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Infiltration Zonation Using Kostiakov Methods in Leftbank Jatigede District Indonesia

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Abstract

West Java Province is one of the vulnerable areas for having land movements in Indonesia. Sumedang Regency, the research area, has a varying level of soil movement, from low to high. Administratively it is located in the Eretan and surrounding areas, Jatigede District, Sumedang Regency, West Java Province. Based on the geological conditions and the engineering materials, the research area was divided into six engineering geological units, soft weathered rock units (SW), medium weathered rock units (MW), high weathered rock units (HW), sand gravel - perfect gravel units (CW), residual soil units (XW), and alluvial sediment units. Infiltration analysis can be carried out using an infiltrometer double ring and measurement and calculation. The study was aimed to determine the infrazation zone in each lithology in the study area. The data were analyzed by the infiltration method using the Kostiakov equation to obtain the final infiltration rate in the study area. The results showed that the infiltration rates at the surface of the ground were diverse, the infiltration zone of the tuffaceous breccia group at 0.0287 - 0.8375 cm/minute, the infiltration zone of claystone group, at 0.2754 - 0.6315 cm/minute and absorption zone the volcanic breccia group of sandstone inserts was 0.0852 - 0.2482 cm/minute. The final infiltration rate (f) was very diverse, from the lowest of 0.0852 cm/minute (5.11 cm/hour) to the highest 0.8375 cm/minute (50.25 cm/hour). The value could be used as a reference to determine the level of water saturation on the ground and the ability of the soil for passing the water.

Keywords: *infiltration. Jatigede dam, Sumedang, slope stability, water content*

1. Introduction

Sumedang is located in the eastern part of Bogor [13]. Jatigede dam, located in the eastern part of Sumedang and constructed in 2008, has multipurpose and covers 90.000 ha of irrigation areas. This dam has a net water capacity up to 979 million m3 and a raw water flow of 3,500 L/sec, and other purposes including hydropower plants with an installed capacity of 110 MW [6].

This study aimed to analyze the infiltration rate of the soil surface to know the potential of land movement. To achieve this goal, we classify the rock mass based on geomechanical characteristics (RMR), then test the surface of the soil, calculate the infiltration rate, and determine its distribution based on infiltration. Secondary data in the form of rainfall.

This study also aimed to determine the geological and geological conditions of the study area through geological mapping techniques. Furthermore, this study will evaluate the soil surface infiltration rate in the west pedestal Jatigede Dam.

This study will provide information on the slope stability through the analysis and zoning of water absorption rates, information on the geological conditions from field mapping in the form of structural data, petrology, weather levels of the study area [9], and empirical calculations to determine the final water absorption rate on the ground surface. Add and update geological information and data in the study area.

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2. Geology of Research Areas

The study area was located in the eastern part of Bogor regency which is a convex anticlinorium zone to the north with a west-east fold axis [13]. Arjawinangun regional geology sheet [4] presented the geology of the study area and all 3 formations from the earliest to the newest namely:

1. Halang Formation (Mhu & Mhl)

   This formation consists of two parts, namely the upper Halang and the lower Halang consisting predominately of sandstone and other material such as tuffs, claystone, and conglomerates in the top, while the bottom is characterized by volcanoes with andesite and basalt fragments, and also tuffs, sandstones, and conglomerates with a sediment environmental at sea as the results of volcanic activity.

2. Collapsible Breccia Formation (Qob)

   This formation consists of volcanic breccia, coarse sandstones, tuffaceous clay, tuffaceous breccia, and greywacke with depositional environment on land.

3. Alluvium (Qa) Formation

   This formation consists of clay, silt, and gravel material, derived from river sediment nowadays.

3. Methodology

In this study, the geomorphological, geological, geotechnical data (degree of weathering and soil sampling) were obtained. Various methods were used to analyze the infiltration rates or water infiltration, one of them was Kostiakov's equation [10], calculating the final infiltration rate using a tool called a double-ring infiltrometer.

This infiltration test was carried out until the water flowing rate reaches a constant. This constant speed is also referred to as infiltration capacity. Young sequences, namely:

4. Results and Discussion

The research area had aspects of geomorphological, geological, geotechnical engineering, and soil permeability resulting in zoning potential for landslides.

