

Study on The Making Of a Breakwell For Water Standing Management in Sitinggil Residence Jember

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Abstract: Drainage is one of the facilities used to drain water so that it does not cause puddles that can disrupt people's activities and the economy. In the de sitinggil residential area, Patrang District, Jember Regency, there are flood problems caused by high rainfall and significant land use changes. Changes in land use from rice fields or empty land to settlements. The change in land use results in a larger runoff. Besides that, there is sediment deposition which reduces the wet cross-sectional area, as a result the dimensions of the existing drainage channels cannot accommodate the maximum flood discharge. To anticipate the problems that occur because, it is necessary to plan an absorption well. So based on the existing process, several conclusions can be drawn, namely the runoff discharge at the 10 year return period in the housing of 0.445 m³ / s by making 20 communal infiltration wells which will be able to reduce flooding that enters the river.

Keywords: drainage; wells; infiltration; flood; residence

INTRODUCTION

In line with economic growth, there are many realities that must be faced by both central and local governments. Among them is the need for infrastructure to support economic activity. One of them is the need for easy, safe, comfortable, and fast transportation facilities. However, the means of transportation will not be in accordance with the planned age if it is not equipped with a drainage system. Drainage is one of the facilities used to drain water so as not to cause puddles that can disrupt people's activities and the economy. In the residential area of De Sitinggil Housing, Patrang District, Jember Regency, there are flood problems caused by high rainfall and significant land use changes. Changes in land use from rice fields or empty land to settlements.

The change in land use results in a larger runoff. Besides that, there is sediment deposition which reduces the wet cross-sectional area, as a result the dimensions of the existing drainage channels cannot accommodate the maximum flood discharge. To anticipate the problems that occur because, it is necessary to plan an alternative by making infiltration wells.

Purpose and objectives

The aims and objectives of the implementation of this research are related to alternative solutions for inundation disaster management, including:

1. Knowing the flood discharge plan with a 25 year return period
2. Determine the capacity of the existing channels and plan the solutions given.
3. Determine the construction and number of infiltration wells required to accommodate and drain the maximum flood discharge in the area.

LITERATURE REVIEW

There are several methods to estimate the peak flow rate (flood discharge). The method used at a location is more determined by the availability of data. In practice, the flood discharge estimation is carried out by several methods and the design flood denit is determined based on technical considerations (engineering judgment). In general, the methods commonly used are the Rational Method and the Flood Hydrograph Method.

The Rational Method is an old method that is still used today to estimate peak discharge. The idea behind the rational method is that if rainfall with intensity I occurs continuously, then the direct runoff rate will increase until it reaches the concentration time t_c . the time t_c concentration is reached when all sections

of the watershed have contributed to the flow at the outlet. The input rate in the system is the result of rainfall with intensity I in the watershed with area A . The ratio between the input rate and the peak discharge rate (Q_p) that occurs at t_c is stated as the run off coefficient (C) with a value of $0 \leq C \leq 1$ (Chow, 1998).

Some of the basic assumptions for prioritizing the Rational method are:

1. Rainfall occurs with a constant intensity within a certain period, at least equal to the concentration time.
2. Direct runoff reaches its maximum when the duration of rain remains the same as the concentration time.
3. The run off coefficient is assumed to be fixed for the duration of the rain.
4. The area of the watershed does not change during the duration of the rain.

This formula is the oldest formula and the best known among other formulas. This formula is widely used for ordinary rivers with large drainage areas and also for planning drainage of relatively narrow drainage areas. The general form of this rational formula is as follows:

$$Q = 0.2778 \cdot C \cdot I \cdot A \quad (2.6)$$

With:

Q = maximum flood discharge (m^3 / s)

C = flow / runoff coefficient

I = average rainfall intensity ($mm / hour$)

The initial concept of infiltration wells is as a solution to increase the quantity of rainwater entering the ground or as a means for storing rainwater and infiltrating it into the ground. This is because in a residential area, the soil infiltration of rainwater has undergone a change in the function of the soil surface and has changed to a watertight layer so that the falling rainwater cannot directly seep into the ground. Based on this concept, the size or dimensions of the wells required for a land or lot depend on several factors, as follows:

