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Automatic "Diver" Observation and Pumping Simulation of Polder Drainage System, Case Study on Terboyo, Semarang, Indonesia

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Abstract: One of the area inundated by flood and sea level rise (rob) in northern of Semarang city is Unissula campus and Terboyo terminal. The inundation in this area is caused by the high of sea levels (rob), so this area is often inundated by flood and rob during rainfall and high tide. The pumping simulation should be carry out in that area. By calculating and evaluating the river reservoir capacity towards the inflow such as hydrograph of design discharge of 10 years return period. Based on the observation results of water level elevation by the automatical "diver", it discovered that the sea level elevation is higher than water level elevation in the land area. To keep the water elevation in Unissula-Terboyo area that is +1.00, so pumping should be working. The one of simulation results with 1.25 m^3/s pump capacity is +1.12 m highest water level elevation and pump is active for 11 hours to reach + 0.95 m elevation. According to the in situ experiment, Polder system and its storage quite effective to maintain water elevation.

Keywords: diver, Semarang, tidal flood, pump, drainage

1. Introduction

Flood problem in Semarang city is extremely complex, thus cannot be solved by only a stakeholder, therefore, the governments and the people must cooperate to overcome it. The one of area that always be in flooding and inundation situation in the northern side of Semarang city is Unissula campus and Terboyo terminal transport. The inundation in these areas are caused by the height of the sea level surface, that resulting flood when rain comes because the stormwater could not flow smoothly to the sea. Despite of the sea level surface which surpass ground elevation, the failure of drainage storage to contain stormwater seems to be the main factor of inundation caused by flood (Pratiwi & Wahyudi, 2018).

The Unissula campus and Terboyo terminal transport geographical location is located at Semarang coastal area, then it implicates flooding every year. These areas laid on +0.000 MSL, meanwhile the highest inundation is +1.45 MSL,

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therefore the areas are assured to be inundate (Wahyudi et al., 2017). The connecting channel between Unissula to Sringin river is 2.553 m length and 54.5 ha of catchment area. This research is conducted by planting a monitor equipment to watch over the water elevation when flood arrived, and it's called "Diver". This study is subjected to find out the water elevation in polder system using an automatic measurement "Diver", and to simulate the storage and pumping to polder system.

2. Condition and Theoretical Review

To understand the Automatic Observation of Water Elevation Using "Diver" and Simulation of Unissula Polder Sub-system pump are rainfall plan calculation, water elevation calculation of "Diver" observation results, flood discharge calculation using Nakayasu Unit Synthesis Hydrograph, calculation of water level elevation simulation with pump.

2.1 Rainfall Plan Calculation

The method must be determined by looking at the characteristics of rain distribution in the local area. The rainfall data covers 15 years with rainfall station in the area. The return period will be calculated on each method are 2, 5, 10, 25, 50 and 100 years period using Gumbel et al. (2018) and Wahyudi & Pratiwi (2014), equations to calculate rainfall plan are:

$$R\ design = X + \frac{Yt - Yn}{Sn} \times Sx \quad (1)$$

Where x = input data Rainfall intensity, G = Coefficient, S = standard deviation

2.2 Calculation of water elevation level using "Diver"

Diver, is an instrument designed to measure the groundwater's level and temperature. Diver is designed to measure the water pressure and temperature, then those pressure data are converted by formula to get the level of water.

$$WL = TOC - CL + WC,\ WC = 9806{,}65 \quad (2)$$

Where: WL = Water Level, Wc = Water Column, CL = Diver Depth, TOC = Pipe Depth.

