PERCOLATION CHARACTERISTICS WITH VARIATIONS OF RAINFALL INTENSITY, SOIL DENSITY AND SOIL GRADATION TEST.

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ABSTRAK : Water volume quantity may overflow on the surface not only due to natural phenomena, but also because water is less or no longer able to become absorbed into the soil and just flowed on the surface, flooding and damaging the region in its path. This study aims to analyze the influence of rainfall intensity variations and its relationships towards the percolation, which the observe rainfall intensity variations in this study are equal to 120 mm /hour, 275 mm /hour, and 450 mm/hour againts variations of soil density 40%, 60%, 80% for the original soil and soil with variations of sand content 0%, 25%, 50% in a normal type rain and torrential rain, with solum shallow soil depth (25 cm), without vegetation, and without slope. This study is done by measuring the intensity of rainfall using a rainfall simulator which was designed in such a way so it can obtain the rainfall intensity which is determined on soil samples that had been prepared in the test bucket with a thickness of 25 cm sample. The results showed that the highest percolation value is equal to 1.47 x 10-8 m^3/sec for 120 mm/h of the rainfall intensity on 40% of soil density with 50% of sand content. The highest runoff values is equal to 3.75 x 10-8 m3 for 450 mm / h of rainfall intensity at 0% of soil density and 80% of sand content.

Keywords : The intensity of rainfall, soil density, infiltration, surface runoff

INTRODUCTION

Water on earth have a cycle through a series of events that take place constantly, where we do not know when and where the initially there was going to stop. The series of this event called the hydrologic cycle. But this hydrological cycle is not evenly distributed, which is influenced by meteorological conditions (temperature, atmospheric pressure, wind, etc.) and topography (slope, soil type, etc.).

In the hydrologic cycle there are several important components, including: precipitation, evaporation and transpiration, surface runoff and groundwater. Precipitation that falls on the earth surface spread to different directions in different ways. Some will flow as the flow of runoff and partially into the ground as water infiltration and percolation. Subsequent runoff flow into surface runoff.

Ground water as a source of urban water is often used but still not done whit its conservation efforts. Utilization of ground water that has not resulted in a decrease of control flow and groundwater quality. For the regions which close to the beach will be very vulnerable to sea water seep into the aquifer layer (saltwater intrusion). In addition, void-free layer of the aquifer may result in decreased soil surface, which is dangerous to life and infrastructure.

The changes of land use in catchment's areas from development of residential, industrial and urban facilities are expected to have disrupted the hydrological cycle chain. The rapid physical development as a joint effect of high population growth, economic growth, and development of tourism growth, result in land cover caused by water-resistant buildings (concrete, asphalt, and the like), these things may cause a reduction in infiltration of rainwater into the soil, and increases the amount of surface run-off. Ground water's saving become greatly reduced, because this surface runoff will quickly flow to the drainage channel and immediately thrown into the sea. Due to this background, it is very interesting to do research on the potential seepage of rain in order to control flooding and soil water conservation.

RESEARCH METHODOLOGY

Soil Samples Preparations

The soil samples which used in this study is the soil that often used as an embankment construction material. A number of tests performed to obtain the index properties, permeability and standard proctor compaction. Before testing, soil samples stored in closed containers (poly bag) to maintain the authenticity of the soil. The available silty sand sample should be shieved first through No.4 before mix it with sand, while the sand soil samples sieved through No. 10. The weight of sand to be added is calculated based on the dry weight of soil sample which mixed with sand.

Rainfall Intensity Test Mode

This test is using a rainfall simulator with simple tools that are designed in such a way that made from water reservoirs where the pedestal tub was a hole with 1 mm diameter and has 2 cm distance between the holes. The hole will be passed by water to form beads of rain, this is intended to obtain the desired rainfall intensity I = 120mm/ day, I = 275mm/ day, and 450mm/day. The intensity is obtained by filling water reservoirs up to a certain height, where height is intended to provide different pressures resulting intensity variation. This method is also called rainfall simulator with the constant method.

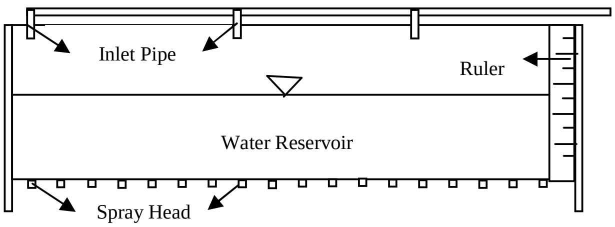

Figure 1. Rainfall simulator with the constant head method's model

How to Test The Soil Samples

To determine the soil parameters is necessary to take soil samples at varying, where the soil has been tested on its properties then mixed until homogeneous with high levels of sand (sand content) different from the 0%, 25% and 50% to the optimum water content. From each soil is compacted to varying density that is 40% (0:49 gr/cm3), 60% (0.73 gr/cm3), 80% (0.98 gr/cm3) , then permeability should be tested to get the value of its permeability coefficient (k), and then inserted into the test basin size 150 x 50 x 50 cm where there is a partition therein to divide the volume of infiltration and runoff volume. High ground in the test bucket is 25 cm.

