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Infiltration with Rock Permeability Coefficients for Subgrade Design

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Abstract— *Flood is still one of the disasters of concern, because it has a destructive force that is quite disturbing, even causing losses and endangering safety. The majority of floods are dominated by water which is an accumulation of surface runoff, so to control it, efforts must be focused on how to maximize the infiltration of rainwater into the ground. The majority of land owners in the catchment area, which are generally referred to as watersheds (DAS), are the community. Therefore, efforts to control it must involve the community. A simple construction that is quite effective to use is an infiltration well, because it has a large enough capacity but is easily made by the community, with a relatively small risk. However, from a review of the drainage system, the use of infiltration wells requires a higher cost than the construction of drainage channels to drain rain into rivers. Therefore we need design optimization efforts to get the cheapest cost. The design will be appropriate if accurate data is used, therefore testing the permeability coefficient of the subsurface rocks.*

Keywords— *Flood, surface runoff, infiltration well design; permeability coefficient.*

I. INTRODUCTION

Flood is still one of the disasters of concern, because it has a destructive force that is quite disturbing, even causing losses and endangering safety. The majority of floods are dominated by water which is an accumulation of surface runoff, so to control it, efforts must be focused on how to maximize the infiltration of rainwater into the ground. The majority of land owners in the catchment area, which are generally referred to as watersheds (DAS), are the community. Therefore, efforts to control it must involve the community. A simple construction that is quite effective to use is an infiltration well, because it has a large enough capacity but is easily made by the community, with a relatively small risk. However, from a review of the drainage system, the use of infiltration wells requires a higher cost than the construction of drainage channels to drain rain into rivers. Therefore we need design optimization efforts to get the cheapest cost. The design will be appropriate if accurate data is used, therefore testing the permeability coefficient of the subsurface rocks.

Control measures are arranged with maximization orientation: collecting rainwater below the ground surface (upstream), storing flood water in the riverbed (middle part), and channeling water that cannot be utilized (downstream). Maximization of rainwater storage below the land surface will be effective if it is carried out with land conservation which is strengthened by the use of multi-function infiltration well construction.

The low capacity of each infiltration well causes the use of infiltration wells to be expensive, so that it becomes an obstacle when mass movements are carried out with the public budget. This requires efforts to increase the capacity of infiltration wells and control the quality of groundwater.

A. Soil Permeability Coefficient

Soil permeability is the ability of the soil to pass or drain water, which is represented by the magnitude of the velocity of water seeping into the soil, both horizontally and vertically through soil pores. The rate of water infiltration is influenced by the texture of the soil. Darcy's law describes the ability of water to flow in cavities (pores) in the soil and the properties that influence it. There are two main assumptions used in determining Darcy's law. The first assumption states that the flow of fluids / fluids in the soil is laminar. Meanwhile, the second assumption states that the soil is in a saturated state. According to Sunjoto, the soil permeability coefficient can be determined using the following formulations:

$$K = \frac{\pi R^2}{F(t2 - t1)h1} \ln \frac{h2}{}$$

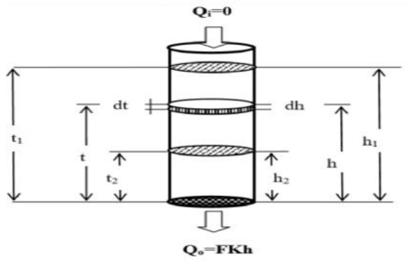

Figure 1. Flow Schematic in a Borehole

The formula is to calculate the soil permeability coefficient (K) according to Forchheimer (1930), if it is known that the change in water level is a function of time in the bore hole with a discharge of Q = 0 (water is poured in an instant)

Sunjoto (1988) builds this formula on the principle:

1. The flow of water into the well is assumed to be constant the same as Q. This is in accordance with the physical condition, namely that during a rainy period there will be discharge from the roof that enters the well.
2. The discharge (sink) is equal to the geometric factor times the permeability coefficient of the function of the water level in the well Qo = F K h (Forchheimer, 1930).
3. This unsteady flow condition formula is the same as Forchheimer's (1930) formula, the difference is that the latter is a steady flow condition. If time is infinite, Sunjoto's formula

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will be the same as the steady flow condition and the formula will be exactly the same as Forchheimer's (1930) formula.

