THE ABSORPTION COEFFICIENT CHARACTERISTICS OF MAKASSAR CITY INUNDATION

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ABSTRACT

The inundation is the main issue in Makassar city problem such as the Bung Resident, BTN Hamzy, and BTP resident due to some factors. One of the factors is soil condition which influences the absorption capacity. To determine the value of permeability coefficient, the factors that influence the absorption, and discharge water entering the absorption wells, the physical and mechanical characteristics of soil test were conducted in the laboratory. From the test results obtained by the permeability coefficient (k) values on Bung Resident, BTN Hamzy, and BTP resident respectively are 1.38 x10^4 cm / sec, 1.23 x10^4 cm / sec, and 1.02 x10^4 cm / sec. Factors affecting the absorption are soil and grain size, permeability, soil density, water content in soil and ground water level. The value of permeability used in the calculation of discharge on the absorption wells.

Keyword: Makassar city, inundation, absorption, permeability

INTRODUCTION

As a metropolitan city, the city of Makassar experiencing economic growth which is increased the population level and impact the environment. The growing population and the increasing of development resulting in many lands (swamp), which reclaimed a residential area so that there is a change in the flow of the existing system and result in reduced function of the region as a means of catchment areas that can accommodate the excess water during the heavy rain. This poses a considerable impact on urban drainage system resulting in disruption of the drainage system. In such circumstances when the rainy season, there are some areas flooded. Some of inundation critical points are Eastern cities and the District of Tamalanrea Biringkanaya. The problem is how much the value of permeability coefficient (k) type of soil in inundation areas, what factors affect the absorption and how much the value of discharge (Q) after the making of absorption wells.

To solve the problem, this research is limited as follows:
1. Testing soil characteristics according to ASTM and SNI.
2. Soil material was taken from three locations in the District of Tamalanrea which is puddle of Bung resident, BTN Hamzy, and BTP resident.

LITERATURE REVIEW

Flooding is the inundation events and setting the mainland (usually dry) because of the increased volume of water. Floods caused by natural factors and human actions.

The characteristics of flood inundation are the depth of inundation, duration of inundation, inundation area, and volume pools. At the sub district of Tamalanrea some areas flood caused by overflow of river Tello, as happened in Bung resident and BTN Hamzy, can be seen in Fig. 1.

Fig. 1 Puddles in the area of Perintis Kemerdekaan

Coefficient of Permeability

Permeability is defined as the hollow nature of the material that allows water or other fluids to penetrate or seep through a relation between pore (Djatmiko Soedarmo, et al, 2001).
Falling head permeability test

Falling head permeability test is used when the power seeped a small ground, the water that seeps into the soil samples will be very little.

\[ k = \frac{Q}{A \times L} \times \ln \left( \frac{h_i}{h_f} \right) \]  

(1)

where:
- \( k \) = permeability coefficient (cm/sec)
- \( Q \) = volume of water coming out (cm³)
- \( L \) = sample length (cm)
- \( A \) = sample cross-sectional area (cm²)
- \( h_i \) = high of water at first(cm)
- \( h_f \) = high water end of the experiment (cm)
- \( t \) = test time (seconds)

According to the Law of Darcy velocity, groundwater flow is proportional to hydraulic gradient, that is:

\[ v = k \times i \]  

(2)

\[ Q = A \times v \]  

(3)

\[ Q = A \times k \times i \]  

(4)

where:
- \( Q \) = quantity of water per unit time
- \( V \) = flow velocity
- \( A \) = cross-sectional area of soil
- \( k \) = permeability coefficient
- \( i \) = hydraulic gradient

Testing the soil volume weight

\[ \gamma = \frac{W}{V} \]  

(5)

\[ \gamma_d = \frac{\gamma}{1 + \frac{w}{100}} \]  

(6)

where:
- \( W \) = weight of soil (gram)
- \( V \) = volume of soil (cm³)
- \( \gamma \) = weight of wet soil volume (gram/cm³)
- \( \gamma_d \) = dry soil bulk density (gram/cm³)
- \( w \) = water content (%)

Specific gravity

\[ G_s = \frac{W_2 - W_1}{W_4 - W_3} \]  

(7)

where:
- \( G_s \) = Specific Gravity, Gs
- \( W_1 \) = weight of pycnometer (gram)
- \( W_2 \) = weight of pycnometer + dry matter (gram)
- \( W_3 \) = weight of pycnometer + dry matter + water (gram)
- \( W_4 \) = weight of pycnometer + water (gram)

Sieve analysis

The coefficient of uniformity is calculated by the formula:

\[ Cu = \frac{D_{60}}{D_{10}} \]  

(8)