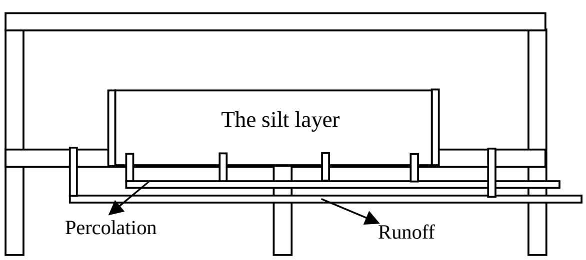

Figure 2. Rainfall simulator's bucket

How To Test The Percolation Volume

The method used in this test is the method of direct measurement and observation, where the percolation of water collected for each minute intervals until the volume becomes constant. But the volume of runoff also remain measured as comparative data.

How To Analysze The Data

The test results OF infiltration and runoff volume then converted into units of debit mm3/detik. In cases, debit is the ratio between volume and time.

From the data obtained then plotted into the hydrograph. Then make conclusions from the pattern of relations that occur from determining the maximum and minimum values.

RESULT AND DISCUSSION

The soil which used in this test is easy to obtain, it an embankment soil. For the results of soil properties attached by the table below.

Table 1. Soil properties

Type of Investigation	Value
Water content	29,33 %
Spesific gravity	2,5036
Gradation of grain	Sand = 98,38 % Silt = 0,94 % Clay = 0,68 %
Atterberg limits	LL = 51,32 % PL = 44,77 % SL = 35,62 % PI = 6,55 %
Soil classification	USCS : SM AASHTO : A-2-5 From the classifications, the category of the soil is silty sand

Proctor standard compaction test is used to obtain the compaction characteristic from the soil sample with or without sand content (SC = 0 %), so that we could know the effect that occured from the sand increment with a certain persentate of the soil sample compression.

The following graphics will describe the relation of percolation with rainfall intensity, soil density and soil gradation.

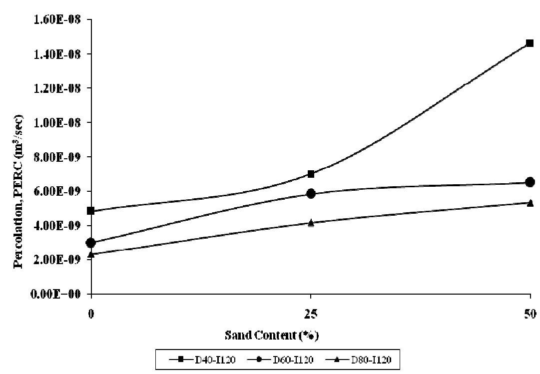

Figure 3. Relation of percolation and sand content for each density at 120 mm/hour of rainfall intensity.

Figure 3 is showing that the percolation rate will reach its maximum value at 47 x 10^{-8} m^3/sec or at 50% of sand content and 40% of soil density, while its minimum value at 2,33 x 10^{-9} mm^3/sec or 0% of sand content and 80% of soil density.

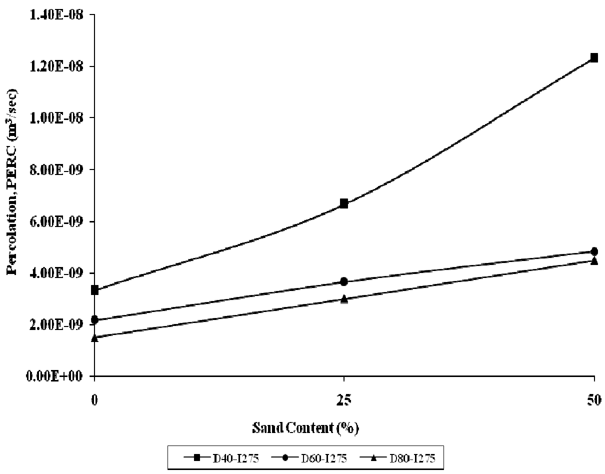

Figure 4. Relation of percolation and sand content for each density at 275 mm/hour of rainfall

Figure 4 is showing that the percolation rate will reach its maximum value at 1,23 x 10^{-8} m^3/sec or at 50% of sand content and 40% of soil density, while its minimum value at 1,50 x 10^{-9} mm^3/sec or 0% of sand content and 80% of soil density.

