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Design of Infiltration Well in Wetlands Area that Suitable for Giving Maximum Groundwater Recharge

IRFAN PRASETIA
Dept. of Civil Engineering, Faculty of Engineering,
Lambung Mangkurat University

ABSTRACT

Growth in residential, industrial, and office area,are significantly occurred in all city in Indonesia. Unfortunately, this is also caused more land that being covered by pavement and concrete in the cities. Realized or not it will disturb the availability of the groundwater and also lead to flooding in the rainy season. One of the effective solutions to solve this problem is by making sufficient numbers of infiltration well in the city, especially in the residential area. This research was conducted to analyze the ideal design of the infiltration well in the residential area. The design was made according to the equation by Sunjoto, which also refers to Indonesia standard (SNI) No: 03- 2453-2002. The results show that the ideal dimension for the infiltration well is to use the radius of the well (R) of 1.25 m. With the R of 1.25 will give a significant recharge to the groundwater as much as ≈ 2.400 liter. It is expected that this research encourage a development in the urban drainage systems which will consider the environment and the groundwater reservation for the balance of our ecosystem.

Keywords : infiltration well, groundwater reservation, ecosystem balance.

INTRODUCTION

Nowadays, flooding has become a routine agenda that occurred in several big cities in Indonesia. A fast growth of cities in Indonesia is one of the causes of this problem. New residential, industrial, and office area that opened made the water catchment area become smaller. This condition can lead to imbalance in the ecosystem which will cause to surface runoff, erosion, and lack of groundwater reservation.

According to the conventional concept, urban drainage system is only trying todrain the water from the flooded area to the river, retention areas and/or sea. This system will only move the puddles from one place to another place. Thus, new concept that is being developed nowadays is a drainage system which is environmentally friendly which so called as eco-drainage system.

Correspondence: Irfan Prasetia, Dept. of Civil Engineering, Faculty of Engineering, Lambung Mangkurat University.
Email: *prasetia.07@gmail.com*

An effective solution that can be offered through this eco-drainage system is by making the infiltration well.The infiltration well can recharge the ground water by injecting the rain water to the soil. The area that need this infiltration well such as farming area, residential, industrial, office area, and another public service areas. For the infiltration well's design in the residential area has to comply to the Indonesia standard (SNI) No: 03-2453-2002 (Litbang Pemukiman PU, 1990). This standard define how to design the infiltration well for residential yards, including the general and technical requirements regarding the ground water level limit, the value of the permeability of the soil, the distance of the building, the calculation and determination of the infiltration well. However, this standard has not yet determines the ideal design for infiltration well.

Therefore, this research obtective is to determine the ideal design infiltration well in the residential area. The design was made according to the equation by Sunjoto (1993), which also refers to Indonesia standard (SNI)

No: 03- 2453-2002. It is expected that this research will encourage a development in the urban drainage systems which will consider the environment and the ground water reservation for the balance of our ecosystem.

METHODS

The design was made according to the equation by Sunjoto (1993). To facilitate the research works, the residential area of Lambung Mangkurat University's lecturer at Banjarbaru city, South Kalimantan Province, Indonesia, was chosen. As for the equation, these data have been set as the reference:

1. the roof surface area: ranged between 50 m^2until 1.000 m^2
2. the radius of the well (R): ranged between 0,5 m until 1,5 m
3. the depth of the infiltration well:

$$H = \frac{Q}{F\,K}\left[1 - \exp\left(\frac{-F\,K\,T}{\pi\,R^2}\right)\right] \quad \text{(eq. 1)}$$

where: H = Water level in the well (m)
Q = Discharge of rainwater (m^3/hr),
F = Geometric factor (m),
K = Soil permeability value (m/hr)
T = Dominant rainfall duration (hr)
R = radius of the well (m)

4. The geometric factor:
   For impermeable wall of the infiltration well is
   $F = 2\,\pi\,R$ (eq. 2)

RESULTS AND DISCUSSIONS

Hydrology Data

Hydrology data of the research works area was taken from the community service report of the lecturer team of the Faculty of Engineering Unlam Banjarbaru (Shadiq et al, 2006). The data that being obtained from the team are:

1. The maximum discharge of rainwater (Qp) according to rational method:

   Qp = 0,002778 . C . I . A
   = 0,002778 . 0,1 . 356,7 . A
   = 0,099 A m^3/sec

   where:
   Qp = The maximum discharge of rainwater,
   C = Roof surface flow coefficient,
   I = Rain intensity,
   A = Roof surface area

2. Dominant rainfall duration
   According to the Kirpich method, with length of the trench = 0.016 km and the river slope = 0.05 m/m, then the calculation for the Dominant rainfall duration (T) is 0.5 hours.
3. Permeability (K)
   Value of the average permeability of the soil in the research works area is $1.23\text{x}10^{-3}$ cm/secor 4 cm/hr or 0.04 m/h. This value is in accordance to the requirement value that specified in the SNI No: 03-2453-2002 with the soil permeability value more than 2.0 cm/hr. Thus, this area is suitable for designing the infiltration well.

Design of the infiltration well

With the hydrology data that already mentioned above, the depth of the infiltration well can be calculated according to the eq.1. The calculation can be seen in Table 1. In addition, maximum volume of the infiltration well can be seen in Table 2.