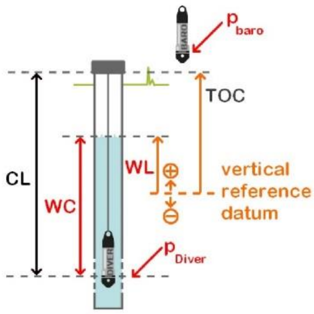

Fig. 1 - Measuring Instrument of Water Elevation Level "Diver" (Schlumberger, 2017)

2.3 Pumping Simulation

Retention pond accommodates flood discharge by drain collector, then simulation pump capacity. The difference of flood discharge and pump discharge is a change in the volume of the retention pond (Segeren, 2016). So we try to simulate pump capacity. The scheme of retention pond simulation can be seen in the Fig. 2.

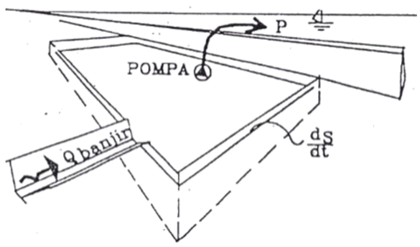

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Fig. 2 - Scheme of Retention Simulation Capacity. (Wahyudi et al., 2017)

Where by simulates the continuity law are treated formula as follows: (Suripin, 2014)

$$S = Vin + Vinf - Vout \quad (3)$$

Where S =Storage (reservoir volume), Vin = Inlet Volume,Vinf =Infiltration Volume, Vout = Volume exited by pump.

If the volume is created for a certain period of time equation becomes

$$\frac{dS}{dt} = Q_{in} + Q_{\inf} - P \quad (4)$$

Because dike is protected by concrete sheet-pile, the simulation assumed Qinf = 0. So that the equation becomes

$$\frac{dS}{dt} = Q_{in} - P \quad (5)$$

Where dS/dt = rate of change of reservoir volume, Qin = Flood water discharge (m3/dt), P = Pump discharge capacity (outlet) m^3/ dt. For the time interval t, the equation changes in the reservoir volume that can be written. (Buchori et al., 2018)

$$0{,}5(Q_{in1} + Q_{in2})t + (S_1 - 0{,}5P_1t) = (S_2 + 0{,}5P_2t) \quad (6)$$

3. Research Location

The research methods are field survey, the collection of primary and secondary data, installation "diver" instrument, data processing, analysis the data, and pumping simulation.

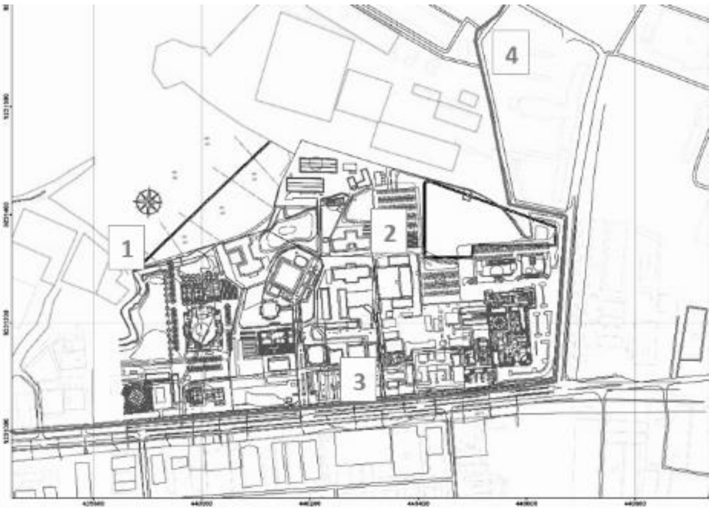

Fig. 3 - Location of "Diver" water level monitoring in the Polder area

In this research, the data collected by the result of diver measurement. The rainfall data used are three rainfal station in karangroto, pucang gading, dan simongan station during 10 years observation since 2007 till 2016 (Sherly et al., 2016). The result data of diver measurement is analyzed to find out the level water elevation. The rainfall data is analyzed by Gumbel method become rainfall plan with the return period 2,5,10, 25, and 100 years. pumping simulation mention the pump capacity illustration and the duration of heavy rain (Liao et al., 2016).