Gradation coefficient calculated by the formula:

\[ Cc = \frac{D_{30}^2}{D_{60} \times D_{10}} \]  

(9)

where:
- \( Cu \) = coefficient of uniformity
- \( Cc \) = gradation coefficient
- \( D_{10} \) = Diameter of grains associated with a 10% (mm)
- \( D_{30} \) = Diameter of grains associated with a 30% pass (mm)
- \( D_{60} \) = Diameter of grains associated with a 60% pass(mm)

RESEARCH METHODOLOGY

Soil testing in laboratory:
- Permeability experiments, carried out by falling head method (ASTM D2434-68)
- Soil density experiment, carried out by testing the soil water content and soil bulk density according to the procedure. Procedures for testing water content (SNI 03-1965-1990). Volume weight of soil testing procedures (SNI 03-1965-1990).
• Soil density testing (ASTM D 422)
• Testing soil grain size (sieve analysis) (ASTM D-1140)
• Testing hydrometer (SNI 03-3423-1994).

Results and Discussions

From the laboratory test, result is shown in Tables 1 to 3 as follows:

Table 1 Soil test results on the location of Bung resident

<table>
<thead>
<tr>
<th>No</th>
<th>Type of testing</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Specific Gravity, Gs</td>
<td>2.41</td>
</tr>
<tr>
<td>2</td>
<td>Density of soil</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. Water content</td>
<td>54.79 %</td>
</tr>
<tr>
<td></td>
<td>b. Heavy wet volume (γw)</td>
<td>1.84 gr/cm³</td>
</tr>
<tr>
<td></td>
<td>c. Dry density (γd)</td>
<td>1.19 gr/cm³</td>
</tr>
<tr>
<td>3</td>
<td>Sieve analysis and hydrometer</td>
<td>78.11 %</td>
</tr>
<tr>
<td>4</td>
<td>Permeability</td>
<td>0.000138105 cm/sec</td>
</tr>
</tbody>
</table>

Table 2 Soil test results on BTN Hamzy location

<table>
<thead>
<tr>
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<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Specific Gravity, Gs</td>
<td>2.35</td>
</tr>
<tr>
<td>2</td>
<td>Density of soil</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. Water content</td>
<td>52.67 %</td>
</tr>
<tr>
<td></td>
<td>b. Heavy wet volume (γw)</td>
<td>1.93 gr/cm³</td>
</tr>
<tr>
<td></td>
<td>c. Dry density (γd)</td>
<td>1.26 gr/cm³</td>
</tr>
<tr>
<td>3</td>
<td>Sieve analysis and hydrometer</td>
<td>77.06 %</td>
</tr>
<tr>
<td>4</td>
<td>Permeability</td>
<td>0.000123122 cm/sec</td>
</tr>
</tbody>
</table>

Table 3 Soil test results on BTP resident

<table>
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<tr>
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<td>Permeability</td>
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</tr>
</tbody>
</table>

These following factors cause the inundation of water absorption of the less well:

Topography

Areas of research include low-lying areas and its proximity to the river so susceptible to flooding due to overflowing of river water.

Types of Land and Grain Size

Based on soil density test on the location of inundation was obtained specific gravity between 2.00 to 2.55. Based on the specification table of soil type, soil moisture can contain minerals Halloysite which is one of the clay minerals. Clay soil types according to the USCS has a grain size < 0.075 mm. A new type of fine soil was investigated and when mixed with water the soil become wet and tend to be swelling. The development resulted in reduction in pore volume, so its infiltration will decline.

From the test results obtained by sieving and hydrometer particle size distribution graphs for each area of research.
Fig. 4  Soil particle size distribution graph in Bung resident

From the graph (Fig. 4) obtained value of $D_{10} = 0.06$ mm, $D_{30} = 0.15$ mm, $D_{60} = 0.33$ mm, so the obtained value:
- Uniformity coefficient
  $$(Cu) = D_{60} / D_{10} = 0.33 / 0.06 = 5.50$$
- Gradation coefficient
  $$(Cc) = D_{30}^2 / (D_{60} \times D_{10})$$
  $$= 0.15^2 / (0.33 \times 0.06) = 1.14$$

Fig. 5  Soil particle size distribution graph in BTN Hamzy

From the graph (Fig. 5) obtained value of $D_{10} = 0.06$ mm, $D_{30} = 0.125$ mm, $D_{60} = 0.28$ mm, so the obtained value:
- Uniformity coefficient
  $$(Cu) = D_{60} / D_{10} = 0.28 / 0.06 = 4.67$$
- Gradation coefficient
  $$(Cc) = D_{30}^2 / (D_{60} \times D_{10})$$
  $$= 0.125^2 / (0.28 \times 0.06) = 0.93$$

Fig. 6  Soil particle size distribution graph in BTP resident

Based on the value of Cu from three locations, the soil classification is mainly poorly graded soil. Based on the value of Cc for housing Bung and BTP complex, it is found that the good gradation soil was obtained while on BTN Hamzy poor graded was observed.

