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SIGMA-1 EKSAKTA

Review of the Tegalwaru Weir Design Using the Tyrolean Weir Model and the USBR Model Energy Damper

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Abstract : Tegalwaru Dam is a permanent weir located in Sumber Kejayan Village, Mayang District, Jember Regency which serves an irrigation area of 85 Ha. Over time, the Tegalwaru weir, which was built in the Mayang watershed, experienced some damage. Therefore, an assessment of the effectiveness of the Tegalwaru Dam was carried out by constructing a USBR energy dampening building and also planning the type of weir using the *Tyrol weir*. The aim of this research is to find the planned flood discharge at the Tegalwaru weir by utilizing HEC-HMS software and to be able to plan the weir building using the Tyrol weir and design an appropriate energy dampening building for the weir. From the research results, it was found that the planned flood discharge at the Tegalwaru weir was 150.7 m ^{3}/sec which occurred on December 24 2014. The planned weir at the Tegalwaru weir used the Tyrol weir type with a filter slope of 20˚ and a filter length of 1 meter with a wide storage channel. 1.6 meters wide and the reservoir channel is 1 meter deep. To reduce energy, use a USBR type IV energy reducer.

Keywords: Tegalwaru Dam; Tyrol Weir; USBR Energy Reducer.

INTRODUCTION

A weir is a building made from stone masonry, gabions or concrete, which is located across a river, which of course can also be used for purposes other than irrigation, such as for drinking water, electricity generation or for flood control. According to the type of weir, it is divided into two, namely permanent weirs and temporary weirs. Permanent weirs are buildings whose construction mostly consists of doors that can be moved to regulate the height of the river water level, while non-permanent weirs are structures that are used to raise the water level in the river, up to the height required so that water can be channeled to irrigation channels and tertiary plots (Mangore et al, 2013) .

Geographically, Tegalwaru Dam in Jember Regency is located at coordinates 8˚10'33.14" south latitude and 113˚50'22.21" east longitude. The Tegalwaru Dam, which was built in the Mayang river basin, not only functions to raise the water level of the weir, but also functions to irrigate the irrigation area in Mayang District with an area of 85 hectares covering 3 areas, namely in Sumber Kejayan Village, Tegalrejo Village and Tegalwaru Village.

In the current condition, the Tegalwaru Dam is experiencing damage in several parts, including a fairly high accumulation of sedimentation in the upstream part of the weir due to the flushing door being damaged and unable to operate properly. The accumulation of sedimentation occurred due to the porousness of the flushing floor so that the flushing door could not be opened which was useful for flushing out sedimentation upstream of the weir. Other damage was the collapse of the retaining wall at one of the downstream parts of the weir. The collapse of the retaining wall downstream of the weir was caused by the high surge of water from the weir beacon when there was a very high peak flood discharge, resulting in significant soil erosion in one part of the weir structure. This erosion occurred due to the overflow of water flowing from the Mercu Weir.

To prevent scour downstream of the weir, an energy damper is made, the energy dampening building which is usually used is a stilling *basin* . The type of stilling pond that will be planned downstream of the weir depends on the energy of the water flow that jumps from the weir beacon and enters the stilling pond, which is expressed by the Froude number. To overcome the sedimentation that accumulates in the upstream part of the weir, a filter must be made to rinse out floating sedimentation in the river. Therefore, a type of weir is planned using a *Tyrol weir* which can tap river water and rinse out fine sedimentation in the river flow using filters and collecting channels.

The aim of conducting research on the Tegalwaru weir is to be able to analyze the planned flood discharge that occurs at the Tegalwaru weir, apart from that, we can also plan energy reducing buildings that are suitable for the Tegalwaru weir and to be able to determine the pressure force and lifting force of water due to water seepage under the Tegalwaru weir. .

METHOD

Research sites

Tegalwaru Dam was built in Sumber Kejayan Village, Mayang District, Jember Regency, East Java Province with coordinates of 8˚10'33.14" S and 113˚50'22.21" E.

