Seepage on landfill dam model: a laboratory study of the development of soil density variation

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Abstract. Water losses due to seepage through the body of the dam is something problems that often occur in planning a dam. The purpose of this research to knows the phenomenon of the seepage flow on the soil through the dam body or under the body of landfill dam. The research methods used the Test Laboratory simulations of homogeny Dams model using with three of the soil density (58.20%, 68.27%, and 76.33%) and with the application of the three theories of seepage in dam body (Dupuit, Schaffernak, Cassagrande). The results of this research indicate seepage flow far that the more the long time it takes to perk, the higher the discharge and the farther the distance small then the seepage discharge of seepage, and the higher the density of the ground than the lower depths of the seepage

1. Introduction
Water loss due to seepage through the body of the dam is something that needs to be considered in planning a dam. Every dam must experience water seepage, but how the influence of water seepage on dams is very dependent on the density and type of dam material. The volume of seepage is too large, resulting in the operation of the dam to be disrupted, making it prone to landslides and even collapse. The purpose of this study was to determine the effect of soil density on the discharge of water seepage on the body of soil dam. The Physical Hydraulics Model Test is expected to be able to develop planning results, so that the safety of the dam [3] The higher runoff, the heavier the pressure of the liquid will be, so the seepage velocity will be even greater parameters including the permeability of the shell material and the presence of impervious core and its location and thickness[4].

2. Literature Review
Soil compaction is a process in which soil particles are pushed into more proximity to one another by reducing air voids by grinding or other mechanical methods. The method was developed and tested theoretically in the laboratory, [8] using conservative trackers, and then demonstrated on leaky soil dams as high as 12 m from a 100 m high complex, the method can quickly detect seepage zones found and illustrates the dominant direction of seepage through dams. Model of the dam made from yellowish clay by varying the density of the soil by 60%, 65%, and 70%[1].To calculate the level of seepage that occurs in the body of a dam. A physical model of a homogeneous dam was formed from modified soil in the form of a mixture of 80% native soil and 20% sand[5].

The urugan dam is a dam that is built by accumulating materials, such as rock, crack, gravel, sand, and soil, in a certain position with a function as a gutter or lifting the surface of the water contained in the reservoir, The equipment used was Drainage and Seepage Tank. The seepage velocity on sand 1 (medium sand) and sand 2 (fine sand) with water level 40 cm, 30 cm, and 25 cm [10] To find out the
effect of soil particle size, the water level on the seepage velocity and seepage flow pattern on the
dam. The method used in this study is Darcy's law, the phreatic flow pattern that occurs in the body of
the dam and calculates the seepage discharge produced. To control the gradient of seepage foundations
made of plastic concrete. To provide seepage cutoff walls that have sufficient strength to withstand
static and seismic pressure beneath the new embankment [8]

Several methods are given to determine the amount of seepage that passes through a dam built
from homogeneous soil [9]. The following are some ways to determine seepage discharge.

- Dupuit Method
  \[ q = \frac{k}{2d} (H1^2 - H2^2) \]

- Schaffernak Method
  \[ q = ka \sin \alpha \tan \alpha \]

- Casagrande Method
  \[ q = ka \sin 2 \alpha \]

3. Methods
This research was conducted at the Hydraulics laboratory of the Civil Engineering Department,
Engineering Faculty, Muhammadiyah University of Makassar by making a dam model tool such as
Figure 1.

![Figure 1. Sketch of a model tool that will be used to research](image)

This research was conducted to develop using variations in soil density of 58.20%, 68.27%, and
76.33%. With the model testing procedure as follows:

- Setting the model tool and running empty
- The soil is compacted using wooden blocks. Soil compressed layer (10 cm layer) with a fixed
  number of collisions and based on the desired level of soil density. The soil is piled up to form
  a trapezium with a dam width of 4 cm, a length of 72 cm and a height of 28 cm.
- Water is filled upstream of the dam body as a puddle with a water level of 20cm
- Observation of flow seepage in the body of the dam
- Calculating the time of seepage in each hose.
- Observation is carried out three times with a height of 20 cm storage water.

4. Results And Discussion
Measurement of seepage discharge directly on the dam model is done by measuring the amount of
seepage discharge that comes out in each hose. The measurement results of seepage discharge as in
Graph 2
Figure 2. Comparison of seepage discharge with seepage distance

Graph 2 shows that the relationship between soil density and seepage discharge and the relationship between seepage distance and seepage discharge the longer the seepage distance, the longer it takes to seep. with a density of 58.20% (collision 5), a density of 68.27% (collision 10) has increased seepage speed compared to a density of 58.20% (collision 5). The smaller the seepage discharge. The farther the seepage distance, the smaller the seepage discharge.

The relationship between pressure and seepage distance from the observations for each soil density varies (58.20%, 68.27%, and 76.33%), concluded that the relationship between seepage depth and seepage distance could be seen in the flow pattern as shown in Figure 3.

Figure 3. Relationship between seepage distance and seepage depth

Figure 3 the relationship between depth and seepage distance with three variations in soil density and water level upstream of the dam (H = 20 cm) are the same. The higher the density of the soil, the smaller the seepage pressure. For densities of 58.20%, the seepage pressure averaged 13.8 cm, a density of 68.27% at 11.8 cm, and a density of 76.33% at 10.3 cm.
Figure 4. The Relationship between Relative Density and Seepage

Picture 4 shows that the Dupuit method at a density of 58.20% seepage discharge of 1.483 mL/hour is greater than the density of 76.33% with seepage yield of 0.884 mL/hour. In the Schaffernak method at a density of 58.20%, the yield of seepage of 1.595 mL/hour is greater than the density of 76.33% with the yield of seepage of 0.687 mL/hour. Cassagrande method at a density of 58.20% the seepage discharge of 1.715 mL/hour is greater than the density of 76.33%, the seepage results are 0.828 mL/hour, and direct observation for a density of 58.20% of seepage discharge of 3.128 mL/hour, a density of 68.27% of seepage discharge of 2.080 mL/hour, and a density of 76.33% of seepage discharge of 0.501 mL/hour.

5. Conclusion
The results of the research with three variations in soil density (58,20%, 68,27%, and 76,33%) by applying three theories of seepage to the body of the dam (Dupuit, Schaffernak, and L. Cassagrande). The further the seepage flow (1,60 ml/hour, 1,26 ml/hour and 0,80 ml/hour), the longer duration to seep, the higher the soil density, the smaller the seepage discharge and the further the seepage distance, the smaller the seepage discharge, and the higher the soil density, the lower the seepage depth. This is in accordance with Sukirman’s research.

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