IOP Conf. Series: Materials Science and Engineering **732** (2020) 012033 doi:10.1088/1757-899X/732/1/012033

The reservoir porous as a solution to control the urban flood in Pagarsih road Bandung

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Abstract. Urban floods have become a critical phenomenon recently. Which are mostly caused by the fast increase of building growths. The need of mitigation of floods to save road users becomes an important aspect in urban area. This paper is to find a solution the case of flood in Pagarsih Road which was occurred at 2016 with standard the rain falls cycles for 25 years. The characteristic of Pagarsih Road floods is due to the overflow of Citepus River which lays beside the road. A kind of the road infrastructure proposed to solve the problem is a porous reservoir which functioned as the water storage of run off. The method used in this research is a simulation using a physical model as well as the manual calculation using Hec Ras. The model is to simulate the existing condition as well as the proposed solutions. The alternative solution developed is tested by providing several reservoir volumes and also by adding porous facilities to increase the reservoir capacity. The validation test is carried out by using HECRAS-5.0.7 to achieve a certain reliable solution. The result shows that the reservoir storage capacity is the dominant parameter to mitigate the risk of floods.

1. Introduction

Pagarsih road is often floods. One of the floods that takes attention occurred on Wednesday, November 9, 2016. From PUSAIR research, at that event the flood dragged several cars on the road into the Citepus river laying on the side of the road (Figure 1) [1]. The catchment area considered is 10.23 km2 and the length of the main river is 7.7 km. The location of floods is shown in the figure 2.

Figure 1. Flood at Pagarsih road.

Figure 2. Flood location.

The flood needs to be solved in order to eliminate any negative impact to the environment. From PUSAIR research, there are several causes of flood on Pagarsih road. The cause of the flood is the reducing land infiltration due to uncontrolled development, the river is unable to cover high-intensity rainwater discharge and the narrowing of the river and the presence of several bridges along Pagarsih road.

The purpose of this paper is to evaluate the existing flood conditions by carrying out hydrological calculations and finding any solutions to mitigate flood's impacts. In Sutrisno's research in 2015 reservoir porous can handling flood and reduced flow velocity so, in this research reservoir porous will be used. Same as Saul's research, velocity is used as the observed variable [2].

2. Literature review

2.1. River discharge

The calculation of discharge needs some, such as data the form of land use maps, topography, annual rainfall and catchment area. The land use map is used to determine the value of drainage coefficient (C). The annual rainfall is used to find the value of rainfall intensity. The topographic map is determining the slope of the catchment area. In the calculation of river discharge used the rational calculation method. the rational method formula is as follows:

$$Q = 0.278\, C \times I \times A$$

Where,
Q = Estimated Flood (m3/s)
C = Runoff coefficient
I = Average rainfall intensity (mm/hour)
A = Area (km2)

2.2. Reservoir porous

In Sutrisno's research in 2015, flood handling experiments were carried out in the form of porous infrastructure, reservoir and the combination of reservoir and porous infrastructure. In this research, it shows that combining the reservoir with porous infrastructure is the best solution to reduce flood discharge [3]. The result shows that a combined design of 1 m^3 reservoir with porous can reduce the flood volume of 0.327 m3 [4]. The comparison of several solutions is shown in table 1.

Table 1. Flood solution capacity.

Flood Solution	Capacity (m^3)
a normal infiltration 5x5 m^2 at wet ground	0.075
a point porous infrastructure 5x5 m^2 at wet ground	0.327
a reservoir 1 m^3 and porous infrastructure	1.327
a reservoir volume 1 m^3	1

Aldila's research also says that retention ponds can handle floods [5]. Samang's research says that ponds and drainage retention can handle floods too [6].