Figure 1. Location of Tegalwaru Dam

Source: Google Earth Pro 2023

Data collection

1. Data collection in this research was carried out in two ways, namely:

Primary data

Primary data is data obtained in the field by making direct observations at the research location. These data are in the form of:

- Weir elevation data
- Weir technical measurement data in the field
- Tegalwaru weir documentation
- Making watershed maps, Thiessen polygon maps, land cover maps, soil type maps, slope maps and overlay maps

Secondary Data

Secondary data was obtained from related agencies and also from the Mayang general observer service. The data is in the form of:

- Rainfall data for the last 10 years starting from 2012 to 2021.
- National Digital Elevation Model (DEMNAS) SHP data
- Indonesian Earth SHP Data (RBI)
- Data on SHP of soil type and SHP of land cover
- Data on river water level and intake discharge.

RESULTS AND DISCUSSION

A. Determining Average River Slope

According to (Mangore et al, 2013), in determining the average river slope, the river bed slope is measured on average as far as 2 km from the weir location. After the researchers carried out measurements at the Tegalwaru weir, they obtained an average river slope of 0.018, with the initial step of determining the stake points 500 meters upstream and downstream of the weir using the Google Earth 2023 application. Next, the height difference between one stake and another was measured using the Google Earth 2023 application. a distance of 100 meters, so that the height difference between one stake and another is obtained. The next step is to calculate the average of each stake to obtain an average river slope of 0.018

Table 1 Determining Average River Slope

No	Stake No	L(m)	Elevation (m)	ΔH (m)	ΔH/L
1	P10	100	256	4	0.04
2	P9	100	252	0	0
3	P8	100	252	1	0.01
4	P7	100	251	2	0.02
5	P6	100	249	4	0.04
6	P0	100	245	1	0.01
7	P5	100	244	1	0.01
8	P4	100	243	2	0.02
9	P3	100	241	0	0
10	P2	100	241	3	0.03
11	P1		238		
Amount		1000	2712	18	0.18
i = 0.018 (Average River Slope)					

Source: Calculation Results

B. Effective Width of Weir

The width of the weir is the same as the width of the river around the Tegalwaru weir. From the results of calculations and measurements in the field, it was found that the width of the weir was 20 meters wide. According to (Mangore et al, 2013) the effective width of the weir is the width of the weir that works effectively to pass discharge in the river. In determining the effective width of the weir at the Tegalwaru weir, the effective width of the weir is measured in the field using a roll meter. This measurement is carried out by measuring the weir axle from the left side wall of the weir to the right side wall of the weir so that we get a width of 20 meters.

