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The Comparison between the Research and Calculation Results to the Amount of Ground Water Debit in Recharge Reservoir using Sand Columns

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ABSTRACT

The objective of this study was to identify the groundwater recharge difference between the research results and developed Darcy Formula results. This study was an experimental research carried out in the Soil Mechanics and Hydraulics Laboratory, Department of Civil Engineering, Polytechnic State of Ujung Pandang. Two samples of soil, consisting of clay with low permeability and sand with high permeability, were applied as partition layer between reservoir and as sand columns material, respectively. When sand columns were used as the parameter, the variable studied was the hydraulic head difference, the height of sand the columns, the reservoir water level, and the amount and diameter of the sand columns. Research result indicated that, within all parameters, the debit obtained was larger than the calculation results. Despite the difference, the groundwater recharge resulted from both methods showed same direction. The debit increased along with the increasing Hydraulic head difference and the density of sand columns. Debit resulted from the research and from the calculation were strongly related because the determination coefficient was R^2 = 0,998 or R = 0,999 (> 0,60 and approaching 1) with equation y = 1,028x.

Key words : Calculation Result, Groundwater, sand columns the standard procedures, including: SNI, ASTM, AASHTO.

I. INTRODUCTION

Rapid growth of urban area is indicated by the existence of settlement and industrial area, which causes increasing need of water and may disturb the balance between water demand and supply. This is worsening by the inadequate capability of the Government through Regional Drinking Water Company (PDAM) to provide clean water and to cover all service area. In the effort to obtain clean water, one of the alternatives is by siphoning groundwater using wells and drilling (Kodoatie and Sjarif, 2010). However, excessive exploitation may cause land subsidence and the impacts include flood, sea water intrusion, ground water surface decrease, and ground water quality degradation (Tresnadi, 2007).

To cope with those problems, efforts to *recharge* into the groundwater reservoir are made by using the bio-pore holes or other recharge techniques. However the results have not been optimum. Thus, the developed recharge reservoir is expected to become the solution. The problem occurs when it is going to be built in specific area with small permeability and low absorbance power, where water reaches the aquifer slowly. This may lead failure to the reservoir regarding its function as a recharge reservoir. Therefore, it is required to study the use of sand columns model put on the base of the recharge reservoir and directly connected to the aquifer layer within several parameters.

The objective of this study was to identify the difference of ground water recharge debit between the research and the developed Darcy formula results.

II. RESEARCH METHOD

1. Soil and sand material sample testing.

Data about the soil characteristics and properties were obtained through physical and mechanical characteristics testing. The physical characteristic testing was applied to identify the type of the soil to be used in this study in refer to

The permeability testing was carried out to determine the permeability coefficient based on the test standard of ASTM D2434-68. When the seepage power was very small and cannot be measured precisely, the *falling head permeability test* was taken. The *constant head permeability test* was carried out when water was sufficiently plenty that it could seepage into the sample quickly.

2. Recharge reservoir model with sand column.

This research used square specimen model in 180 cm x 115 cm x 60 cm dimension. On the bottom part, a hole was made for seepage water exit (See Figure 37). After given with tests of physical soil characteristic and permeability, the required samples were put into a basin of 150 cm x 100 cm x 50 cm dimension, in the model test instrument. Then, in the soil layer, sand column was set and the surface part was given with input debit (Q_1) constantly to maintain the water surface height. Side flow debit (Q_2) was given to identify the Hydraulic head difference. To identify the recharge debit entering the reservoir (Q_1), side flow debit (Q_2) as seen in Figure 38 (a), debit runoff reservoir (Q_3), debit coming out of the aquifer layer (Q_4) as seen in Figure 38 (b), time recording were taken when filling the 1000 ml measuring cup, each in five times. When the stable flow condition was achieved and the soil has become water *saturated*, which was indicated by balanced water debit enter and exit, measurement was taken for water exiting the aquifer layer (Q_4) and for the Hydraulic head difference (Δh).