Based on geomorphology (morphology, morphometry, and morphogenesis), the study area was divided into 3 units according to [7]:

1. Unit steep structural sloping hills
2. Unit denudational sloping hills
3. The sloping hill unit is slightly fluvial sloping for geological

The study area was also grouped into 4 units (Figure 1) from field observations by dominance and petrographic analysis for naming [5], [8], fossil analysis as a determinant of age [1] and the depositional and comparative environment [4] unit reference to the formation of the old to:

1. Volcanic breccia unit
2. Claystone Unit
3. Tuff breccia unit
4. Unit of alluvium deposits

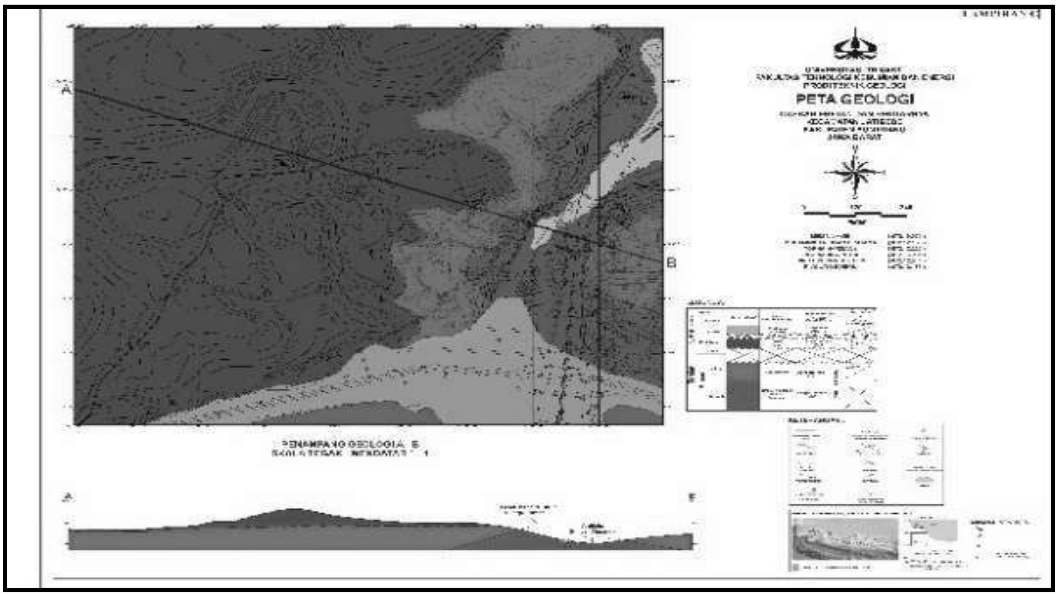

Figure 1. Geological Map of the Research Area

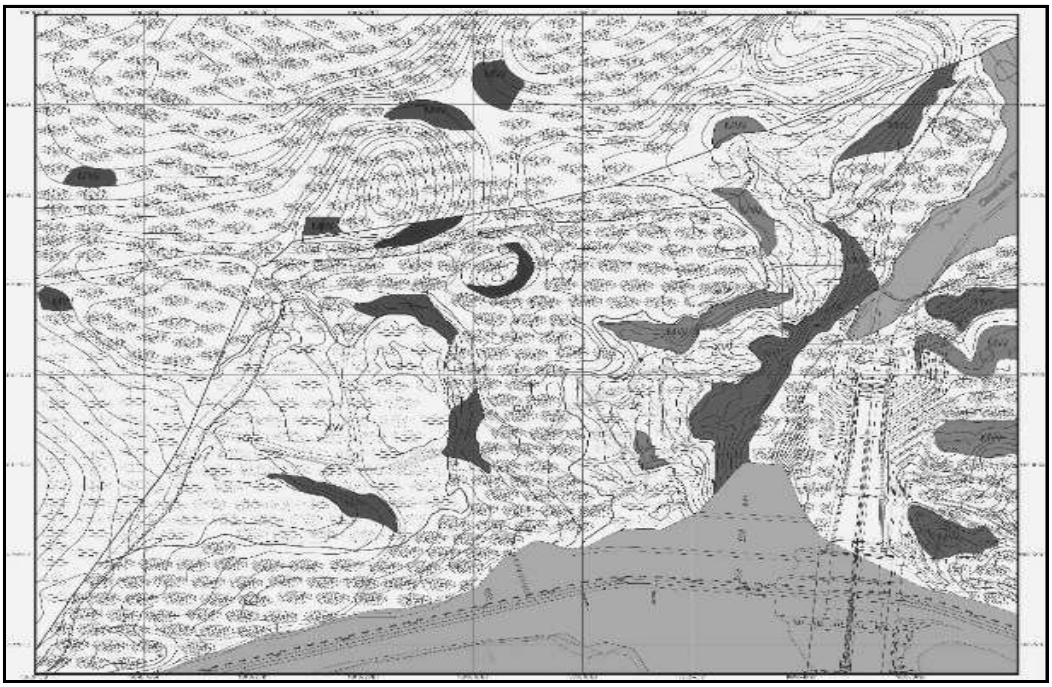

Figure 2. Engineering Geological Map of the Research Area

Based on geological engineering, the research area was divided into 5 (Figure 2) degrees of weathering, according to [9]:

1. Light weathered (SW)
2. Medium Weathered medium (MW)
3. Strong Weathered (HW)
4. Perfect weathered (CW)
5. Very Perfect Weathered (HW)

The infiltration rate is generally expressed in the same unit as the rainfall intensity unit, which is millimeter per hour (Table 1) [2].