**Permeability**

The coefficient of permeability of three (3) locations is quite different as follow:
- Bung resident, $Q = 0.00168$ cm$^3$/det
- BTN Hamzy, $Q = 0.00134$ cm$^3$/det
- BTP resident, $Q = 0.00093$ cm$^3$/det

The coefficient of soil permeability test of those three (3) areas can be classified as land that is very slow to pass water flow. It was probably because the soil surface flow has lower ability to absorb water.

**Soil Density**

The higher density of soil in a field, the seepage that occurs will be smaller. High density level means the space between the pores in the soil is also more tightly.

**Levels of Water in Soil**

Base on the laboratory results, the water content of Bung resident is 54.79%, BTN Hamzy is 52.67% and 50.83% in BTP resident. From the water content values above the soil can be classified as moist soil.

If the soil in humid conditions, the infiltration will be lower than the soil in dry conditions. This due to moist soil has a low pore volume due to fill by water.

**Factors of Geology and Soil Types**

The types of land in Makassar consist of inceptisol and ultisol soil. The spread of soil is mainly in the plain between the hills, river levees,
swamp behind the river, alluvial plain, some structural on flat plains. Sometimes the conditions are similar for a long time interval at a depth of 40 to 50 cm. Inceptisol soil clay content characterized by the existence of which has not formed properly due to dry and wet process washout processes in the soil layer.

**Higher Ground Water Front**

From the location at the time of sampling showed that the ground water locations close to this surface so that when the rain came just a few water can seep into the soil therefore the inundation was happened in research location area.

One way to cope with the floodwaters in a residential area is by making absorption wells. Absorption wells are designed to try making appropriate pool to replace the lost recharge area due to construction.

- **Bung Resident**
  - With an area of inundation areas 0,196549 km², with a value of $k$ for 0,00000138105 m/sec and $R = 0.5$ m
  - Thus, $Q = 5.5 \times 0.5 \times 0.00000138105 \times 1$
  - $Q = 3.798 \times 10^{-6}$ m³/sec
- **BTN Hamzy**
  - With an area of inundation areas 0.236217 km², with a value of $k$ for 0.00000123122 m/sec and $R = 0.5$ m
  - Thus, $Q = 5.5 \times 0.5 \times 0.00000123122 \times 1$
  - $Q = 3.386 \times 10^{-6}$ m³/sec
- **BTP Resident**
  - With an area of inundation areas 1.164812 km², with a value of $k$ for 0.00000102128 m/sec and $R = 0.5$ m
  - Thus, $Q = 5.5 \times 0.5 \times 0.00000102128 \times 1$
  - $Q = 2.809 \times 10^{-6}$ m³/sec

**CONCLUSIONS AND SUGGESTIONS**

Based on the results of laboratory research on the characteristics of the absorption coefficient at three (3) locations in the city of Makassar ground water storage can be concluded as follow:

- The value of coefficient of permeability ($k$) on Bung resident, BTN Hamzy, and BTP resident in
  a row is $1.38 \times 10^{-4}$ cm/sec, $1.23 \times 10^{-4}$ cm/sec, and $1.02 \times 10^{-4}$ cm/sec respectively, and indicates that the land has low permeability. Based on the test results, the specific gravity of 2.41, 2.35, and 2.45, indicating that the soil at the three locations contains the mineral halloysite clay puddle. And the density (volume weight and water content) test results showed that the condition of the three locations in the state of soil moisture.

- Factors that influence the absorption is the type of soil and grain size, permeability, soil density, water content in soil and ground water level.

- One way the flood prevention is by making absorption wells in residential areas. Value of discharge ($Q$) in the wells is absorption of the three locations are housing Bung for $3.798 \times 10^{-6}$ m / sec, BTN Hamzy of $3.386 \times 10^{-6}$ m / sec and $2.809$ for BTP Complex $x 10^{-6}$ m / sec. By investigating at the ground water level is less than 3 m, the place of well-planned research cannot recharge.

**ACKNOWLEDGMENTS**

The author addressed a grateful to the Dean of the Faculty of Engineering, Hasanuddin University, Chairman of the Department of Civil Engineering, lecturer of Civil Engineering Department, Soil Mechanics laboratory staff, and students of Civil Engineering Department for their help and cooperation in this research.

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