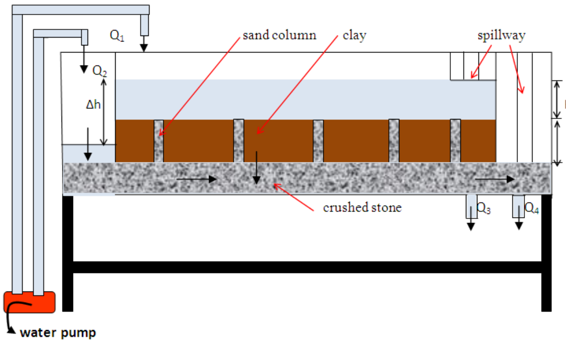

Figure 1: The concept of recharge reservoir with sand columns

3. Analysis Technique

The debit data resulted from the research was compared to the calculation result. Equation applied was the developed Darcy Formula as the following (Azis, 2013):

$$Qa = k_1.\frac{\Delta h}{z}.(A - \frac{1}{4}\pi.d^2.N_{kp}) + k_2.\frac{\Delta h}{z}.\frac{1}{4}\pi.d^2.N_{kp} \qquad (1)$$

III. DISCUSION OF RESULT

1. Soil Type

The test result of soil and sand sample based on the four soil classification systems indicated that the soil used in this research was silt with low plasticity and the sand was coarse.

2. The comparison between the research and calculation results

To compare the research results and calculation results, Equation 1 was applied. Data used in this equation was the same as used in the test of recharge reservoir. The results are presented on Table 1.

Table 1. The comparison between the research and calculation results

Δh (cm)	Debit of Groundwater Recharge, Q_a (cm³/det) — Density of The Sand Column (ƺ)								
	0,0019			0,0033			0,0052		
	Research	Calculation	Dev (%)	Research	Calculation	Dev (%)	Research	Calculation	Dev (%)
30,2	5,98	5,90	1,87	10,25	10,11	1,38	15,80	15,51	1,87
30,9	6,13	6,04	2,33	10,56	10,34	2,13	16,24	15,87	2,33
32,0	6,33	6,25	1,89	10,86	10,71	1,40	16,74	16,43	1,89
32,5	6,47	6,35	2,46	11,11	10,88	2,11	17,10	16,69	2,46
32,8	6,49	6,41	1,84	11,13	10,98	1,37	17,16	16,85	1,84
34,2	6,77	6,68	1,94	11,62	11,44	1,57	17,90	17,56	1,94
34,9	6,91	6,82	1,90	11,85	11,68	1,46	18,26	17,92	1,90
35,0	6,92	6,84	1,89	11,88	11,71	1,45	18,32	17,98	1,89
37,4	7,40	7,31	3,71	12,70	12,52	1,44	19,57	18,87	3,71
Average			1,37			1,59			2,20

Table 1 shows that ground water recharge debit increased from the smallest Hydraulic head difference, which was 30,2, to larger one within all density values of the sand column. Also, the table shows that the average difference of groundwater discharge debit between the research and theoretical calculation results at density of 0,0019, 030033 and 0,0052 were 1,37%, 1,59% and 2,2%, respectively. It was also indicated that the research results was larger than the calculation in all parameters. Although there was difference, the ground water recharge debit of both results indicated the same direction of tendency. The recharge debit increased along with the increasing Hydraulic head difference and density of the sand column. However in smaller density, coincides tendency was compared to larger density. This was because the larger density with shorter distance between columns would cause shorter water lane length to enter the sand column. This would add more water to enter the sand column.

Figure 2 shows that the minimum groundwater recharge debit based on the research and calculation results were 5,98 cm³/sec and 5,9 cm³/sec, respectively. The maximum debit based on the research and the calculation were 7,4 cm³/sec and 7,31 cm³/sec, respectively.

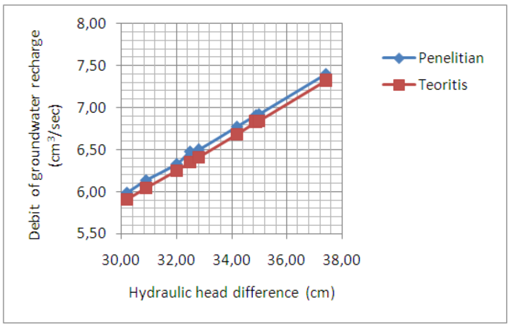

Figure 2: The comparison of the research and calculation results at ƺ = 0,0019

Figure 3 indicates that the minimum groundwater debit based on the research and calculation results were 10,25 cm³/sec and 10,11 cm³/sec, respectively. The maximum debit based on the research and the calculation were 12,7 cm³/sec and 12,52 cm³/sec, respectively.