4. Result and Discussion

4.1 Result of Rain Fall Plan Calculation

The result of rainfall intensity which calculates by Gumbel methods to determine the largest annual rainfall (R) with a return period (Tr) of 2, 5, 10, 25, 50 and 100 years is showing in the table 1.

Table 1 - Result of Effective Rainfall Calculation

No	Tr (Years)	R (mm)
1	2	127. 7931
2	5	155.0827
3	10	173.1508
4	25	195.9799
5	50	212.9159
6	100	229.7267

4.2 The Result of Diver Measurement

In order to get maximum results so this research uses 4 divers installed for 6 days start from 12 to February 17, 2018, the location of diver installation in the following table:

Table 2 - The Location of Diver Installation

NO	CODE	LOCATION
1	R6412	Flooding Dike Protection
2	R8053	Campus Canal
3	R8051	Unissula Storage
4	R8055	Terboyo Transport Station

1. *Diver* (R6412) installed behind the dike of Unissula Rob records the lowest EMA happened on 15-02-2018 (12.00) = 0.725 m and the highest EMA happened on 16-02-2018 (05.15) = 1.187 m

2. *Diver* (R8053) installed in front of Engineering Faculty of Unissula records the lowest EMA happened on 12-02-2018 (00.00) = 0.080 m and the highest EMA happened on 16-02-2018 (18.00) = 1.187 m
3. *Diver* (R8051) installed in Unissula's Polder records the lowest EMA happened on 15-02-2018 (22.00) = 0.003 m and the highest EMA happened on 16-02-2018 (15.15) = 1.480 m
4. *Diver* (R8055) installed in Terboyo canal records the lowest EMA happened on 12-02-2018 (01.30) = 0.193 m and the highest EMA happened on 16-02-2018 (07.30) = 1.169 m

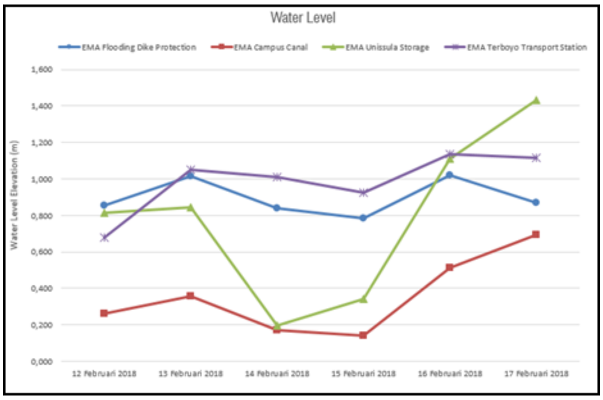

Fig. 4 - Water Level Elevation curve in Polder System.

4.3 Pumping Simulation Result

The technical data of pumping simulation: Catchment Area: 54.5 ha, Canal Length : 2553 m, Canal Depth: 2 m, Storage Volume: 16350 m^3, According to another polder system in Semarang area, Pump capacity is used in this simulation are varies, they are 0.5 m^3/dt, 0.75 m^3/dt, 1 m^3/dt, and 1.25 m^3/dt, distribution analysis uses normal method with return period 10 years and rainfall 173.1508 mm/day, discharge analysis uses Nakayatsu method with flood discharge 7.255 m^3/hour in 10 years return period, road around elevation estimated +1.00 m whereas dike elevation +1.50 m and the water is maintained so it is not passing the road elevation.

1. The simulation results with 0.5 m^3/dt pump capacity is the highest water level elevation + 1.37 m and the pump is active for 25 hours to reach + 0.98 m elevation.

2. The simulation results with 0.75 m^3/dt pump capacity is the highest water level elevation +1.28 m and the pump is active for 17 hours to reach + 0.96 m elevation.

