HYDRAULICS SIMULATION OF RUBBER DAM FOR OPERASIONAL AND EMERGENCY RESPOND GUIDELINES IN WEST FLOOD CANAL, SEMARANG, INDONESIA

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ABSTRACT

West Flood Canal (KBB) is a flood control river in the middle & west areas of Semarang, Central Java, Indonesia. A rubber dam is being built at downstream of the River to prevent sea water intrusion and facilitate rowing. There is permanent dam at upstream the river, Simongan dam, which is approximately 2 km away. The operation of rubber dam is controlled from the water elevation in Simongan dam. It is necessary to simulate the hydraulics of the water condition between the rubber dam and Simongan dam. The research aims to simulate several scenarios of emergency conditions in rainy season and compile parameters for rubber dam operation and parameters for early warning system. The methods of the research are survey, observation and field measurement. The hydraulics simulation is conducted with the help of HEC-RAS program with validation of field observation and measurement. The result of the research is used for operational rubber dam guidelines in two conditions which must be considered by rubber dam operator. During the existing condition, the rubber dam was upfront when the water level above the Simongan dam Spillway 1.4 m with a flood discharge of 199.20 M3 / sec. Then after normalization the rubber dam could be opened when the water in the Simongan weir reached 3.30 m or flood discharge was 740 m3 / sec. A live-stream observation instrument will be installed in the next research to facilitate the rubber dam operation and validation of more detailed simulation result.

Keywords: rubber dam, operational, emergency, flow rate, elevation, simulation

1. INTRODUCTION

Semarang city has two large rivers as flood control. The two rivers are West Flood Canal (KBB) and East Flood Canal (KBT). The West Flood Canal is the longest river in Semarang city whose main function as flood control and in addition to being a place for taking upstream drinking water and becoming an inlet for several city drainage channels downstream. (Roehman, F. et al. 2019)

This river is a meeting point of three rivers, namely Kreo, Kripik and Garang River. The meeting point of those three rivers is in the upper Simongan weir. During extreme rainy weather, where the rainfall intensity is more than 200 mm, the morphological capacity of the existing conditions of the western flood canal is unable to accommodate the water discharge from these three rivers causing water to overflow and flood. Based on this experience, the government adopted a policy to control flooding through three components, namely the Normalization of the West Flood Canal, the construction of the Jatibarang dam and the arrangement of the Semarang City drainage system. Normalization of the West Flood Canal and Kali Garang is a project of the central government to control floods. (Adi H. P. and Wahyudi S. I., 2018). Technical works carried out are dredging, widening, strengthening embankments to increase the capacity of the West Flood Canal water discharge so that it is able to accommodate the flow of the three rivers above and the water does not overflow to the mainland. (Liao, Le and Nguyen, 2016)

Many improvements have been made in the West Flood Canal, which is primarily a flood management project, and also serves as one of the Tourism Destinations. The construction was carried out simultaneously in the upstream area to realize the Jatibarang Reservoir, then carry out the normalization of the western flood canals to the estuary. Structuring downstream of the West Flood Canal which is carried out for the position, namely around Simongan Dam and the construction of the Rubber Dam in its downstream.

From 2010 to 2015, the Normalization of Garang River and West Flood Canal have been carried out. Then in 2017 until 2019, the construction of the Rubber Dam was constructed. The function of the weir as a reservoir of water for raw water is needed during the dry season, preventing intrusion of sea water entering the land, and other benefits which can also be used as a means of rowing water sports. During the rainy season, the rubber dam can be opened to drain the flood. (Hunter *et al.*, 2017)

The construction of the rubber dam in the West Flood Canal is expected to cause backwater in the upstream part of the weir. Backwater is caused by the backflow of river water upstream when the weir closes. As a result of the backwater, the water elevation upstream of the weir will slowly rise. If the capacity of the river is insufficient, it is feared that water can close the city drainage outlets and also run off to the right and left side of the river and cause inundation in the upstream area of the rubber weir. (Muis *et al.*, 2016)
To minimize the risk of backwater in the Weir Dam, operational guidelines and emergency responds are needed to the weir by making hydraulic simulation. The simulation results are also useful for reviewing the height of the parapet upstream and the elevation of the drainage channels of residents entering the river. (Slinger, 2017)

Figure 1. Location and rubber dam system downstream of the West Flood Canal

The purpose of this research activity is to determine the extent to which the effect of backwater on the river channel in the upstream of the West Flood Canal Movement. The effect is reviewed on the elevation of drain outlets and river revetments.