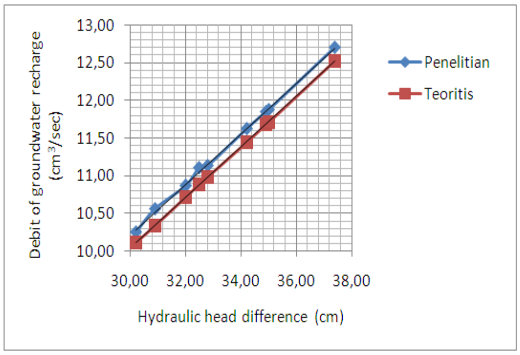

Figure 3: The comparison between the research and calculation results at ƺ = 0,0033.

Figure 4 shows that maximum groundwater recharge debit based on the calculation and research results were 15,8 cm³/sec and 15,51 cm³/sec, respectably. The maximum debit based on the research and calculation results were 19,57 cm³/sec and 18,87 cm³/sec, respectively.

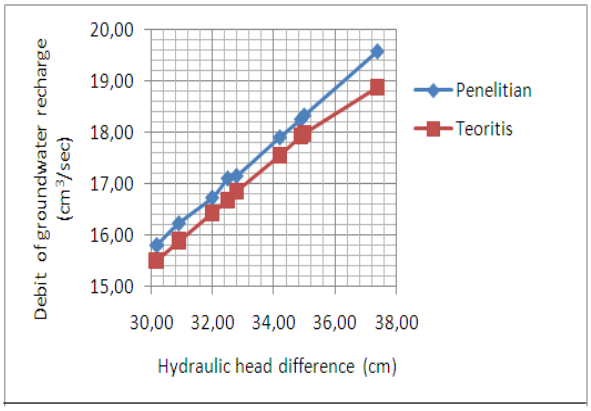

Figure 4: The comparison between the research and calculation results ε = 0,0052

Figure 2, 3, and 4 show the relationship between recharge debit of ground water and Hydraulic head difference at density of sand column. Based on these correlation graphics, same pattern between the research and the calculation can be indicated. The higher the Hydraulic head difference and density of sand column, the larger the resulted debit will be. This strengthens the hypothesis that the smaller the pizometrik pressure, the wider the sand column surface will be and the larger the ground water recharge debit will be.

Figure 5 show the relations between the research and calculation results which presents dispersion points approaching the linear line as the standard.

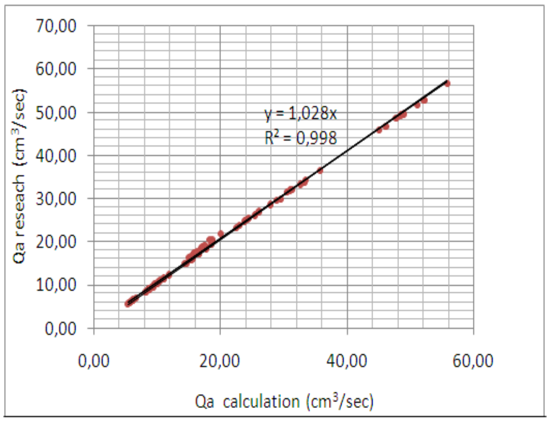

Figure 5: The relationship between the debit resulted from the research and from the calculation

This correlation graphic follows the linear pattern with determination coefficient R^2 = 0,998 or R = 0,999 (> 0,60 and approaching 1) under the equation y = 1,028x. This indicates that the relationship between debit resulted from the research and from the calculation showed strong correlation.

IV. CONCLUSION

Based on this study, conclusions can be drawn as the following s:

1. The larger the hydraulic head difference and density of sand column, the larger the ground water recharge debit will be
2. There was a difference between the research and calculation results , although insignificant, which was less than 5%.
3. The relationship between debit from research and calculation results showed strong correlation with determination correlation of R = 0,999.

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