- a. Cover surface area, which is land where water will be accommodated in infiltration wells, including parking lots, roof areas, and other pavements.
- b. Rain characteristics, including rain intensity, rain duration, rain interval, the longer the rain lasts, it requires a larger volume of infiltration wells. Meanwhile, large rainfall intervals can reduce the volume of wells required
- c. Soil permeability coefficient, which is the ability of the soil to pass water per unit time. Sandy soils have a higher probability coefficient than clay soils.
- d. Groundwater level. In deep groundwater conditions. Infiltration wells need to be constructed on a large scale because the soil really requires filling water through infiltration wells. On the other hand, on land with shallow water levels, making infiltration wells is less effective, especially in tidal areas or swamp areas where the groundwater is very shallow.

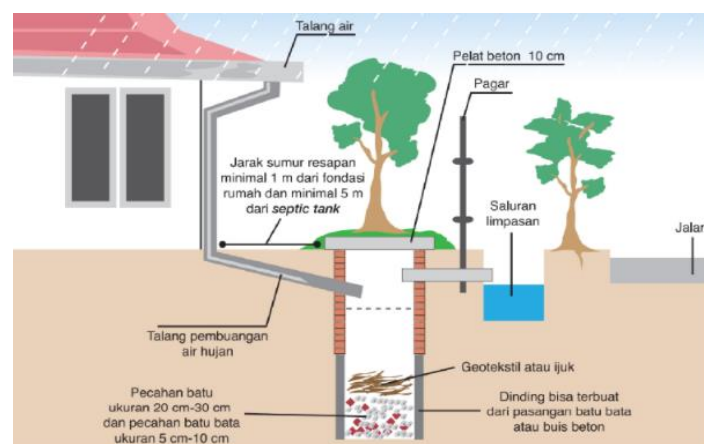


Figure 1. Example infiltration well in housing

The volume and efficiency of infiltration wells can be calculated based on the balance of water entering the well and water infiltrating the ground. Sunjoto (1988).

$$H = [1 - e^{-FKT / \pi R^2}]$$

With:

- H = water level in the well (m).
- F = geometric factor (m).
- Q = intake water flow (m³ / s).
- T = flow time (sec).
- K = soil permeability coefficient (m / s).
- R = well radius (m).

In general, it can be stated in the equation:

$$Q_0 = F.K.H.$$

The effective depth of the infiltration well is calculated from the groundwater level if the bottom of the well is below the groundwater level. We recommend that the bottom of the well be in a layer of soil with high permeability. To calculate the number of infiltration wells are:

$$\text{Total SR} = H / h$$

Where:

- H = total water height required
- h = height of each infiltration well

For the dimensions of infiltration wells based on Indonesian standards (SNI No: 03-2459-1991) circular cross section with R_s well 0.5 m; height (h) of well = 2m. Several prototypes of infiltration wells in Indonesia are presented in Figure 2.



Figure 2. Prototype of infiltration wells in the field

METHOD

In the planning analysis of the dimensions of this infiltration well, the initial stage that must be carried out is a field survey, this survey was carried out from March to May 2020. The location is located in the De Sitinggil Housing area, Patrang District, Jember Regency, in addition to that, a literature study was also carried out. intended to analyze complementary data obtained from the Jember Irrigation Office. The data used are:

- a. Housing and drainage condition data
- b. Rainfall data (Dinas Pengairan Jember).
- c. Population data
- d. Housing siteplans and elevation data, etc.
- e. The data above are used to determine the amount of rainfall plan and planned flood discharge.
- f. Soil data, which is useful for determining soil permeability.

RESULTS AND DISCUSSION

In planning the drainage system in the de sitinggil housing area, there are 3 types of land use patterns, including settlements, vacant land / yards, and roads (asphalt). The coefficient is defined as the ratio of the maximum velocity of water flow from the catchment area. This coefficient is the comparative value between the share of rain that forms direct runoff and the total rainfall that occurs. The value of C depends on several characteristics of the catchment area, which includes:

- a. Relief or slope of the catchment area
- b. Regional characteristics, such as vegetation protection, soil type and watertight areas
- c. Storage or other detention characteristics.