3. Methodology

The research methodology consists of the following process:

- Data collection such as rain fall, river profile and catchment area
- Hydrological Calculation of River Discharge. The method used to calculate the discharge is a rational method

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- Verification of Hec-RAS 5.0.7 with Manual Calculation, the aim of this step is to check that Hec-ras calculation is appropriate. The parameters that observed is elevation of floods.
- Evaluation of Existing Conditions. This model follows the conditions in the existing. In this modelling the flow characteristics will be seen during test. The scale used is 1: 100.
- Flood Analysis with HEC-RAS 5.0.7. The calculated discharge will be cumulated on HEC-RAS. The HEC-RAS input are discharge and river profiles. The output of this analysis is water level and flow velocity.
- Experiment Model Flood Control Solutions. The main concept of flood management is to hold the flow so that it does not run over the road by providing a reservoir and infiltration to increase the capacity of the reservoir. This experiment will use a reservoir with several sizes and the addition of the porous function.
- Validation using HEC-RAS 5.0.7, This step is to evaluate the success of the solution using Hec Rass 5.0.7. All evaluations were carried out on each alternative trial. Variables observed were river water level and flow velocity.

4. Calculation

4.1. Rainfall frequency analysis
The maximum rainfall data at the Cemara, Lembang and Dago station can be describing in table 2.

Table 2. Rainfall.

No.	Year	STA dago pakar	STA Lembang	STA cemara
		Mm	mm	Mm
1	2014	79	56	62
2	2015	85	39	77.7
3	2008	80	72	67.8
4	2012	70	75	83
5	2009	73	78	88.9
6	2006	70	79	94
7	2011	45	140	73.5
8	2013	95	94	68.4
9	2007	133	79	69
10	2010	104	68.7	122.9

4.2. River discharge
The calculation of river discharge is by using the Rational Method. This calculation needs several data such as run off coefficient (C), rainfall intensity and catchment area. The Mononobe graph for 25 years' period can determine the value of rainfall intensity, which shown in the figure 3.

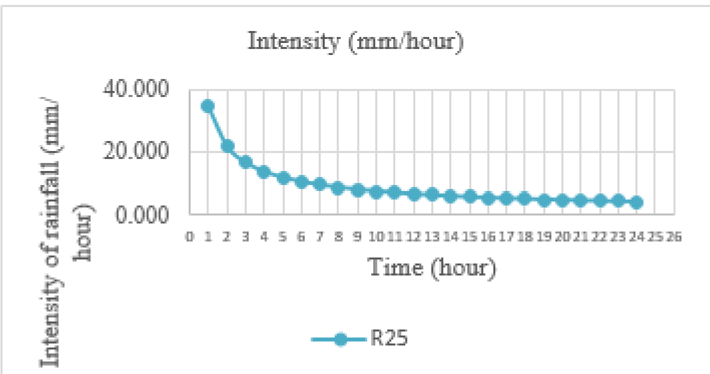

Figure 3. Mononobe graph.

The concentration time from graph is 1.24 hours, then it can be obtained value of sensitivity of 27.55mm/hour.

Discharge calculation is as follows,

$$Q = 0.278\, C \times I \times A$$
$$Q = 0.278 \times 0.7 \times 27.55 \times 10.23$$
$$= 60 m^3/s$$

5. Physical experiments

5.1. Existing model experiments

The experiment using the physical model is to find out the existing characteristic river flow. The result of experiment by using the river water discharge is of 60 m3/s shows that the floods is occurred. The schematic diagram of experiments can be shown at the figure 4.

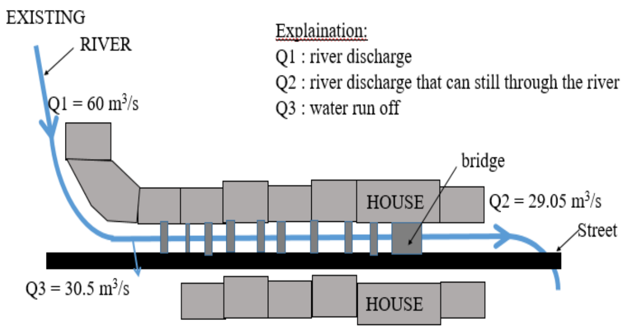

Figure 4. Existing condition.

5.2. Solution model experiments

This experiment consists of 6 alternative solutions as follows:

- Alternative I is using a reservoir of 19.017 m3
- Alternative II is using a reservoir of 23.520 m3
- Alternative III is using a reservoir of 32.022 m3
- Alternative IV is using a reservoir of 19.017 m3 with porous infrastructure
- Alternative V is using a reservoir of 23.520 m3 with porous infrastructure
- Alternative VI is using a reservoir of 32.022 m3 with porous infrastructure

The results of experiments show that each solution provides the different water discharge reduction in the river as shown in the figure 5-10.