This study aims to present a backwater simulation in existing conditions and after re-dredging. Then, the formulation for the operation of the weir with two scenarios of existing conditions and conditions after river normalization are presented.

2. RESEARCH METHOD

This research method includes the stages of data collection, data analysis and hydraulic simulation. Simulation results were used as operational guidelines and emergency responses for rubber dams.

2.1 Data Collection Technique

Data collected were in the form of primary and secondary data. Primary data were data obtained by direct field measurements and observations which include measurements of river dimensions, drainage network inventory entering the river and observations of water elevation in the Simongan Dam. Whereas secondary data were obtained from several institutions related to rainfall, debit data from previous readings. (Andrea G. et al., 2016)
River dimensions are measured to determine the cross-profile of the river, including the cross-sectional dimensions and elevation of the channel base and the wet cross-sectional area of the channel. This measurement is carried out using a measuring instrument that is the total station and measuring basket. Observations were also made of water elevation in Simongan Dam. Then inventory of drainage channels enters the river upstream of the West Flood Canal rubber dam. Observations were made to verify the impact of backwater on this drainage inlet. (Triyanti *et al.,* 2017)
For secondary data, rainfall data were obtained from BMKG Tanjung Mas Semarang Maritime Meteorological Station 2011 - 2017. While the discharge data used were the maximum annual flood discharge data at Simongan Dam. Simongan weir curve rating was in the form of water elevation data in Simongan weir and the maximum flowing flow. (Wahyudi S. I. *et al.,* 2017)

2.2 Data Analysis Stage

The KBB Catchment Area (CA) as a whole has an area of 200.17 km^2. The Catchment area consists of three large areas in the upstream and one small area downstream. The three CA consist of the Garang Sub-watershed with an area of 94.56 km^2, the Kripik Sub-watershed with an area of 37.50 km^2, and the Kreo Sub-watershed with an area of 64.67 km^2. Then a small CA called Bulu drain with an area of 3.43 km^2, for the Das Kreo sub has a reservoir on its head. Next is the picture of the three big CA sub-regions and one small CA sub.

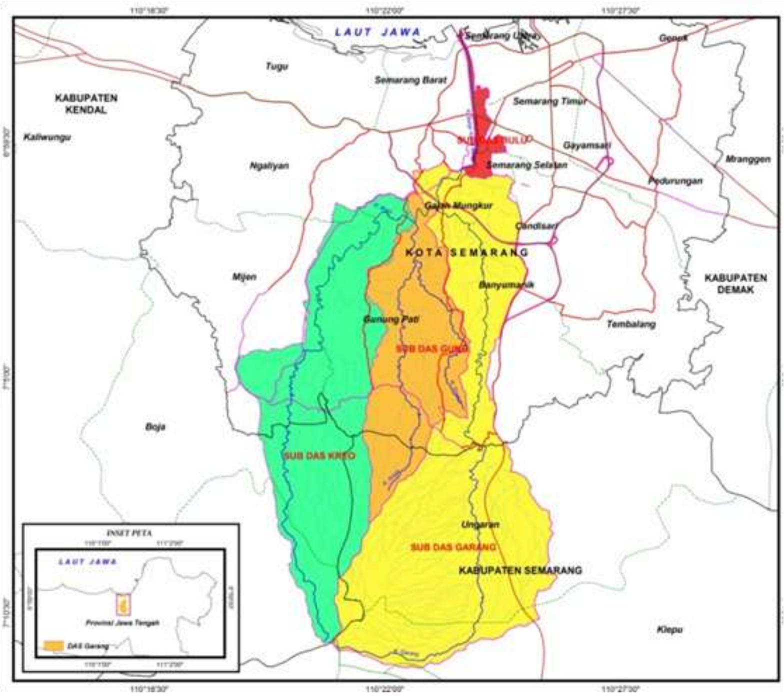

Figure 2. Map of Kreo River Catchment Area (green), Kripik River Catchment Area (orange), Garang River Catchment Area (yellow), and Bulu River Catchment Area (red)