Figure 5 is showing that the percolation rate will reach its maximum value at 1,03 x 10-8 m^3/sec or at 50% of sand content and 40% of soil density, while its minimum value at 1,23 x 10-9 mm^3/sec or 0% of sand content and 80% of soil density.

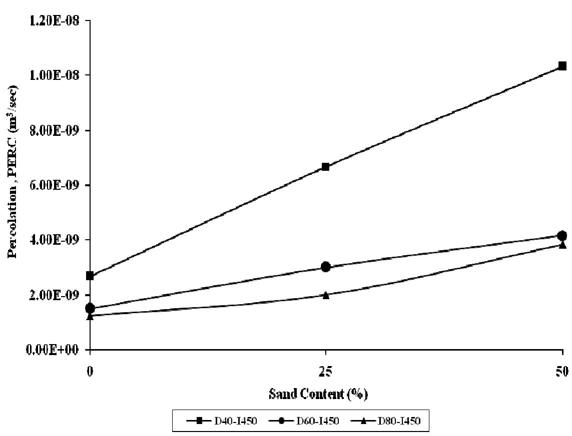

Figure 5. Relation of percolation and sand content for each density at 450 mm/hour of rainfall

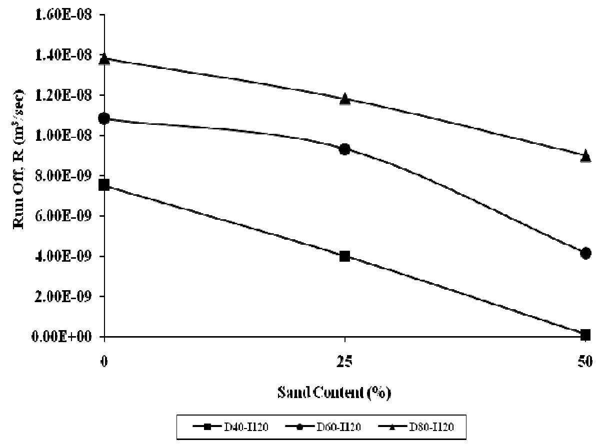

Figure 6. Relation of runoff and sand content for each density at 120 mm/hour of rainfall intensity.

Figure 6 is showing that the runoff rate will reach its maximum value at 1,38 x 10^{-8} m^3/sec or at 0% of sand content and 80% of soil density, while its minimum value at 1,33 x 10^{-10} mm^3/sec or 80% of sand content and 40% of soil density.

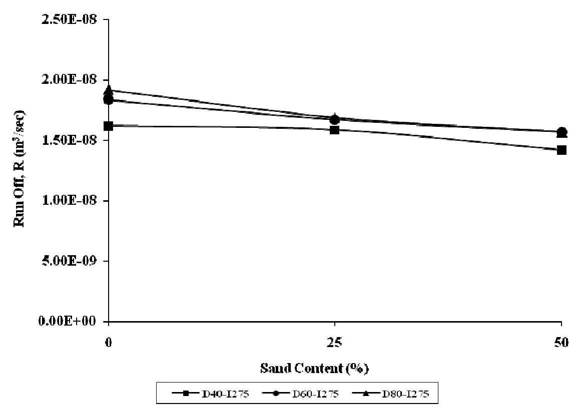

Figure7. Relation of runoff and sand content for each density at 275 mm/hour of rainfall intensity.

Figure 7 is showing that the runoff rate will reach its maximum value at 1,92 x 10^{-8} m^3/sec or at 0% of sand content and 80% of soil density, while its minimum value at 1,42 x 10^{-8} mm^3/sec or 50% of sand content and 40% of soil density.

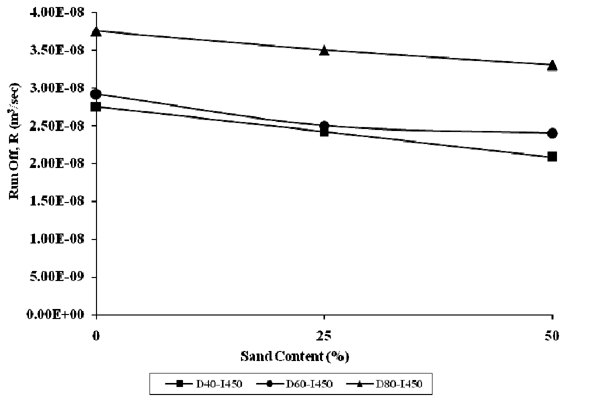

Figure 8. Relation of runoff and sand content for each density at 450 mm/hour of rainfall intensity.