Table 1. Classification of Infiltration [2]

Class	Classification	Infiltration (cm/Hour)
0	Very slow	<1
1	Slow	1-5
2	A little slow	5-20
3	medium	20-63
4	Rather fast	63-127
5	Fast	127-254
6	Very Fast	>254

The results of the infiltration measurement presented various values. These diverse characteristics were further grouped into 3 (Figure 3) groups consisting of:

a. Tufaan Breccia recharge zone

b. Sandstone group recharge zone

c. The absorption zone of the Volcanic Breccia group of Sandstone Inserts.

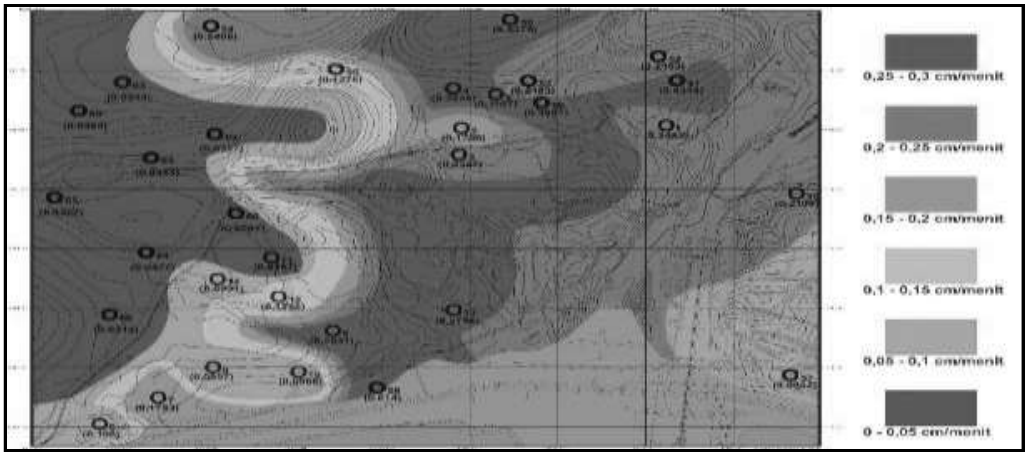

Figure 3. Distribution of infiltration rate values on the west side of the dam

4.1. Alluvial Deposition Group Infiltration

This infiltration testing in this group of 4 points spread in several areas in the study area. As explained in the previous chapter, the Alluvium Plain unit consists of clay-sized, silt, sand, gravel and crust sized rocks which are weathered and originated from broken older rocks and occupy the middle to the east region of the study area.

The diversity of the final infiltration rate was generated in the type of soil that tends to be the same. One of the phenomena was reflected in the final infiltration rate between locations: Q1– with values f = 0.2482 cm / min and Q35 - values f = 0. 2109cm / minute (Table 2). Both to the found in the Alluvium Plain with almost the same land tendency, namely silt clay.

Table 2. Infiltration rate in the area of alluvial sedimentation seepage

No.	Location	Depth of Infiltrometer from Ground Level (cm)	Unit	Infiltration Rate (cm /Minute)
1	Q1	15	Cm/minute	0,2482
2	Q35	15	Cm/ minute	0,2109
3	Q52	15	Cm/ minute	0,2163
4	Q53	15	Cm/ minute	0,2163

Graph infiltration rate Vs Time with a Final rate of 0.2109 cm / minute.

