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Urban Street Drainage Improvement by Means of Infiltration Wells

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ABSTRACT

Urban drainage is the drainage system in the administration area of the city and urban area that serves to control surface water from the residential area of rain and can provide benefits to human life. In an urban drainage function as controllers and drain the excess rainwater runoff safely and also to channel the excess water courses that have an impact disturb or pollute the environment. Application of urban drainage systems still use a mixed system in which rainwater and wastewater is channeled through the same channel. Therefore, this study will discuss the improvement of drainage in urban areas by using infiltration wells. Infiltration wells that can be applied in urban areas in the form of individual wells or collectively. Some function of infiltration wells for human life is as flood control, protect and repair the conservation groundwater, and reducing the rate of erosion. There are two infiltration wells within one kilometers at a cost of one unit of infiltration wells amount to IDR 18 million.
KEYWORDS: Infiltration Wells, Urban Drainage, Street, Runoff

INTRODUCTION

Urban drainage generally always use the surface drainage. In urban surface drainage closed as the street shoulders or sidewalks. Although there is also the surface drainage not closed with the top side of the channel flat with the street surface so that water can enter freely [1]. The ground level such as roads, parking lots, and roofs cause increased runoff volume which will increase the mass of pollutants that reach the receiving water bodies [2], [3] and [4]. Drainage is designed to reduced the volume of runoff and improve the quality of the water before it reaches surface water sources [5].

Methods of infiltration wells can increase the utilization of ground water at this time as a result of the rapid growth in population. Infiltration wells has a circular or rectangular shape with a certain depth which serves to accommodate and absorb rainwater above ground either through the roof of the building, street, or courtyard. The problems that occurred in the current urban drainage channel that serves as a wastewater disposal is considered as a garbage dump by the public and affecting the water that goes into the ground. Therefore it needed an improvement using infiltration wells that helps permeated water, reduce inundation, replenishes groundwater began to decrease.

MATERIALS AND METHODS

In this study, the application of infiltration wells to improve the drainage channel on street. The method used is quantitative descriptive. Activities carried out by conducting site surveys, analyze and interpret the data obtained for solutions and solving problems found in the field. Data obtained derived from the information society and institutions.

Data collected to determine the dimensions of infiltration wells to be able to accommodate the rain water is:

1. The intensity of the rainfall, the higher the intensity the greater rainfall infiltration wells required dimensions.
2. Groundwater conditions, the ground water in the infiltration wells need to be made on a large scale and shallow groundwater levels if it is less effective.
3. The permeability of the soil is the determination of the volume on the infiltration wells that will be created and affect the speed of infiltration.
4. Topography, infiltration wells must be located in a flat area.
5. Land use, effect on the percentage of water that seep into the soil by surface runoff.

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RESULTS AND DISCUSSION

A. Infiltration Wells Construction

Infiltration wells as a construction that function as the permeated of water into the soil, infiltration wells have provisions into consideration in planning. The requirements that must be fulfilled include:

- Having depth (H) is sufficient, it is closely related to the purpose of infiltration discharge.
- Having a broad field (A) enough, both on the walls of the well and the bottom of the well.
- Has the volume capacity (V) which is sufficient for water to be absorbed, so that water runoff is not happening.

According to the Indonesian National Standard (SNI 03-2453-2002) Planning Procedures Infiltration Wells for Rain Water courtyard fit some general requirements such as:

- Rainwater infiltration wells placed on relatively flat land, not on the ground slopes, steep or unstable
- Infiltration Wells leach away from landfill, away from the septic tank (minimum 5 m measured from the edge), 1,5 m of a public road and a minimum of 1 m from the building foundation.
- The depth of the groundwater table minimum of 1,5 m during the rainy season. Infiltration wells maximum of 2 m below the ground surface.
- The structure of the soil must have soil permeability (ability of the soil to absorb water) is greater than or equal to 2,0 cm/hour (that is, a puddle of water as high as 2 cm will absorb out within 1 hour), with three classifications, namely:
  - Permeability moderate, i.e. 2,0 to 3,6 cm/hour.
  - Permeability ground rather quickly (fine sand), i.e. 3.6 to 36 cm/hour.
  - Permeability fast ground (coarse sand), i.e. greater than 36 cm/hour.