This catchment area is used as a basis for hydrological analysis to obtain flood discharge plans and hydrograph units. (Le Cozannet *et al.*, 2015)

2.2 The Hydraulic Simulation Stage

The boundary conditions of the hydraulic simulation are made based on the operational stages that will be applied, namely the condition of the rubber weir with the river that has not been normalized (dredged) and the condition of the river after normalization. The hydraulics simulation in this study used the help of the HEC-RAS 4.1.0 program. (Giustolisi et al, 2014)The primary data from the results of the Semarang City Flood Canal measurement are input complete with coordinates and elevation to determine the wet cross-sectional area of the river, the slope of the river bed and other required river hydraulic data. Analysis of flow patterns used the fixed flow and non-permanent flow methods. Hydraulic analysis needs to take into account the backflow due to a weir using the elevation data for each cross section of the river. (Giustolisi et al., 2014)

The simulation results are used as an operational basis, especially in the location of the West Flood Canal Dam Weir to Simongan Weir. Then control the elevation of the inlet of the drainage channels of residents entering the river upstream of the weir. Following are the locations which are simulated in the figure 3. We can see position of Simongan dam and Rubber5 dam in the figure.

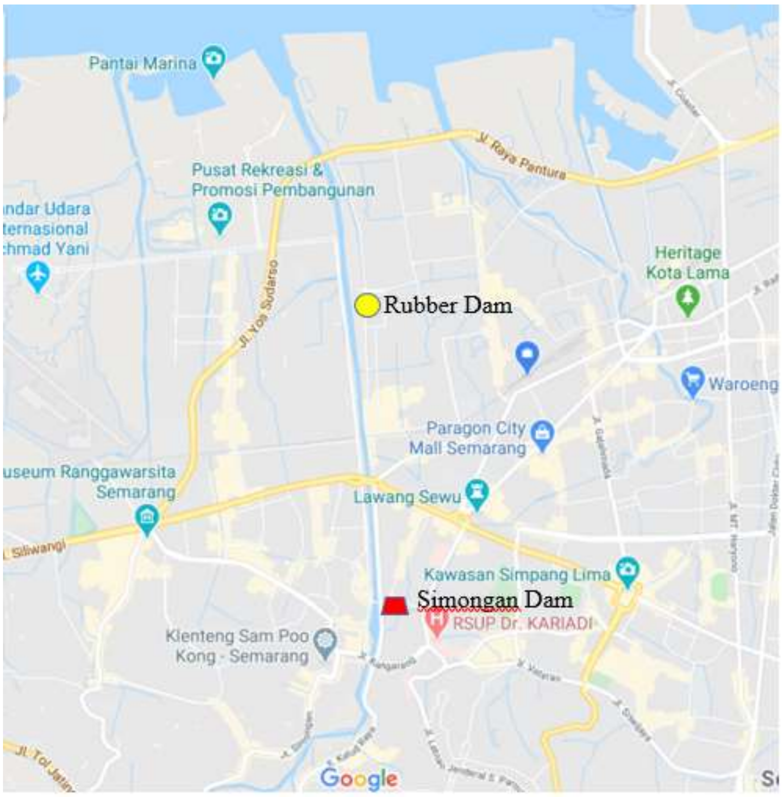

Figure 3. Location of simulation research reviewed

3. RESULT AND DISCUSSION

The results presented in this study are the correlation curve rating between dam water level and runoff discharge in Simongan dam, then the hydraulic simulations was done with two operational scenarios. The first simulation in the existing condition (before normalization) and secondly simulation in the condition after normalization (dredging). The simulation result will be based for operation procedure. (Wahyudi S. I. *et al.*, 2017)

3.1 Rating Curve Correlation of Dam Water Level and Runoff Discharge of Simongan Dam

The discharge data used was the maximum annual flood discharge data at Simongan Dam. The following is the Simongan Weir Rating Curve.