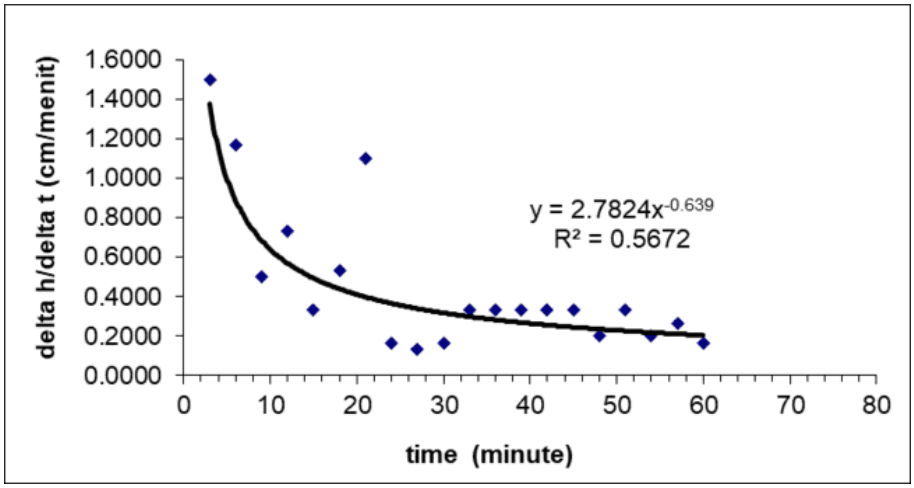

Figure 4. Infiltration rate in Jatigede area

Based on field data, the two test sites are land with almost the same existing land use. At this measurement location is open land that is overgrown with grass with a consistency of hard [11].

Surface land and is quite dense, whereas in the southern part of the study area is an open land that is soft but some parts are quite hard and rocky.

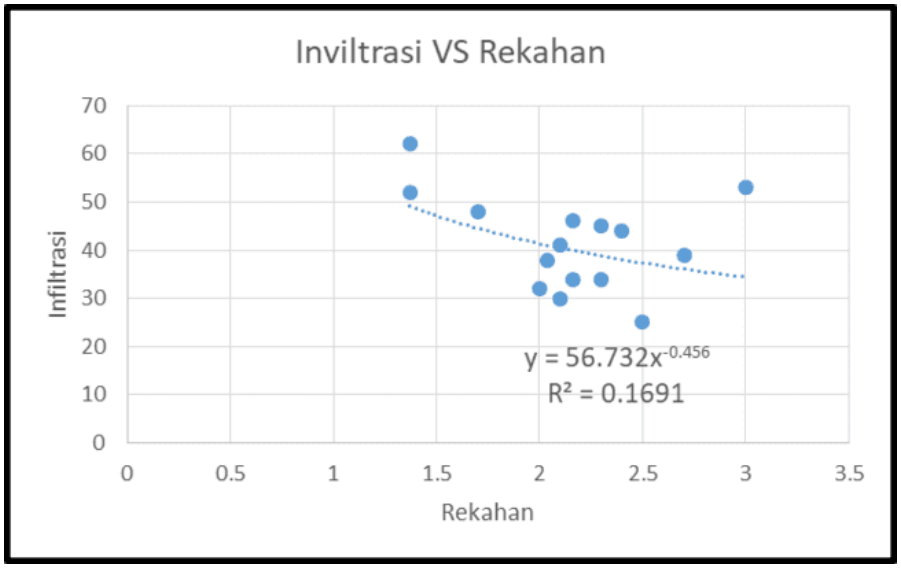

Figure 5. Relationship of infiltration and fracture on parameter values used

4.2. Relationship of infiltration and RMR (Rock Mass Rating)

Determination of slope mass rating (SMR) among others involves Rock Mass Rating parameters [12]. RMR was weighing the rock mass based on the geomechanical classification of rocks. The weight is the sum of the parameter weight values for each component, here the infiltration and RMR relationships have fundamental differences. Based on the value of the RMR, geomechanical classification can also be used to estimate the stability of rock mass slopes as a result of cutting.

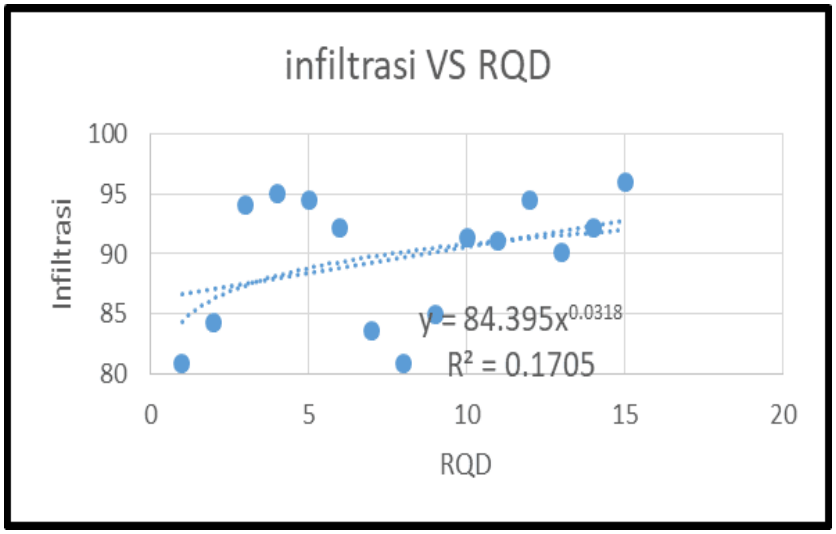

Figure 6. The relationship between Infiltration and RQD on the parameter values used