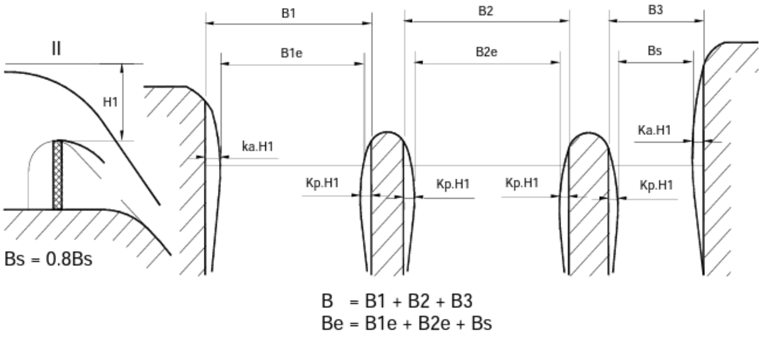

Figure 2 Effective width of the weir

Source: Irrigation Planning Standard, KP-02, 2013

C. Determining the Height of Flood Water Above Mercu

To determine the height of the flood water above the mercu weir, trials are carried out by entering the H1 and Cd values until a trial and error Cd value is obtained which is the same as the result of the calculated Cd value. From the calculation results, it was found that the Cd value was trial and error with the same calculated Cd value, namely 1.215, so the Cd value was acceptable. The height of the flood water above the mercu is the height of the water between the river water level and the mercu weir. According to (Mawardi and Memed, 2010) the water level above the mercu can be calculated using the energy height – discharge equation. This energy level can be calculated using an equation $Q = Cd\ .\frac{2}{3}\ .\sqrt{\frac{2}{3}\ g.Be.H^{1\ 1.5}}$ to obtain a flood discharge of 150.7 m ^{3}/s at the Tegalwaru weir with an H1 value of 2,365 and a trial Cd value of 1,215. After obtaining the value of H1 and Cd, try it out, then a calculation is carried out to get the calculated Cd value. The calculated Cd value is obtained from the C_0, C_1 and $C_{2\ values}$ from the graph. From the graph, the C_0 value is 1.3, the $C_{1\ value}$ is 0.93 and the $C_{2\ value}$ is 1.005, then calculations are carried out to obtain a calculated Cd value of 1.215. The condition for the Cd value is acceptable if the Cd value is the same as the calculated Cd value. From the calculation results, it is obtained that the Cd value is trial and error with the calculated Cd value being the same so that the Cd value is acceptable.

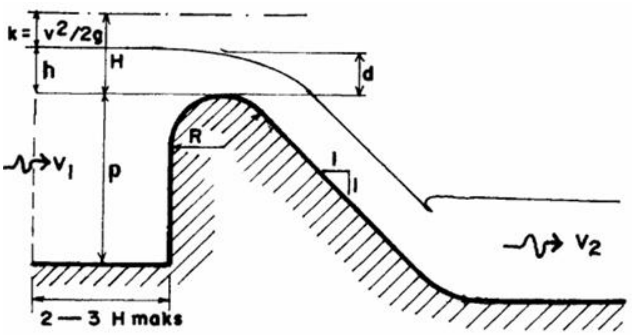

Figure 3 Water height above Mercu

Source: Fixed weir hydraulic design, Mawardi and Memed, 2010

D. Determining the Mercu Weir Type

The planned type of lighthouse is an Ogee type I lighthouse. From the planning results using a type I Ogee lighthouse, calculation results were obtained on the X axis of 0.386 meters and on the Y axis of 0.041 meters. According to (KP Irrigation Planning Standards – 02, 2013) mercu weirs are still divided into 2, namely mercu round and mercu ogee. In ogee lighthouses, there are four types of ogee lighthouses, namely types I, II, III and IV. Type I ogee beacons have beacon radii of 0.2 and 0.5 with a radius distance of R1 0.175 and R2 0.282. then calculations were carried out to obtain R1 and R2 values of 1,183 meters and 0.473 meters with a distance of R1 and R2 of 0.414 meters and 0.667 meters. The next step is to find the X axis and Y axis with a downstream slope of 1:1 and a K value of 1,873 and an N value of 1,776, which is then calculated to obtain a downstream slope on the X axis of 0.386 meters and the Y axis of 0.041 meters.

