Field Performance of Shallow Recharge Well

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Background

Population Growth → Land Use Change

1. Changes In Watershed Response to Rain
2. Increased Flood Discharge
3. Decrease Ground Water
Background

- Regulation number 13/2017 described in the Regional Spatial Plan is required to apply zero delta Q policy

Article 99
(3) Zoning regulations for water catchment areas prepared with attention to:
- limited space utilization for cultivation activities that are not built has a high ability in holding rainwater runoff;
- provision of absorption wells and / or reservoirs on existing built land; and
- application of principle z, ero delta Q policg against every cultivation activity that awakens submitted his permission
Background

Applied technical calculations for the reduction of peak flood:

- How many recharge wells are needed?
- How much is the diameter?
- How deep is it?

It is necessary to calculate the number and dimensions of the absorption pool in a practical and easier way.
Literature Review

Some calculations of recharge wells used are

- Horton

\[ f_t = f_c + (f_0 - f_c) \cdot e^{-kt} \]

This formula is not entirely justifiable (Elizar, 2011, Agus, 2005).
• Indonesian National Standard (SNI),

\[
H_{total} = \frac{0.855 \times C_{tadah} \times A_{tadah} \times R - \frac{t_e}{24} \times A_{total} \times \frac{K_v \cdot A_h + K_h \cdot (P \times H_{total})}{A_h \cdot (P \times H_{total})}}{A_h}
\]

• HMTL-ITB formulas

\[
A_{br} = \frac{0.7 \times 0.9 \times 6 \times A \times R^{24j} \times \sqrt{p}}{128}
\]

• Ministry of Public Work

\[
H = \frac{AIT - A_s KT}{A_s}
\]
These formulas are not appropriate dimensional analysis principles (Sunjoto, 2011)
This formula is for rainwater storage building, it is not a formula of rainwater absorption because it is not influenced by soil ability parameters for water impregnation. (Sunjoto, 2011)

Sunjoto

\[ H = \frac{Q}{FK} \left\{ 1 - \exp \left( \frac{-FKT}{\pi R^2} \right) \right\} \]

This formula is appropriate with dimensional analysis, but it is not easy to use because there is variable not easy to be measured.
The basic formula of absorption in the soil was proposed by Forchheimer (1930)

\[ q_0 = F K h \]

\( q_0 \) = absorption recharge (\( m^3 / \) sec)
\( F \) = geometric factor of recharge wells (m)
\( K \) = permeability of soil (m / sec)
\( h \) = water depth (m)
According to Darcy's law, the flow discharge through a cross section A, the hydraulic conductivity of soil K, and the length of flow L are formulated by equation (Fetter, 1994):

\[ Q = KA \left( \frac{dh}{dl} \right) \]

\[ \frac{Q}{A} = K \left( \frac{dh}{dl} \right) \]

The quantities Q, A, K, and dh for the recharge well are all clearly measurable, but dl is unknown in length. Then the above equation can be written:

\[ \frac{Q}{A} = f(K, h) \]

H : the water level in the well,
Q/A : the absorption recharge per unit area obtained from the measurement
Methodology

1. Determination of Research Sites
   - Research of Recharge Well
     - Diameter of pipe 10 cm, 20 cm, 30 cm, 40 cm, and 50 cm
     - Depth of pipe 2 m with not perforated
   - Soil Investigation
     - Water Content
     - Percentage of fine soil
     - Soil permeability

2. Variable Analysis
   - Pipe diameter
   - Soil permeability
   - Water depth

3. Equation of Recharge Wells

4. Statistics Criteria
   - Diagram of the need for dimensions of recharge wells

5. Finished
Results and Discussion

Soil Characteristics

<table>
<thead>
<tr>
<th>No.</th>
<th>Water Content (%)</th>
<th>Percentage of Soil Passing Sieve # 200 (%)</th>
<th>Soil Permeability (cm/hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>26,43</td>
<td>50,45</td>
<td>25,20</td>
</tr>
<tr>
<td>2.</td>
<td>36,18</td>
<td>66,20</td>
<td>4,68</td>
</tr>
<tr>
<td>3.</td>
<td>37,27</td>
<td>51,33</td>
<td>3,96</td>
</tr>
<tr>
<td>4.</td>
<td>12,37</td>
<td>59,15</td>
<td>3,06</td>
</tr>
<tr>
<td>5.</td>
<td>22,31</td>
<td>57,03</td>
<td>2,84</td>
</tr>
<tr>
<td>6.</td>
<td>28,29</td>
<td>56,48</td>
<td>1,40</td>
</tr>
</tbody>
</table>

With relatively small soil water content, then before the observation of the infiltration, wellbore filled with water until the condition is saturated more or less for 1 hour. Percentage passing through the No. 200 sieve more than 35%, according to AASHTO criteria or more than 50% according to the others, classified as silt-clay materials. According to Fetter (1994) cohesive sediment with a low conductivities, permeability is measured by a falling head.
Plotting Recharge to Water High

Water Height: H (cm)

Recharge per unit area: Q/A (cm/sec)

- K1 = 25.20 cm/hour
- K2 = 4.68 cm/hour
- K3 = 3.96 cm/hour
- K4 = 3.06 cm/hour
- K5 = 2.84 cm/hour
- K6 = 1.40 cm/hour
Graph Dimensions of Recharge Wells
The steps of using the graph are as follows:

1. Investigate the soil permeability of the well location plan
2. Calculate the discharge that will be reduced by a recharge well ($Q_r$) based on hydrological and hydraulic analysis
3. Plan the number of wells to be used ($n$)
4. Calculate the absorption recharge of a well ($Q = Q_r / n$)
5. Plan the well diameter to be used
6. Calculate the discharge value per unit area ($Q / A$)
7. Drag the vertical line upward until intersected with the appropriate soil permeability curve. If nothing is exactly the same, interpolation can be done.
8. Drag the horizontal line to get the required depth of well.
9. If no suitable recharge well dimension of technical standard, either diameter or depth, then repeat again from step number 3
Graph Dimensions of Recharge Wells

For Example:
We need to decrease: 0.50 m³/sec
We use diameter well 1.00 m
So \( Q/A = 0.06 \text{ cm/sec} \)
If \( K=25.2 \text{ cm/hour} \) → \( H=70 \text{ cm} \)
If \( K=4.68 \text{ cm/hour} \) → \( H=110 \text{ cm} \)
If \( K=3.96 \text{ cm/hour} \) → \( H=120 \text{ cm} \)
If \( K=3.06 \text{ cm/hour} \) → \( H=138 \text{ cm} \)
etc
Conclusion

1. The relation between the recharge per unit of well cross-sectional area to water height is in the form of parabolic curve.
2. Recharge wells are proportional to cross-sectional area and soil permeability.
3. Absorption of recharge wells with nonperforated walls is relatively low, so it needs to be innovated recharge wells with greater absorption.
Thank you