B. Dimensional Infiltration Wells

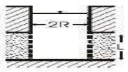
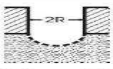
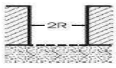
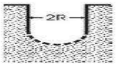
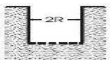
To calculate the dimensions of infiltration wells can be used the following formula [6]:

$$H = \frac{Q}{F.K}\left(1 - e^{\frac{F.K.T}{\pi.R^2}}\right) \quad (1)$$

where:

H = High water level in the well (m)
Q = Incoming water discharge (m^3/sec)
T = Time flow (second)
F = Geometric Factor (m), see Table 1 and Table 2
K = Permeability Coefficient (m/sec)
R = Radius of infiltration wells (m)

Table 1. Geometric Factor Infiltration Wells

No	Condition	Shape Factor of Well (F)	Value of F when R=1; H=0 L=0, except for F1, L=1	References
1		$\frac{2\pi L}{\ln\left\{\frac{2(L+2R)}{R}+\sqrt{\left(\frac{2L}{R}\right)^2+1}\right\}}$	2.980	Sunjoto (1989)
2a		4 π R	12.566	Samsioe (1931) Dachler (1936) Aravin (1965)
2b		18 R	18.000	Sunjoto (2002)
3a		2 π R	6.283	Samsioe (1931) Dachler (1936) Aravin (1965)
3b		4 R	4.000	Forchheimer (1930) Dachler (1936) Aravin (1965)
4a		π^2 R	9.870	Sunjoto (2002)
4b		5.5 R	5.500	Harza (1935) Taylor (1948) Hvorslev (1951)
		2 π R	6.283	Sunjoto (2002)

Source: [7]

Table 2. Geometric Factor Infiltration Wells Description

Condition	Description
1	Infiltration on land located between the porous soil is waterproof at the bottom and top with porous walls as high as L.
2.a	Infiltration spherical porous walled with vertical channels are waterproof and wholly porous soil.
2.b	Infiltration porous walled cube with vertical channels are waterproof and wholly porous soil.
3.a	Infiltration in the soil is waterproof at the top and bottom porous soil with a hemispherical shaped base.
3.b	Infiltration in the soil is waterproof at the top and bottom porous soil with flat bottom.
4.a	Infiltration is located on land which is entirely porous wall waterproof absorption and hemispherical shaped base.
4.b	Infiltration is located on land which is entirely porous wall waterproof absorption and flat bottom.

Source: [7]

C. Infiltration Wells Planning

While the wall is planned to recharge wells made of masonry empty and not plastered to facilitated the water can soak into the ground. Infiltration wells planning is rectangular shape with the following factors:

- Layer on filter media = 40 cm
- H = 6 m
- F = 3,85 m
- K = 0,00015 m/sec
- Diameter = 1,4 m
- Q_0 = 0,0037 (m^3/sec)

The effective depth of infiltration wells calculated groundwater levels when the bottom of the well is below the ground water level, and is measured from the bottom of the well when the ground water level is below the bottom of the well. Bottom hole should be at the soil layer with high permeability. To reduce inundation occurred around drainage on the street, then infiltration wells built around the drainage system in areas that are still included in the catchment are of the channel.

For the design of infiltration wells for street or park can be seen in Figure 1 and for the calculation of the amount of infiltration wells can be seen in Table 3.

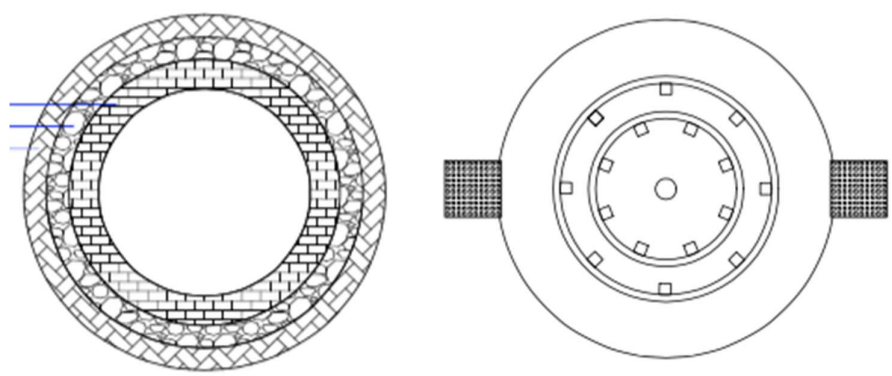


Figure 1. (a) Top View Infiltration Wells Design (b). Cover Infiltration Wells Design

The wall is planned to infiltration wells made of brick masonry empty and not plastered to facilitate the water soak into the ground. Cover of infiltration wells that created holes to facilitate runoff water into the wells.

Table 3. Total Infiltration Wells

Location	K	F	QIn filtration	Qinundation	Infiltration Unit	Max. Capacity
	m/sec	m	m3/sec	m3/sec		m3/sec
Primary Channel						
Urip Sumohardjo 1	0,00015	3,85	0,0037	2,46	665	2,47
Urip Sumohardjo 3	0,00015	3,85	0,0037	1,14	308	1,15

Urip Sumohardjo 4	0,00015	3,85	0,0037	1,75	472	1,75
Urip-Racing	0,00015	3,85	0,0037	1,09	297	1,10
Secondary Channel						
Jl. Pettarani 1	0,00015	3,85	0,0037	1,56	423	1,57
Pengayoman 1	0,00015	3,85	0,0037	0,34	93	0,35
Pengayoman 2	0,00015	3,85	0,0037	0,35	96	0,36
Toddopuli Raya	0,00015	3,85	0,0037	0,14	40	0,15
Jl. Dr. Leimena	0,00015	3,85	0,0037	0,21	59	0,22
Jl. Antang Raya	0,00015	3,85	0,0037	0,11	29	0,11
Jl. Billawayah	0,00015	3,85	0,0037	0,11	30	0,11

Table 3 above, obtained the total of infiltration wells that will be planned in the District Panakkukang amounted to 2.512 units. The location of infiltration wells will be created on the shoulder of street or park which has a lower elevation. The following figure 2 is a map location of recharge wells.