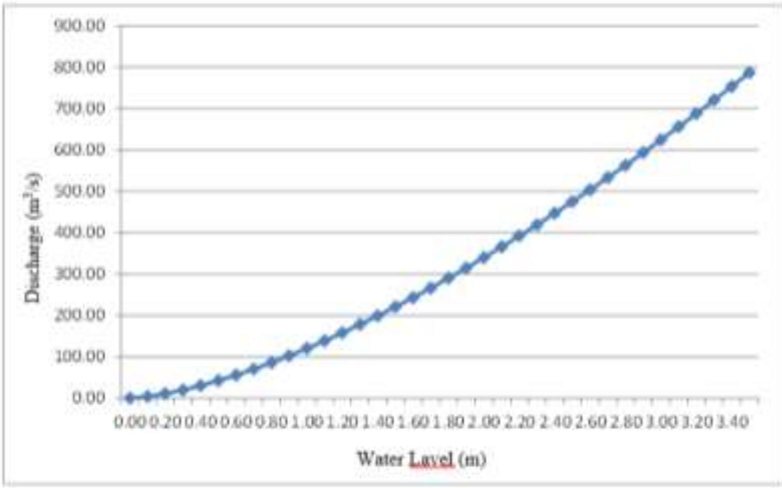

Figure 4. Rating Curve Correlation of high water and runoff discharge at Simongan Dam

The figure of normalization was according to the first design. It can be seen samples of cross sections on sta 1 + 900 or 200 m length up stream of the rubber dam, or cross section from the Railway Bridge towards the rubber dam of the West Flood Canal of Semarang City. The River has about 100 m wide and 4 m depth. (Kuehn *et al.*, 2010)

3.2 Operational Scenarios for Existing Condition

The first scenario was the current condition of the West Flood Canal (before normalization). The measurement was done using cross section data of the West Flood Canal. The results of the last measurement can consider as sedimentation. Runoff discharge used was taken from Simongan Dam. Table during first mitigation, the water level above the dam was 1.40 m 'with Q = 199.02 m3 / sec. The simulation results is presented on the following table.

Table 1. The Result of Scenario C Simulation (Readiness I)

