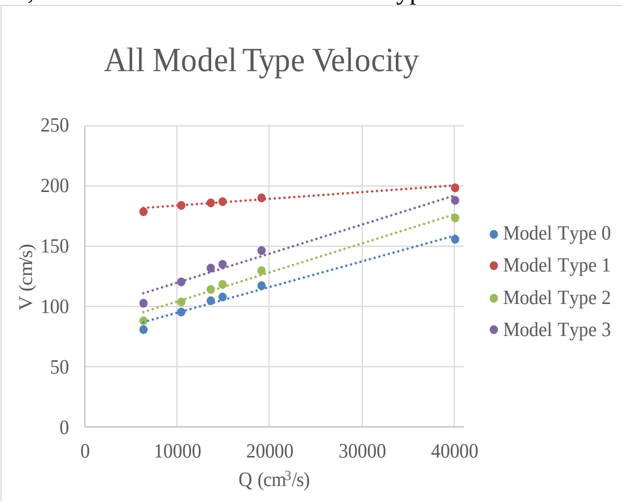

Figure 10 Graph of all model type velocity

D. ALL MODEL TYPE *FROUDE NUMBER* ANALYSIS

Froude number analysis is used to determine the type of flow. *froude number* graph can be seen in the Figure 11 below:

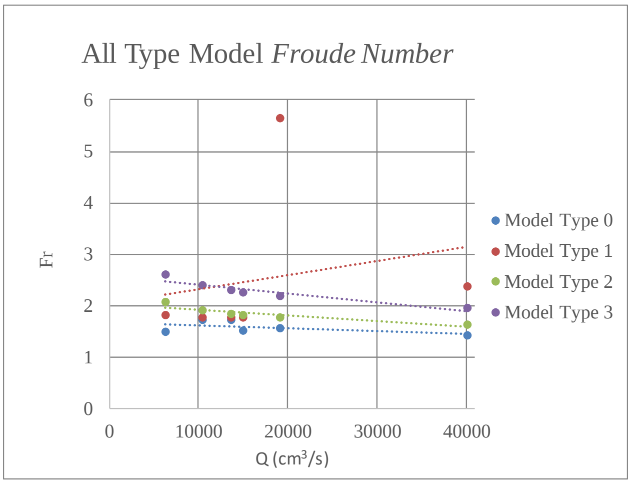

Figure 11 Graph of all models type *froude number*

In the Figure 11, each *froude number* is the average of *froude numbers* of all points (point 1 to point 7). The Figure 11 shows that the type of flow in all series includes supercritical flow (*Froude number* > 1). In the Figure 11, it is shown that the maximum discharge value is the smallest in model type 0 while the largest *froude number* is in model type1.

This is due to the high velocity in model type 1 due to the small flow depth, while in model type 0 the higher flow depth results in large velocity. So the model type 0 is considered to be able to reduce the *froude number*. At maximum discharge, the model type 0 has a smaller *froude number* 0.941 than the model type 1, 0.212 smaller than the model type 2 and 0.523 smaller than the model type 3.

E. ALL MODELS TYPE SPECIFIC ENERGY ANALYSIS

The relationship between the specific energy and the discharge all model type is shown in Figure 12.

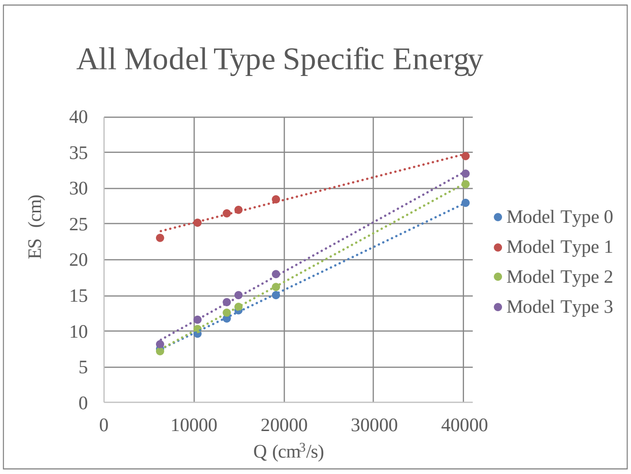

Figure 12 Graph of all model type specific energy

In the Figure 12, each Specific energy is the average of *froude numbers* of all points (point 1 to point 7). Based on the Figure 12, it is shown that the largest average specific energy is found in the model type 1 while the smallest average specific energy is in the type 0 model. This is because the largest velocity is found in the type 1 model and the smallest average velocity is in the model type 0. At maximum discharge, the model type 0 has a specific energy of 6,505 cm smaller than the type 1 model, 2,632 cm smaller than the model type 2, and 4,195 cm smaller than the model type 2.