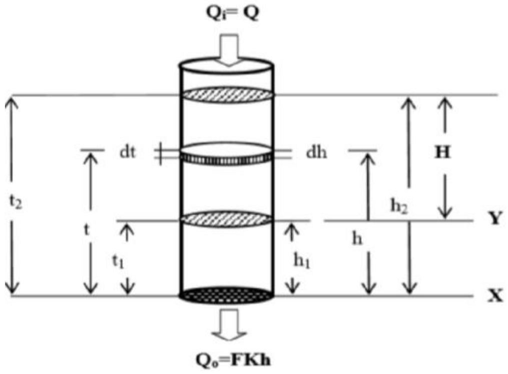

Figure 2. Schematic Flow in a Well

II. METHOD

The research activities are in the form of, excavating the soil according to the well design, taking the test object, testing the permeability coefficient in the soil laboratory. Laboratory test data are used as the basis for analysis of infiltration well designs. The design is carried out with various formulas, then compared with the well capacity data from field observations. The correct formulation will then be used to design various sizes of wells. The best size is selected based on the largest capacity, of the same diameter. Thus, the well depth parameter becomes an optimized factor.

A. Well Geometric Factor (F)

The geometric factor (shape factor) is a price that represents the shape of the well's tip, its appearance, radius, wall tightness and its placement in the soil layer. The geometric factors vary in value depending on the formula used.

The geometric factor formula is a formula that is influenced by the shape of the infiltration well itself, starting from the tip of the well, its appearance, radius, wall tightness and its placement in the soil layer.

The geometric factor is one of the elements used to find the K value (soil permeability coefficient). Then there are many researchers who developed the F formula for various well conditions, such as: Samsioe (1931), Harza (1935), Dachler (1936), Taylor (1948), Hvorslev (1951), Aravin (1965), Sunjoto (1989 - 2002).

This price was first raised by Forchheimer (1930) in looking for K from his research with experiments according to formula (2.1). This method only uses one borehole without monitoring wells, as is usual in the Dupuit-Theim formula based on Darcy's Law (1856) which must use monitoring wells. This Forchheimer method provides convenience in planning calculations because it can explicitly calculate with laboratory data without having to know monitoring well data that can only be measured after drainage occurs in the field. So this Forchheimer concept can be called a new mashub in Groundwater Flow calculations in addition to the existing concept, Darcy's Law.

III. RESULT AND DISCUSSION

A. Rainfall

TABLE 1. Annual Maximum Rainfall Data

No.	R maks	opportunity	Log x	Log x - Log x	(Log x - Log x)^3
	(mm)	(%)			
(1)	(2)	(3)	(4)	(5)	(6)
1	58.55	0.04	1.7675	-0.1152	-0.0015
2	61.17	0.09	1.7865	-0.0962	-0.0009
3	61.28	0.13	1.7873	-0.0954	-0.0009
4	62.82	0.17	1.7981	-0.0847	-0.0006
5	63.53	0.22	1.8030	-0.0798	-0.0005
6	66.78	0.26	1.8246	-0.0581	-0.0002
7	70.92	0.30	1.8508	-0.0320	0.0000
8	71.74	0.35	1.8558	-0.0270	0.0000
9	72.26	0.39	1.8589	-0.0239	0.0000
10	74.99	0.43	1.8750	-0.0078	0.0000
11	75.04	0.48	1.8753	-0.0075	0.0000
12	76.83	0.52	1.8855	0.0028	0.0000
13	80.25	0.57	1.9044	0.0217	0.0000
14	81.83	0.61	1.9129	0.0302	0.0000
15	83.98	0.65	1.9242	0.0414	0.0001
16	83.98	0.70	1.9242	0.0414	0.0001
17	85.67	0.74	1.9328	0.0501	0.0001
18	87.99	0.78	1.9444	0.0617	0.0002
19	88.86	0.83	1.9487	0.0659	0.0003
20	91.52	0.87	1.9615	0.0788	0.0005
21	98.56	0.91	1.9937	0.1109	0.0014
22	101.27	0.96	2.0055	0.1227	0.0018
amount			41.4207	0.0000	-0.0001
average			1.88276	0.0000	0.0000
standard devasi			0.0690	0.0690	0.0007