Sta measurement	Sta HAC-RAS	Q m3/s	Elv Basic channel (m)	flow speed (m/s)	Number Froude	Elv. Water Lavel	Elv. embankment left (m)	Elv. embankment righ (m)	Elv. Fibord Water Level left (m)	Elv. Fibord Water Level righ (m)	explanation
0 + 100	5000	199,02	0,03	1,78	0,44	2,270	8,140	8,140	5,870	5,870	
0 + 200	4900	199,02	-1,27	1,14	0,22	2,300	4,390	6,960	2,090	4,660	
0 + 300	4800	199,02	-0,77	1,25	0,27	2,270	3,390	6,930	1,120	4,660	
0 + 400	4700	199,02	-0,56	1,27	0,27	2,240	3,550	6,670	1,310	4,430	
0 + 500	4600	199,02	-1	1,1	0,22	2,230	5,550	6,520	3,320	4,290	
0 + 600	4500	199,02	-0,61	1,3	0,28	2,180	5,950	6,330	3,770	4,150	
0 + 700	4400	199,02	-0,47	1,4	0,32	2,130	5,810	6,290	3,680	4,160	
0 + 800	4300	199,02	-0,31	1,46	0,34	2,080	5,700	6,460	3,620	4,380	
0 + 900	4200	199,02	-0,82	1,4	0,32	2,040	5,490	5,880	3,450	3,840	
1 + 000	4100	199,02	-0,38	1,37	0,31	2,010	4,980	5,790	2,970	3,780	
1 + 100	4000	199,02	-0,85	1,35	0,3	1,980	4,690	5,450	2,710	3,470	
1 + 200	3900	199,02	-1,07	1,22	0,26	1,960	4,210	5,290	2,250	3,330	
1 + 300	3800	199,02	-0,57	1,42	0,32	1,900	5,230	5,700	3,330	3,800	
1 + 400	3700	199,02	-1,21	1,11	0,23	1,900	4,690	4,080	2,790	2,180	
1 + 500	3600	199,02	-0,86	1,13	0,24	1,870	4,550	4,070	2,680	2,200	
1 + 600	3500	199,02	-0,97	1,05	0,22	1,860	4,600	4,130	2,740	2,270	
1 + 700	3400	199,02	-0,63	1,28	0,29	**1,810**	4,400	4,280	2,590	2,470	Bridge. Train Elv. Girder + 4.026-Aman
1 + 800	3300	199,02	-0,82	1,14	0,25	1,790	3,260	3,040	1,470	1,250	
1 + 900	3200	199,02	-0,8	1,21	0,28	1,760	3,160	2,900	1,400	1,140	
2 + 000	3100	199,02	-0,77	1,11	0,25	1,740	3,200	2,850	1,460	1,110	
2 + 100	3000	199,02	-0,65	1,05	0,24	1,720	2,600	2,810	0,880	1,090	
2 + 200	2900	199,02	-0,91	0,94	0,21	1,710	2,400	2,620	0,690	0,910	
2 + 300	2800	199,02	-0,87	0,9	0,21	1,700	2,290	2,560	0,590	0,860	
2 + 400	2700	199,02	-1,06	0,9	0,22	1,680	2,270	2,370	0,590	0,690	
2 + 500	2600	199,02	-0,92	0,81	0,2	1,670	2,360	2,160	0,690	0,490	
2 + 600	2500	199,02	-0,83	0,74	0,18	1,660	1,980	1,900	0,320	0,240	
2 + 700	2400	199,02	-1,66	0,74	0,18	1,650	1,950	1,900	0,300	0,250	
2 + 800	2300	199,02	-1,39	0,61	0,14	1,640	1,860	1,910	0,220	0,270	
2 + 900	2200	199,02	-1,18	0,77	0,18	1,620	1,630	4,080	0,010	2,460	
Weir Dam											
3 + 000	2100	199,02	-1,2	0,68	0,17	1,570	2,250	2,620	0,680	1,050	
3 + 100	2000	199,02	-0,71	0,82	0,24	1,540	3,850	2,730	2,310	1,190	

Based on the above table of operational standby condition 1, there was no runoff in the upstream of the rubber dam until Sta 2.100. However there was still runoff downstream from the rubber dam.

3.3 Operational Scenarios of Condition after Normalization

The 2nd Scenario was a condition where the West Flood Canal was normalized and returned to the original design using cross section drawing data of the As Build Drawing work of the Integrated Water Resources and Flood Management Project for Semarang in 2009 which had been adjusted for normalization excavation with the upstream level of the Upstream dam and the elevation of the dam downstream floor. After that the simulation was done with the Q50 discharge of the West Flood Canal 740 m3 / sec. (Wahyudi S. I. *et al.*, 2017). The simulation results are presented in the form of the following figure.