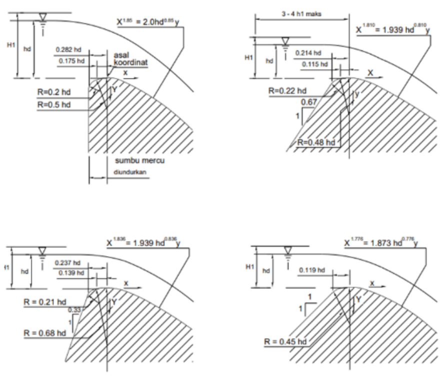

Figure 4 Types of Ogee Mercu

Source: Irrigation Planning Standard, KP-02, 2013

E. Determining the Weir Type

The planned weir model is to use the *Tyrol weir model* . From the calculation results, the result is a filter length of 1 meter with a filter slope of 20˚. The storage channel has a channel width of 1.6 meters and a channel depth of 1 meter which will later be continued to the irrigation channel. The *Tyrol* weir or lower filter weir is a type of weir that is useful for filtering sediment and tapping the water flow that passes through the weir. Based on the results of his research (Annisa et al, 2016), to plan the *Tyrol weir* , it is necessary to first plan the slope and length of the filter as well as the width and depth of the storage channel. To find the length of the filter, it is necessary to plan the slope of the weir filter at 20˚ with a coefficient of 0.837 and a μ value of 0.62 and the cross-section of the channel profile using 100 x 50 WF iron. Then from the planning data it is obtained that the number of rods is 250 rods, the length of the filter grille openings is 20 meters long. meters and the percentage of openings for the correction rod lattice is 0.374%. The next step is to carry out calculations to obtain a tapping capacity length of 1 meter. To plan the storage channel, the width of the storage channel is planned to be 1.6 meters wide and the flow rate in the storage channel, uniform water depth and flow velocity in the storage channel are calculated, so that the depth of the storage channel is 1 meter deep.

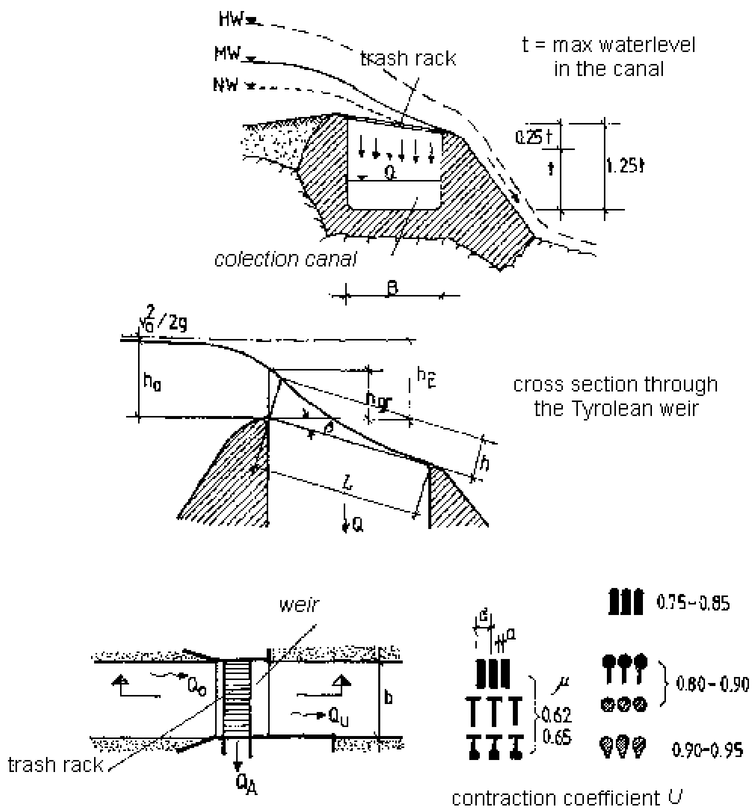

Figure 5 ***Hydraulics Design of a Bottom Intake***

Source: Planning for intake structures, Bucur et al., 2014

F. Determining the Type of Energy Reducer

The energy reducer used in the Tegalwaru weir uses a USBR energy reducer. From the calculation results, it was found that the foam value was 3,170, therefore a USBR type III energy reducer was used with a stilling pool length of 23,691 meters and an endsill height of 1,761 meters. An energy damper is a water structure that functions to reduce energy from the abundant flow of river water from the Mercu Weir to the stilling pond. USBR energy absorbers consist of type I to type IV. According to (Rahardjo et al, 2006) the type of USBR energy reducer used depends on the size of the Froude number. For USBR type I energy absorbers, the stilling pool is built in the form of a ground floor because this energy absorber is only suitable for flowing relatively small discharges with a small energy absorbing capacity. Type II USBR energy absorbers are built with river discharge > 45 m^3/sec/l with hydrostatic pressure > 60, and Fr > 4.5). For type III USBR energy absorbers, it is built with a river discharge of > 18.5 m3/s/m and Fr > 4.5 and for type IV USBR it is built for an Fr number between 2.5 to 4.5.