(eq.2)

From Table 1, with the radius of the well ranging between 1 m until 1.5 m, the depth of the well is below 1 m. Thus,with a depth of less than 1m will facilitate the process of excavation. Therefore, the radius of the well between 1 m until 1.5 m is an ideal dimension for the depth of the infiltration well. Furthermore, according to the Table 2, it could be seen that the difference in the maximum volume of the infiltration well between R = 1.25 m with R = 1.5 m is not significant. Thus, it is more efficient to use R = 1.25 m.

Table 1 Calculation of the depth of the infiltration well

Roof surface area (A) m^2	H (meter)				
	R = 0,5 m	R = 0,75 m	R = 1 m	R = 1,25 m	R = 1,5 m
50	3.0285	1.3639	0.7723	0.4962	0.3455
100	6.0571	2.7277	1.5445	0.9925	0.6910
150	9.0856	4.0916	2.3168	1.4886	1.0366
200	12.1140	5.4554	3.0891	1.9849	1.3821
250	15.1425	6.8194	3.8613	2.4811	1.7276
300	18.1711	8.1833	4.6336	2.9774	2.0731
350	21.1996	9.5471	5.4059	3.4735	2.4186
400	24.2281	10.9110	6.1781	3.9697	2.7640
450	27.2566	12.2748	6.9504	4.4660	3.1097
500	30.2852	13.6387	7.7227	4.9622	3.4552
550	33.3136	15.0026	8.4949	5.4585	3.8006
600	36.3421	16.3664	9.2672	5.9546	4.1461
650	39.3706	17.7303	10.0395	6.4509	4.4916
700	42.3992	19.0941	10.8117	6.9471	4.8373
750	45.4277	20.4581	11.5840	7.4434	5.1827
800	48.4562	21.8220	12.3563	7.9395	5.5282
850	51.4848	23.1858	13.1285	8.4357	5.8737
900	54.5133	24.5497	13.9008	8.9320	6.2192
950	57.5417	25.9135	14.6731	9.4282	6.5648
1000	60.5702	27.3003	15.4453	9.9245	6.9103

Table 2. Maximum volume of the infiltration well

Roof surface area(A) m^2	R = 1 m		R = 1,25 m		R = 1,5 m	
	H (m)	V (l)	H (m)	V (l)	H (m)	V (l)
50	0.7723	2425.022	0.4962	2434.481	0.3455	2440.958
100	1.5445	4849.73	0.9925	4869.453	0.691	4881.915
150	2.3168	7274.752	1.4886	7303.444	1.0366	7323.579
200	3.0891	9699.774	1.9849	9738.416	1.3821	9764.537
250	3.8613	12124.482	2.4811	12172.897	1.7276	12205.494
300	4.6336	14549.504	2.9774	14607.869	2.0731	14646.452
350	5.4059	16974.526	3.4735	17041.859	2.4186	17087.409
400	6.1781	19399.234	3.9697	19476.341	2.764	19527.660
450	6.9504	21824.256	4.466	21911.313	3.1097	21970.031
500	7.7227	24249.278	4.9622	24345.794	3.4552	24410.988
550	8.4949	26673.986	5.4585	26780.766	3.8006	26851.239
600	9.2672	29099.008	5.9546	29214.756	4.1461	29292.197
650	10.0395	31524.03	6.4509	31649.728	4.4916	31733.154
700	10.8117	33948.738	6.9471	34084.209	4.8373	34175.525
750	11.584	36373.76	7.4434	36519.181	5.1827	36615.776
800	12.3563	38798.782	7.9395	38953.172	5.5282	39056.733
850	13.1285	41223.49	8.4357	41387.653	5.8737	41497.691
900	13.9008	43648.512	8.932	43822.625	6.2192	43938.648
950	14.6731	46073.534	9.4282	46257.106	6.5648	46380.312
1000	15.4453	48498.242	9.9245	48692.078	6.9103	48821.270

Based on calculation showed in the Table 1 and 2, it can be concluded that the ideal design for the infiltration well that can be build in the residential area is by using R = 1,25 m. With this R value, it can make the building process of the infiltration well easier. In addition, with this R value will also facilitate the process of excavation which is not to deep and wide. Therefore, it is easy to build this infiltration well and structurally safe. In addition, with the R of 1.25 m will give a significant recharge to the groundwater as much as ≈ 2.400 liter.

CONCLUSIONS

In accordance with the purposes of this study, the ideal design of the infiltration well has been determined. Based on the data and from the analysis of these data, there are several things that can be drawn as a conclusion from this study as follows:

1. The hydrology data that obtained from the field show that the maximum discharge of rainwater (Qp) is 0,099A m3/sec and value of the average permeability of the soil is 4 cm/hr. Thus, this area is suitable for designing the infiltration well which the requirement value that specified in the SNI No: 03-2453-2002 is more than 2,0 cm/hr.
2. The analyses of the data show that the ideal design for the infiltration well build in the residential area is by using the radius of the well (R) of 1.25 m. With this R value will facilitate the process of excavation and also structurally safe.
3. According to this study, the infiltration well will give a significant recharge to the groundwater as much as ≈ 2.400 liter for the roof surface area equal as 50 m^2, until as much as≈ 48.000 for the roof surface area equal as 1.000 m^2.

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