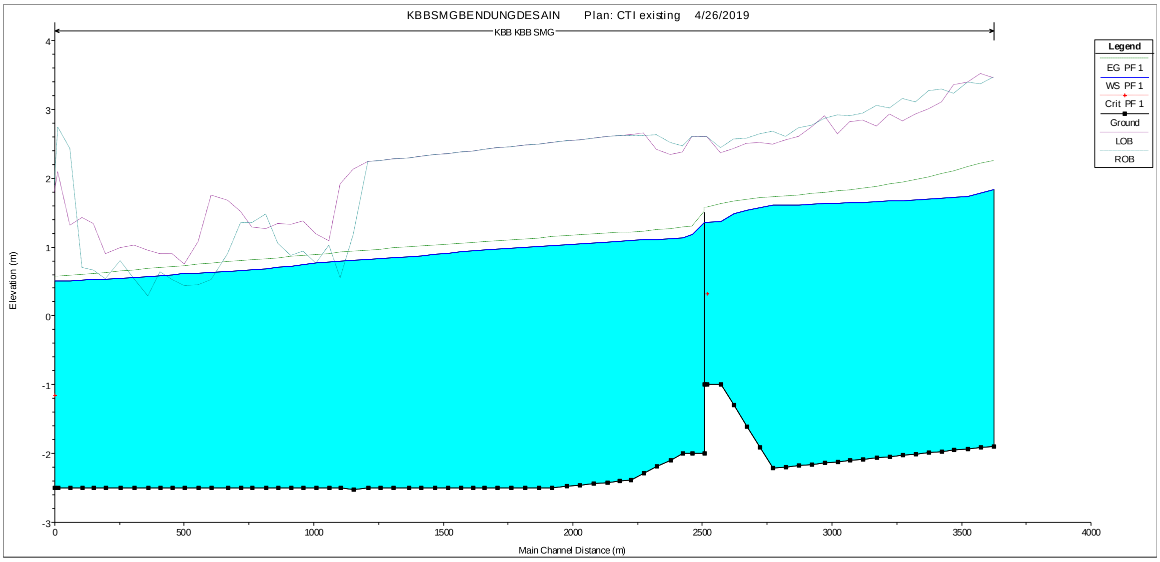

Figure 5. Simulation results for operational conditions which have been normalized

Based on the Figure 5, Simongan dam was at Sta 5000, Jl. Siliwangi at Sta 3400 and rubber dam at Sta 2100. The Sta 0 is in the estuary line.

3.4 Discussion on Simulation

3.1.1 River Dimension According to Existing Conditions

The operation of the rubber dam in the existing condition (not yet normalized) was carried out with several scenarios, namely simulation of standby condition 1st when the water level in Simongan dam was 1.4 m with discharge Q = 199.02 m3 / sec. The simulation results can be seen that with the existing conditions, the West Flood Canal could still accommodate water discharge at Simongan Dam with elevation +1.40 above the Simongan Dam spillway level. Therefore, as an operational guideline, rubber dam must be immediately deflated when the elevation at Simongan weir has reached +1.40 m.

3.1.2 Scenarios of river dimensions with normalized conditions

The operation of rubber dam in KBB has been normalized. Based on the 50 year plan flood discharge, the KBB debit was 740 m3 / s. This condition is identical to the water level at Simongan dam which was 3.30 m. Thus, the guideline for conditions after the normalization of the operation of the rubber dam must begin to open when the water level at Simongan spillway was at 3.30 m. This condition also needs to be controlled for inlet elevation from local drainage. (Trouw *et al.*, 2014)

The control of local residents' Drainage inlet was done by taking 1 or 2 case examples & photos. The construction of the West Flood Canal Dam also affected local residents' channels that entered the river. The following are examples of local drainage inlets that enter KBB. This local drainage inlet gate has a type of sliding door that is operated manually. Then there is also a type of motion door in the form of a valve door. This type of door is automatic and mechanical. Both types of doors still have problems with garbage that interfere with operations. So the operation of the drainage inlet gate follows the operational pattern of the operation of the rubber dam.

Figure 6. Type of local drainage gate inlet

4. CONCLUSIONS

The results of the hydraulic simulation were used as the operational basis of the rubber dam and also Simongan's permanent dam in the upstream which is about 3 km away. Simulation results include conditions in which the dimensions of KBB exist in large amounts of sediment and conditions when there was normalization or channel dredging. During the existing condition, the rubber dam was upfront when the water level above the Simongan spillway dam 1.4 m with a flood discharge of 199.20 M3 / sec. Then after normalization the rubber dam could be opened when the water in the Simongan spill weir reached 3.30 m or flood discharge was 740 m3 / sec. So it is highly recommended to immediately and always maintain the KBB dimension according to the flood discharge plan.

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