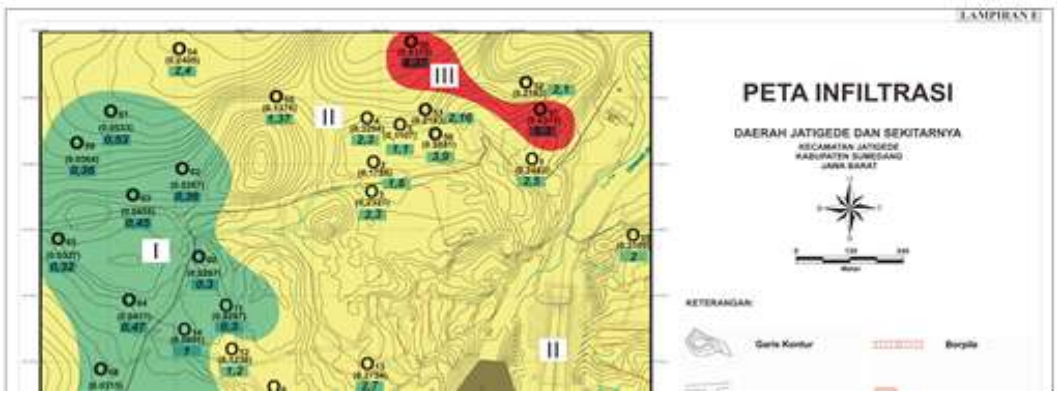

Figure 7. Infiltration map Jatiged

Based on the distribution of infiltration rates and alignment zones, almost all areas were affected, but zones with a lot of alignment is found in the western area with rock conditions in the form of folded breccia seen on the map's red color with relatively hard rock, slightly weathered, slightly exposed, less than half the rock material experiences decomposition or distribution with soil, the condition of fresh rock was loose with relatively hard appearance and slightly weathered and resistant to separation caused by a strong blow from geological hammer. The mineral fillings in the form of ilmenite and clay minerals were illustrated with the symbol MW, while the second breccia were included in the category of very low soil flowing rates seen in the yellow color of the study area which spreads in the west to south of the study area which is divided into 2 weathering levels namely, the weathering rate is very weathered and the weathering level is slightly weathered, where a very weathered weathering rate (XW) shows a very strong

weathering rate with a large decomposition change showing the dominance of clay minerals and very easily separated were all rock material turned into soil, the period of rock structure and material that has been destroyed. There is a large change in volume but the amount of soil transported was insignificant and also in a slightly weathered (MW) relatively hard bit soft and limonite minerals and clay minerals appear with more than half of rock material decomposed or integrated with soil. The condition of fresh or discolored stones presented as a rock core or scaffold. Based on the land settlement that develops, the largest land settlement related to the infiltration rate of the folded breccia area was in the western area to the south while the largest land subsidence is in the middle of the study area, namely the north to south of the study area.

4. Conclusion

1. The geomorphology of the study area is divided into three geomorphological units, namely structural steep slope-sloping geomorphological units (20.7%), denudational hilly slope geomorphological units (58.9%), low-sloping geomorphological sloping geomorphological units (6.25%).
2. The stratigraphy of the study area was divided into four rock units based age sequence starting from the oldest to newest, namely volcanic breccia, sandstone inserts, claystone units, tuffaceous breccia units, and alluvium deposits.
3. The geological structure in the study area consisted of two structures, namely a fault and an anticline fold.
4. The geology of the study area was divided into six units, namely mild weathered rock units (SW), moderate weathered rock units (MW), strong weathered rock units (HW), perfectly weathered sand-gravel soil units (CW), very weathered weather units (XW), and alluvial deposits.
5. The infiltration zone of the study area was divided into three groups consisting of: the absorption zone of tufaan breccia group 0.0287 - 0.8375 cm/minute, the infiltration zone of the claystone group, 0.2754 - 0.6315 cm/minute and the recharge zone of the group volcanic breccia sandstone 0.0852 - 0.2482 cm / minute. The final infiltration rate (f) varied greatly, from the lowest 0.0852 cm/minute (5.11 cm/hour) to the highest of 0.8375 cm/minute (50.25 cm/hour).

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