Source: calculation results

TABLE 2. Planning Rainfall Calculation

Tr	average	Std Deviasi	Slant	opportunity	K	R (plan	
(year)	(log)	(log)	(Cs)	(%)		log	(mm)
5	1.8828	0.0690	-0.0223	20	0.843	1.94	87.29
10	1.8828	0.0690	-0.0223	10	1.280	1.97	93.56
15	1.8828	0.0690	-0.0223	5	1.749	2.00	100.80
20	1.8828	0.0690	-0.0223	2	2.048	2.02	105.71
25	1.8828	0.0690	-0.0223	1	2.320	2.04	110.38

Source: calculation results

TABLE 4. Kolmogorov Smirnov Test Recapitulation

No		D_{critis}	D_{maks}	information	
1	1%	0.3475	0.0935	D_{maks}<D_{critis}	fulfilled
2	5%	0.29	0.0935	D_{maks}<D_{critis}	fulfilled

Source: calculation results

TABLE 5. Distribution of Monobe Period Rainfall

T	t	RT	
(hour)	(hour)		
1	6	0.550	R24
2	6	0.347	R24
3	6	0.265	R24
4	6	0.218	R24
5	6	0.188	R24
6	6	0.167	R24

Source: calculation results

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Information :
RT = R24 / t. (t / T) 2/3
RT = average intensity of rain in T hours (mm / day)
R24 = effective rainfall in 1 day (mm)
T = time it started to rain
t = time of concentration of rain

B. Soil Permeability Coefficient

To determine the permeability of the soil in the field, a test well experiment was used. When the permanent water level has been reached, the following data are obtained:

TABLE 6. Soil Permeanility Coefficient Data

q	=	3,1 m3/minute	r^1	=	21 m
h_1	=	5 m	r^2	=	50 m
h_2	=	6 m			
Soil Permeability Coefficient:					
k	=	$\frac{2{,}3 \cdot q \cdot \text{Log } (r_1/r_2)}{\pi\,(h_2^2 - h_1^2)}$			
	=	$\frac{2{,}3 \cdot (3{,}1 \text{ m3/minute}).\text{ Log } (50 \text{ m}/21 \text{ m})}{\pi\,(6 \text{ m}^2 - 5 \text{ m}^2)}$			
	=	$\frac{2{,}685}{34{,}558}$ = 0,078 m/minute			
k	=	1,3 x 10^{-3} m/second			

TABLE 7. Results of Return Period Analysis

Reset Period C	I	A	Q(m3/second)
5 year		21.620	407.57
10 year		23.170	436.79
15 year	0,45	24.960	150,690470.53
20 year		26.180	493.53
25 year		27.330	515.21

IV. CONCLUSION

From the results of the analysis that has been done, it can be concluded that the discharge of rainwater that enters the aquifer system is not suppressed through the infiltration process in the watershed with a return period of 5 years, 10 years, 15 years, 20 years, and 25 years.

V. SUGGESTION

From the results of the analysis of calculations that have been carried out, it is advisable to make several infiltration wells due to the lack of water absorption which causes large runoff in the watershed area in order to reduce standing in the area.

REFERENCES

[1] Kustamar. 2016. “Conservation of Water Resources in the Upstream Watershed”. Proceedings of the Scientific Meeting Iplbi 2016.
[2] Kustamar (2017). “Strategy To Increase Absorption Well Capacity”. Journal Of Technology And Sciences. Vol.1 No. 1
[3] Bastin Yungga Angguniko. 2010. “Public Perception of Infiltration Well Technology and Biopore Infiltration Holes (Case study: South Tangerang Regency)”. Journal of Social and Social Work, Vol. 2 No.1, April 2010 Pages 9-2067-80.
[4] Department of Energy and Mineral Resources of Central Java Province. 2017. “Making Well Dug / Peg in Central Java”. Terms of Reference (Sis). Not Published.
[5] SNI: 03-2453. (2002). “Procedure for Planning Rainwater Infiltration Wells for Yard Land”. Jakarta: National Standardization Agency for Indonesia
[6] SNI: 8456. (2017). “Rainwater Infiltration Wells and Trenches”. Jakarta: Agency National Standardization.
[7] Sunjoto. (2011). “PRO-AIR Drainage Technique”. Yogyakarta: Gadjah University