The amount of runoff can be small, especially if the rainfall does not exceed the infiltration capacity. As long as the rain occurs is small or moderate, surface runoff only occurs in impermeable and saturated areas in a watershed or falls directly on the surface of the water. If the amount of rainfall that falls is greater than the amount of water that is discharged for evaporation, interception, infiltration, depression deposits and depression reserves, then surface runoff can occur. If the rain that occurs is small, almost all of the rainfall that falls is intercepted by dense vegetation.

In areas where land use changes, the value of the runoff coefficient used should consider developments in the upstream area, for future catchments. This is particularly relevant in situations where a rural catchment area may develop partially or completely into an urban catchment area during the planning of living welfare services. The effect of land use on surface runoff is expressed in runoff coefficient (C), a number that displays the ratio between the amount of runoff and the amount of rainfall. The runoff coefficient figure is an indicator to determine the physical condition of a watershed. C values range from 0-1.

The value of C = 0 indicates that all rainwater is intercepted and infiltrated into the soil, on the other hand, the value of C = 1 indicates that rainwater flows as surface runoff. In a good watershed the price of C is close to zero and the more damaged a watershed is, the price of C is getting closer to one. For more details, it can be seen in Figure 4. To uniform the land use pattern, the land use coefficient is calculated by an equation whose results can be seen in Table 1.

Table 1. Runoff discharge calculation

| No | Return Period (years) | C | I (mm/jam) | A (km ²) | Q (m ³ /sec) |
|----|-----------------------|------|------------|----------------------|-------------------------|
| 1 | 2 | 0.79 | 40.466 | 0.039 | 0.346 |
| 2 | 5 | 0.79 | 48.296 | 0.039 | 0.414 |
| 3 | 10 | 0.79 | 51.975 | 0.039 | 0.445 |
| 4 | 25 | 0.79 | 55.473 | 0.039 | 0.475 |

To determine the flood discharge plan in terms of return periods of 2, 5, 10, and 25 years, the Rational formula is used in the equation. The results of the planned flood discharge calculation are shown in Table 1. In planning an infiltration well, first must know the maximum discharge that can be accommodated by the existing channel. If the maximum debit of the existing channel is smaller than the planned debit, it is necessary to plan an absorption well.

Table 1 is the calculation result of the maximum discharge dimensions of the existing channels in the De Sitinggil Housing channel. Meanwhile, the results of the channel capacity design checks on all sections are presented in tables 2. The equation proposed by Sunjoto (1988) to calculate the depth dimensions of infiltration wells from several known parameters is as follows.

With:

H: water level in the well (m)

F: geometric factor (m)

K: soil permeability coefficient (m / hour)

T: dominant duration of rain (hours)

R: the radius of the well

Q: the discharge of water entering the well, where $Q = C I A$ (m³ / hour)

C: run-off coefficient

I: rain intensity (m / hour)

A: roof area (m²).

The outlets of the housing flow through almost all channels then flow directly into the river. The outlet will collect rainwater and domestic waste from residential residents if it is not able to be infiltrated by the infiltration well of each house or communal infiltration. So that in the planning of this drainage channel, it is calculated that the rainwater is first infused into the reservoir well, the rest is discharged into the communal infiltration, then the rest will be discharged into the river.

Table 2. Calculation of rectangular drainage capacity

| Channel | R | A | P | R | S | V | Q Channel | Q Drain |
|---------|------|-------------------|------|-------|-------|-------|-----------|---------|
| | (m) | (m ²) | (m) | (m) | | | | |
| A | 0.30 | 0.28 | 1.89 | 0.150 | 0.005 | 1.996 | 0.565 | 0.027 |
| B | 0.30 | 0.28 | 1.89 | 0.150 | 0.005 | 1.996 | 0.565 | 0.081 |
| C | 0.30 | 0.28 | 1.89 | 0.150 | 0.005 | 1.996 | 0.565 | 0.081 |
| D | 0.30 | 0.28 | 1.89 | 0.150 | 0.005 | 1.996 | 0.565 | 0.081 |
| E | 0.30 | 0.28 | 1.89 | 0.150 | 0.005 | 1.996 | 0.565 | 0.081 |
| F | 0.30 | 0.28 | 1.89 | 0.150 | 0.005 | 1.996 | 0.565 | 0.054 |
| G | 0.30 | 0.28 | 1.89 | 0.150 | 0.005 | 1.996 | 0.565 | 0.054 |
| H | 0.30 | 0.28 | 1.89 | 0.150 | 0.005 | 1.996 | 0.565 | 0.054 |
| I | 0.30 | 0.28 | 1.89 | 0.150 | 0.005 | 1.996 | 0.565 | 0.027 |