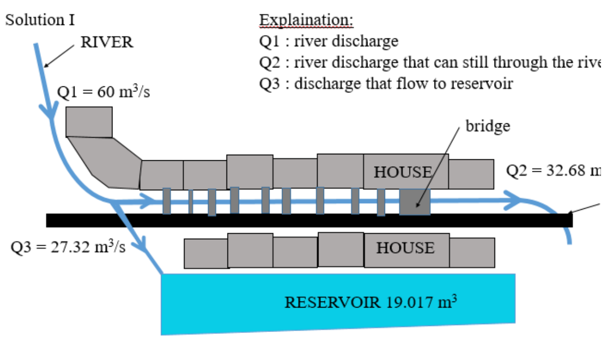

Figure 5. Solution I Model : 27.32 m^3 river discharge reduction.

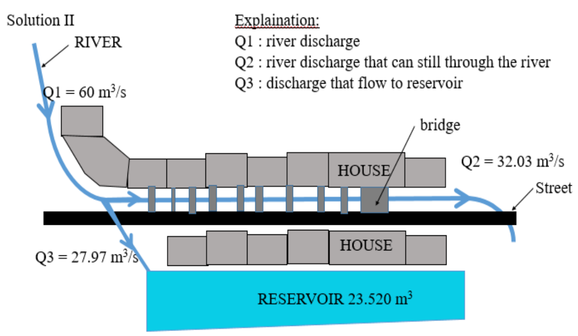

Figure 6. Solution II Model : 27.97 m^3 river discharge reduction.

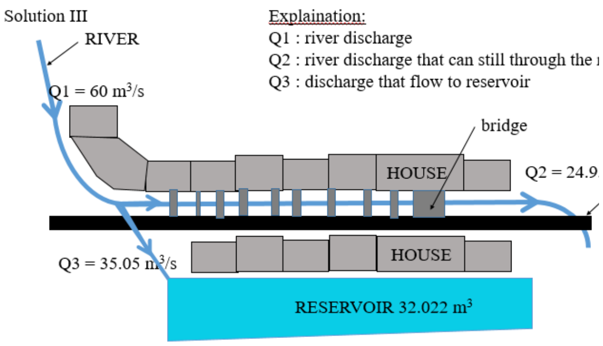

Figure 7. Solution III Model : 35.05 m^3 river discharge reduction.

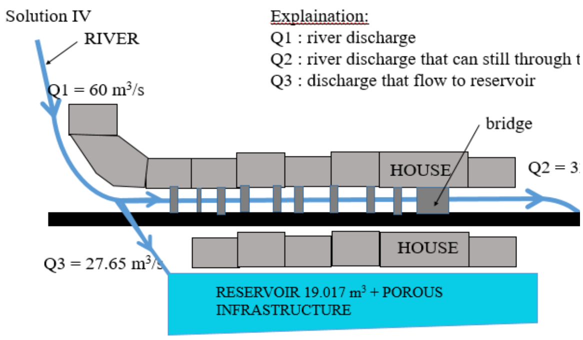

Figure 8. Solution IV Model : 27.65 m^3 river discharge reduction.