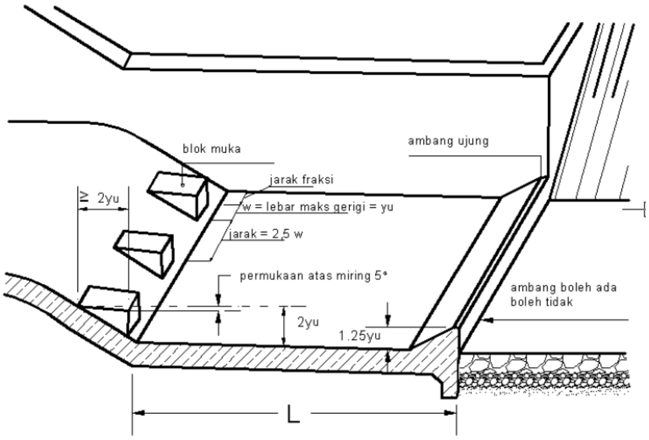

Figure 6 USBR Type IV Energy Reducer

Source: Irrigation Planning Standards, KP-04, 2013

CONCLUSION

From the research results, it was concluded that the average river slope around the Tegalwaru weir has a slope of 0.018 meters with a weir width of 20 meters. The lighthouse used uses an Ogge type 1 lighthouse with a downstream surface slope of 1:1 with the weir model used using the *Tyrol weir model* . the length of the filter is 1 meter and the filter tilt angle is 20˚. The depth of the filter collecting channel is 1 meter deep and the width of the filter collecting channel is 1.6 meters wide and the Froude number obtained is 3,171, therefore the energy reducer used is a USBR type IV energy reducer.

REFRENCES

Annisa, F. W., Samah, M., & Utama, L. (2016). Perencanaan Bendung Saringan Bawah Sungai Salido Kecil Kecamatan Iv Jurai Kabupaten Pesisir Selatan. *Abstract of Undergraduate …*. https://www.ejurnal.bunghatta.ac.id/index.php?journal=JFTSP&page=article&op=view&path%5B%5D=9639

Bucur, D. M., Dunca, G., Cervantes, M. J., Clinoiu, C., & Isbşoiu, E. C. (2014). Simultaneous transient operation of a high head hydro power plant and a storage pumping station in the same hydraulic scheme. In *IOP Conference Series: Earth and Environmental Science* (Vol. 22). https://doi.org/10.1088/1755-1315/22/4/042015

KP-02, S. perencanaan irigasi dan umum. (2013). Standard Perencanaan Irigasi. Kriteria Perencanaan Bagian Bangunan Utama (Headworks) KP-02. *Puslitbang Air*, 240.

KP-04, S. perencanaan irigasi dan umum. (2013). *Standar Perencanaan Irigasi KP-04: Bangunan*. 391.

Mangore, V. R., Wuisan, E. M., Kawet, L., & Tangkudung, H. (2013). Perencanaan Bendung Untuk Daerah Irigasi Sulu. *Jurnal Sipil Statik, 1*(7), 533–541.

Mawardi, E., & Memed, M. (2010). Desain Hidraulik Bendung Tetap untuk Irigasi Teknis. *Alfabeta*, 1–80.

Rahardjo, K., Yuwono, H. J., Surbakti, S., Harsari, I. W., Purwanto, H., Fuadi, S., Witjaksono, A., & Soewarni, I. (2006). STRATEGI PEMILIHAN PEREDAM ENERGI. *Spectra*, *IV*(8), 50–59.