Geometric Factors

The geometric factor is representing the perimeter and surface area of the well, the hydraulic gradient, the state of the soil layer and the position of the well against the layer and the porosity of the well wall is expressed in the amount of the well radius.

It is known that the following data:

$$K = 1.5 \times 10^{-4} \text{ m / sec}$$

$$I = 100 \text{ mm / hour}$$

$$T = 2 \text{ hours}$$

F = condition 3a (see Figure 2)

$$R = 100 \text{ cm}$$

$$C = 0.95$$

Calculating the water depth in the well:

$$H = (243 / (5.5 \times 0.54)) \times (1 - \exp(-3.14 \times 0.54 \times 2 / (3.14 \times 0.5^2))) = 54,033 \text{ m}$$

The water depth in the well is considered high enough. If the groundwater level is at a depth of 4 m from the ground, then the infiltration well needs to be made into a series system where each well with $H = 2$ m. Then the number of infiltration wells required for the series system is $n = 20$. The plan drawing is needed as a reference for making infiltration wells. The dimensions of the infiltration well that will be made refer to the results of the calculation of the dimensions of the infiltration well. The plan for the position of the communal infiltration well is presented in the following figure:

Table 3. the amount of discharge water discharged house

| Channel | house | V | Q Channel | Q Drain | Q House |
|---------|--------|-----------------------|-----------------------|-----------------------|-----------------------|
| | (Buah) | (m ³ /det) | (m ³ /det) | (m ³ /det) | (m ³ /det) |
| A | 5 | 1.996 | 0.565 | 0.027 | 0.030 |
| B | 15 | 1.996 | 0.565 | 0.081 | 0.090 |
| C | 14 | 1.996 | 0.565 | 0.081 | 0.084 |
| D | 12 | 1.996 | 0.565 | 0.081 | 0.072 |
| E | 14 | 1.996 | 0.565 | 0.081 | 0.084 |
| F | 11 | 1.996 | 0.565 | 0.054 | 0.066 |
| G | 9 | 1.996 | 0.565 | 0.054 | 0.054 |
| H | 8 | 1.996 | 0.565 | 0.054 | 0.048 |
| I | 6 | 1.996 | 0.565 | 0.027 | 0.036 |

Table 4. number of infiltration wells

| Saluran | Q Deposite | Q Road | Q Commnal | Amount Well |
|-------------|-----------------------|-----------------------|-----------------------|-------------|
| | (m ³ /det) | (m ³ /det) | (m ³ /det) | (buah) |
| A | 0.000 | 0.005 | 0.005 | 1 |
| B | 0.000 | 0.016 | 0.016 | 3 |
| C | 0.000 | 0.016 | 0.016 | 3 |
| D | 0.009 | 0.016 | 0.025 | 4 |
| E | 0.000 | 0.016 | 0.016 | 3 |
| F | 0.000 | 0.011 | 0.011 | 2 |
| G | 0.000 | 0.011 | 0.011 | 2 |
| H | 0.006 | 0.011 | 0.017 | 3 |
| I | 0.000 | 0.005 | 0.005 | 1 |
| Amount Well | | | | 20 |

Water from each excess discharge from the infiltration well of each house is then flowed to the drainage channel in front of the house then collected at the end of a housing block then collected into a communal infiltration well as shown in Figure 3.