Work	Vol.	unit	Unit Price	Amount
Preparation				
Cleaning			.00	81,120.00
Earthworks				
Soil excavation			.00	855,820.80
Restore soil			.00	22,296.38
Infiltration Wells w				
Red stone 1/2 brick			.00	2,142,390.60
Stone empty			.00	277,453.43
Cover plate concret			.29	1,206,399.29
Coral stone			.00	824,250.00
Plestering 1:4 t=1.5			.00	959,753.40
Instalation of ijuk			.00	9,443,135.52
			TOTAL	**15,812,619.42**
			Tax 10%	**1,581,261.94**
			Total	**17,393,881.36**
			Rounding Off	**17,393,000.00**

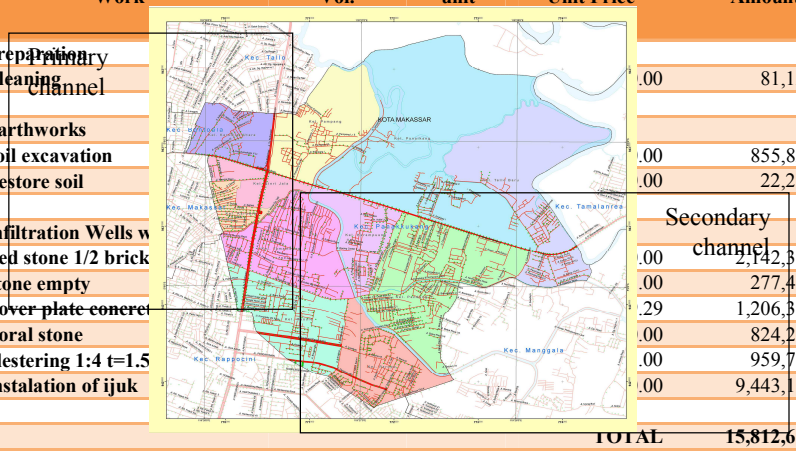


Figure 2. Location Infiltration Wells

D. Calculation of the Budget Plan Infiltration Wells

The calculation of the cost one unit infiltration wells for street or park can be seen in Table IV. Unit price used is the unit price principal activities. Budget plan is made in order to determine the amount of equipment needed in the infiltration wells so it can be easier to calculate and plan costs. Calculations are detailed in Table 4.

Table 4. Calculation of the Budget Plan Infiltration Wells

CONCLUSION

Urban street drainage need of improvement by infiltration wells viewed groundwater conditions of diminishing returns. Infiltration wells absorb water into the soil and also reduce the inundation that occur in urban areas. Diameter 1,4 m, depth of water 6 m and soil permeability 0,00015 m/sec. Discharge of infiltration wells 0,0037 m^3/sec and a circle shape is required 2 units infiltration wells every 1 kilometers. Total costs required to manufacture one unit of infiltration wells is IDR 18 million.

REFERENCES

[1] Kurniawati, R. 2011. Effect of optimizing urban drainage systems to decrease the intensity of flooding in Bandung. http://ri2nkurniawati.blogspot.co.id/2011/12/pengaruh-optimalisasi-sistem-drainase.html
[2] Field, R., 1975. Coping with urban runoff in the United States. Water Res. 9 (5–6), 499–505.
[3] Booth, D.B., Jackson, C.R., 1997. Urbanization of aquatic Systems: Degradation thresholds, storm water detention, and the limits of mitigation. J. Am. Water Resour. Assoc. 33 (5), 1077–1090.
[4] Kayhanian, M., Fruchtman, B., Gulliver, J.S., Montanaro, C., Raniere, E., Wuertz, S., 2012. Review of highway runoff characteristics: comparative analysis and universal implications. Water Res. 46 (9), 6609–6624.
[5] National Research Council, 2008. Urban Stormwater Management in the United States. Rep. No. Committee on Reducing Stormwater Discharge Contributions to Water Pollution, Water Science and Technology Board, Division on Earth and Life Studies. The National Academies Press, Washington, D.C.
[6] Sunjoto, 1991. Hydraulics Infiltration Wells. GadjahMada University, Yogyakarta.
[7] Sunjoto, 2011. Mechanical Drainage Pro Air, 1st edition, GadjahMada University, Yogyakarta.