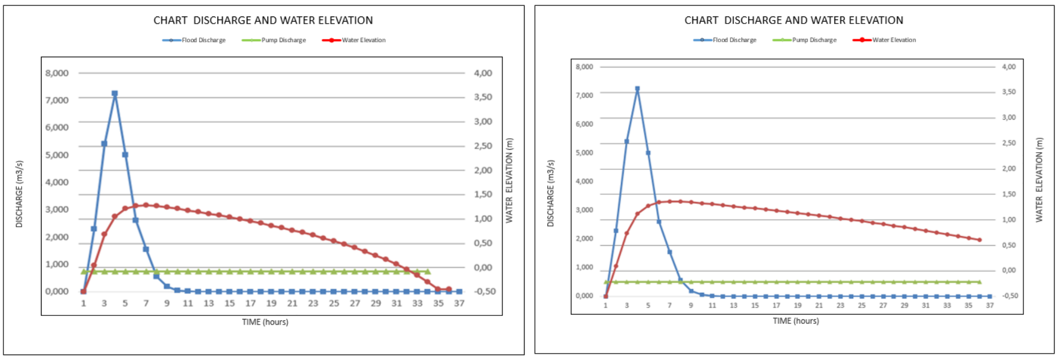

Fig. 5 - The chart of water level elevation simulation with 0.5 m^3/dt & 0.75 m^3/dt pump.

3. The simulation results with 1 m^3/dt pump capacity performance is the highest Water Level Elevation +1.20 m and the pump is active for 12 hours to reach + 0.99 m elevation

4. The simulation result with 1.25 m^3/dt pump capacity performance is the highest Water Level Elevation +1.12 m and the pump is active aktif for 11 hours to reach + 0.95 m elevation.

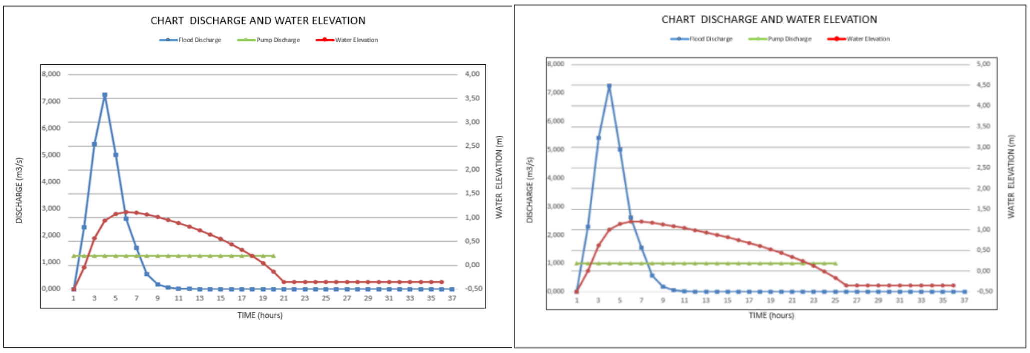

Fig. 6 - The chart of water level elevation simulation with 1 m^3/dt and 1.25 m^3/dt pump.

5. Conclusion

Based on the research results of Automatic "Diver" Observation and Pump Simulation of Polder System Pump Islamic Sultan Agung University – Semarang Terminal Terboyo can be concluded as follows:

1. From maximum daily rainfall data in Karangroto, Pucang Gading, and Simongan Station are obtained plan rainfall of Gumbel Method with return period 10 years respectively is 173.15 mm. From simulation results of "Diver" measurement, it is obtained water level elevation sample Terboyo area, *Diver* (R8055) canal records the lowest water elevation 0.193 m and the highest 1.169 m
2. Pump performance simulation is carried out on canal in front of Unissula to Sringin river. Flood discharge uses the nakayasu method with 10 years return period is`7.255 m^3/ jam. Water elevation is maintained so it is not passing + 1.20 road elevation. The Simulation results with 1.25 m^3/dt pump capacity is +1.12 m highest water level elevation and pump is active for 11 hours to reach + 0.95 m elevation. With 1.25 m^3/s pump capacity can be effective to manage performance water elevation in Polder System.

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