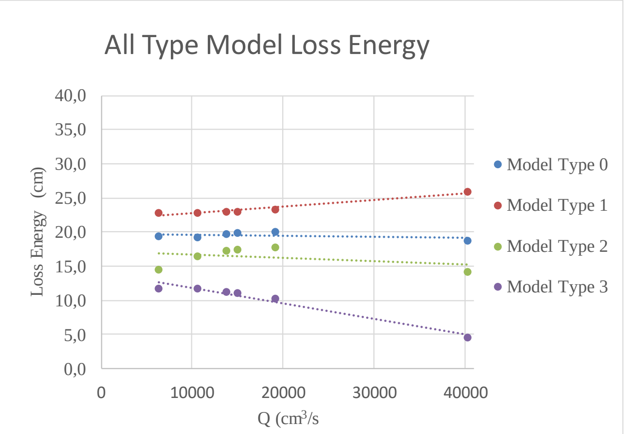

Figure 13 Graph of all models type energy loss

F. ALL MODELS TYPE ENERGY LOSS ANALYSIS

The energy loss is calculated by subtracting the specific energy upstream from the transition downstream. The measurement point upstream of the transition channel is point 2 and the downstream measurement point of the transition channel is point 6. So to calculate the energy loss in the transition channel is to subtract the specific energy of point 2 with the specific energy of point 6.

The calculation results of the specific energy loss for each discharge at each point are shown in Figure 13. In the Figure 13, it can be seen that the largest energy loss at the maximum discharge is in type 1 model. There is an energy loss of 25,943 cm, while the smallest energy loss is in type model 3 of 4.55 cm. The type 1 model is able to absorb 7,111 cm more energy than the type 0 model, 4,630 cm more than the type 2 model and 14,277 cm more than the type 3 model.

G. ALL MODEL TYPE ENERGY LOSS PERCENT

The calculation of the percent loss of energy aims to determine the most effective Model type or to find out which type of model reduces the energy the most. The percent energy loss is calculated by dividing the energy loss previously obtained in section E by the energy at the upstream point of the transition channel (point 6) multiplied by 100%. The results of the percent loss of energy is shown in the figure 14.

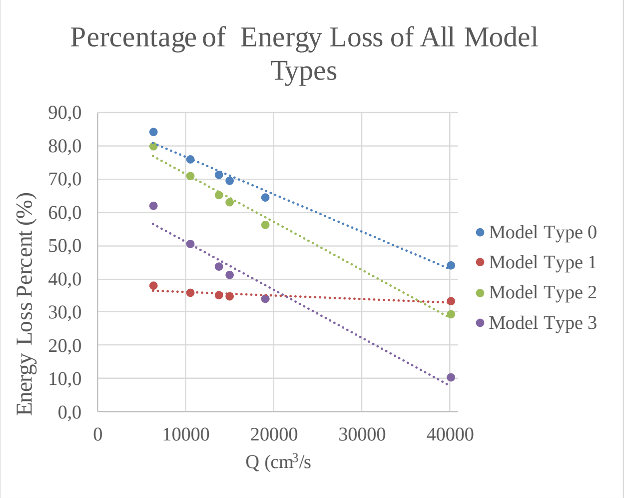

Figure 14 Graph percentage of energy loss of all model types

The Figure 14 shows that at maximum discharge, the model type 0 is able to reduce energy more than the other models type, which is 44.247%, while the type 3 model is able to reduce energy less than the other models type, which is 10.445%. From the Figure 14, it can be seen that the model type 0 has 10,821% greater energy loss % than the type 1 model, 14,889% greater than the model type 2, and 33,802 % greater than the model type 3.

CONCLUSION

1. Based on the analysis of the velocity results, the model type 0 produces the lowest velocity of all models type. Based on the analysis of the velocity results at the maximum discharge the model type 0 is able to provide the smallest average velocity compared to the 3 other models type . The model type 0 has a velocity that is 21.4% less than the model type 1, 9.98% less than the model type 2 and 16.9% less than the model type 3.
2. Based on the analysis of the results of the *froude number* model, the model type 0 produces the lowest *froude number* of all model type. At the maximum discharge the model type 0 is able to produce the smallest average *froude number* compared to the other models. The model type 0 has a velocity of 39.94% less than the model type 1, 13.02% less than the model type 2 and 26.98% less than the model type 3.
3. Based on the analysis results, the lowest specific energy is found in the model type 0. The model type 0 is able

to produce a specific energy of 18.85% lower than the model type 1, 8.56% lower than the model type 2, and 13.02 % lower than the model type 3.

4. Based on the results of the energy loss analysis on the transition channel model type 0 gives the largest energy loss of all models type. The models type 0 reduce energy 10.821% more effectively than the type 1 models, 14,889% more effectively than the models type 2 and 33,803% more effectively than the models type 3.
5. Based on the analysis of % energy loss in the transition channel, the model type 0 produces the largest energy loss. The model type 0 at maximum discharge has a % energy loss 10.821% greater than the model type 1, 14.889% greater than the model type 2 and 33.02 % greater than the model type 3.

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