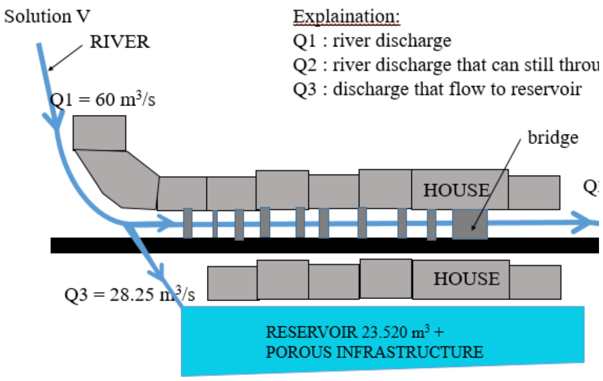

Figure 9. Solution V Model : 28.25 m^3 river discharge reduction

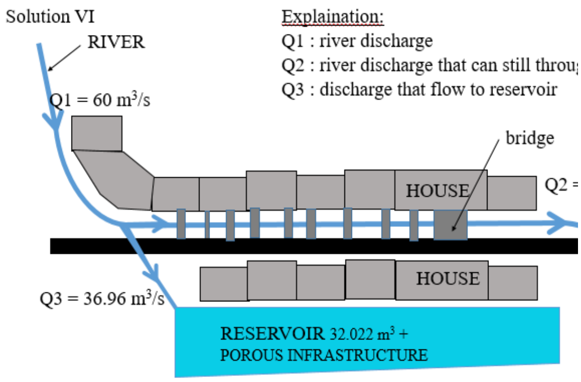

Figure 10. Solution VI Model : 36.96 m^3 river discharge reduction.

6. Results and discussion

Figure 5 is model reservoir with volume 19.017 m^3 where the solution can reduce river flow 27.32 m^3/s. Figure 6 is model reservoir with volume 23.520 m^3 where the solution can reduce river flow 27.97 m^3/s. Figure 7 is model reservoir with volume 32.022 m^3 where the solution can reduce river flow 35.05 m^3/s. Figure 8 is model reservoir with volume 19.017 m^3 with porous where the solution can reduce river flow 27.65 m^3/s. Figure 9 is model reservoir with volume 23.520 m^3 with porous where the solution can reduce river flow 28.25 m^3/s. Figure 10 is model reservoir with volume 32.022 m^3 with porous where the solution can reduce river flow 36.96 m^3/s. It can be concluded that the greater the reservoir capacity, the greater the river discharge can be reduced.

Based on the results of Hec-RAS validation of the solution VI using the reservoir volume of 32,022m^3 and the porous infrastructure show the best result, which the solution reduces of 1.37 m the height of run off at Pagarsih road. Solution VI provides a significant impact on water subsidence. It is shown in the figure 11.

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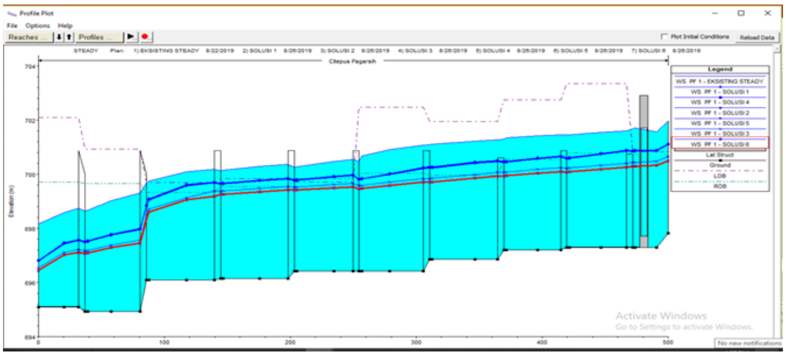

Figure 11. Cross section Hec-RAS.

Same as Sutrisno research reservoir porous can reduce flow velocity. From the HEC-RAS 5.0.7 analysis it is shows that Solution VI which it results indicate as the best solution in reducing the velocity of river flow. The existing velocity of 1.23 m/s becomes into 0.93 m/s. The velocity result of solution I to solution VI is shown in the figure 12.

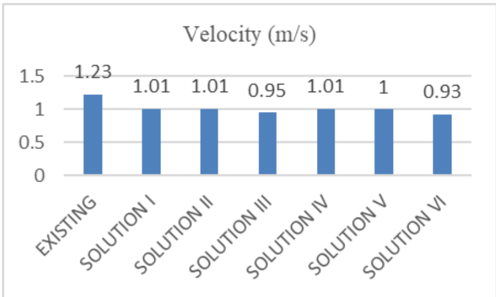

Figure 12. Velocity.

7. Conclusion

Based on the results of the HEC-RAS output, alternative design VI shows the greatest impact to cope with the flood problem in Pagarsih road. The design VI uses the largest volume of reservoir with the porous infrastructure to increase capacity. The volume of reservoir is the most dominant factor in covering the floods. The greater volume of reservoir will be the better of infrastructure in coping with the flood.

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