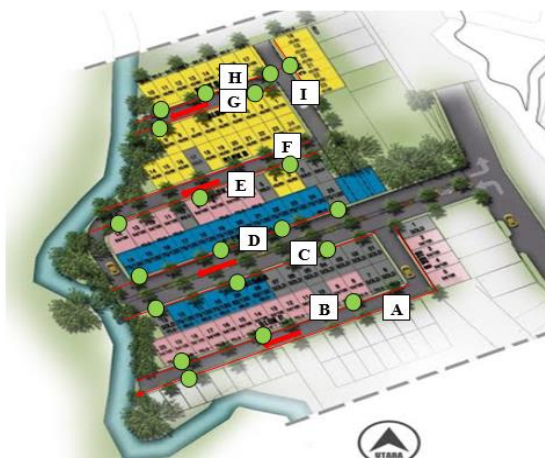


Figure 3. Site plan de sitinggil residence

From a total of 20 communal infiltration wells, they are designed to be simple constructions and easy to apply. The material used is a 1 m diameter concrete culvert, then the bottom part of the infiltration well is equipped with stones and fibers to make cleaning easier.

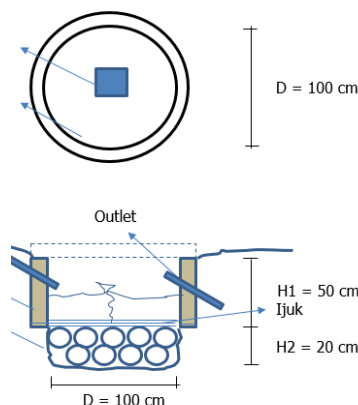


Figure 4. Construction of a Communal Infiltration Well

CONCLUSION

Based on the formulation of the problem and the results of calculations that have been carried out in the previous discussion. So based on the existing process several conclusions can be drawn as follows:

1. Based on the calculated flood discharge plans, the discharge into the residential area is quite large 0.445 m³ / second
2. So if water infiltration is carried out, 20 points are required for infiltration wells in each segment.

Some suggestions can be conveyed in this study so that it may need to be considered for further development:

1. In planning the infiltration well, there is a need for a soil permeability test and a detailed observation of groundwater elevation for each channel segment so that the accuracy of the planning results can be better.
2. It is necessary to make comparisons with the study of widening drainage channels or utilization of biopores so that the solution taken is technically and economically correct.

REFERENCES

- [1] Anugrahayu Metha. 2010. Tugas Akhir. *Studi Analisa Saluran Drainase Perkotaan Dengan Teknologi Sumur Resapan Di Perumahan Taman Mutiara Bondowoso.*
- [2] Botha, N (2005), Stormwater management and related urban environmental issues along the Fourways Spruit, Master of Arts in Environmental Management Dissertation, University of Johannesburg, Johannesburg.
- [3] Brown, R and M Farrelly (2009), "Delivering sustainable urban water management: A review of the hurdles we face", *Water Science and Technology* Vol 59, No 5, pages 839–846. Soemarto, C.D. 1999.
- [4] Dyson, L (2009), "Heavy daily-rainfall characteristics over the Gauteng Province", *WaterSA* Vol 35, No 5, pages 627–638.
- [5] *Hidrologi Teknik*. Jakarta: Erlangga.
- [6] Parkinson, J, Tayler K and O Mark (2007), "Planning and design of urban drainage systems in informal settlements in developing countries", *Urban Water Journal* Vol 4, No 3, pages 137–149.
- [7] Soewarno. 1995. *Hidrologi Aplikasi Metode Statistik Untuk Analisa Data*. Bandung: Nova.
- [8] Suripin. 2004. *Sistem Drainase Perkotaan Yang Berkelanjutan*. Yogyakarta: Andi.
- [9] Suhendra Halauddin. 2011. Abstrak. *Pengaruh Penambahan Polimer Emulsi Vinyl Acecate Coacrylic Pada Tanah Lempung Terhadap Uji Permeabilitas Melalui Constan Head Permeability Test.*
- [10] Sohail, K, S Cavill and A Cotton (2005), "Sustainable operation and maintenance of urban infrastructure: myth or reality", *Journal of Urban Planning and Development* Vol 131, No 1, pages 39–49