Figure 8 is showing that the runoff rate will reach its maximum value at 3,75 x 10^{-8} m^3/sec or at 0% of sand content and 80% of soil density, while its minimum value at 2,08 x 10^{-8} mm^3/sec or 40% of sand content and 50% of soil density.

The percolation characteristic test obtained that relation between percolation and soil gradation (sand content) is directly proportional. The increasing of sand content may followed by the increasing of percolation rate, while the relation between runoff and soil gradation (sand content) is inversely proportional. The decreasing of sand content may followed by the increasing of runoff rate.

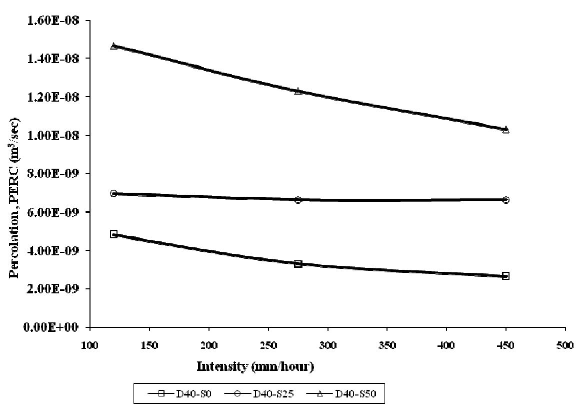

Figure 9. Relation of percolation and rainfall intensity at 40% of soil density ***(D_{40})***

Figure 9 is showing that the percolation rate in 40 % of soil density will reach its maximum value at 1,47 x 10^{-8} m^3/sec or at 50% of sand content and 120 mm/hour of rainfall intensity, while its minimum value at 2,67 x 10^{-9} m^3/sec or at 0% of sand content and 450 mm/hour of rainfall intensity.

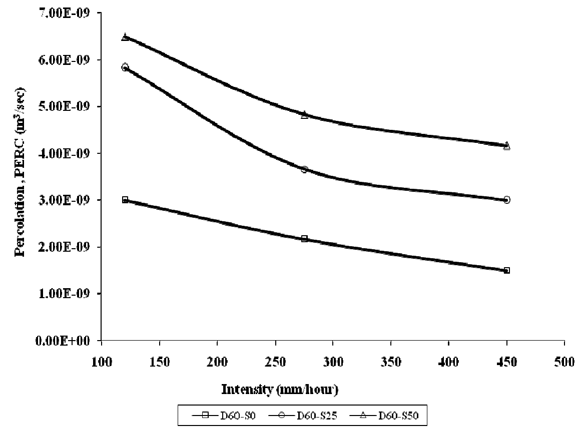

Figure 10. Relation of percolation and rainfall intensity at 60% of soil density ***(D_{60})***

Figure 10 is showing that the percolation rate in 60 % of soil density will reach its maximum value at 6,50 x 10^{-9} m^3/sec or at 50% of sand content and 120 mm/hour of rainfall intensity, while its minimum value at 1,50 x 10^{-9} m^3/sec or at 0% of sand content and 450 mm/hour of rainfall intensity.

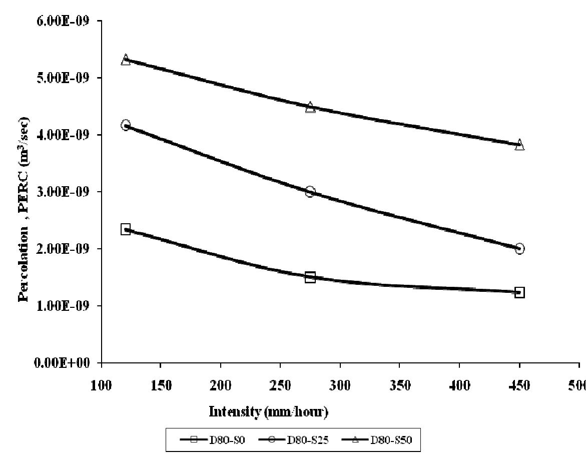

Figure 11. Relation of percolation and rainfall intensity at 80% of soil density ***(D_{80})***

Figure 11 is showing that the percolation rate in 80 % of soil density will reach its maximum value at 5,33 x 10^{-9} m^3/sec or at 50% of sand content and 120 mm/hour of rainfall intensity, while its minimum value at 1,23 x 10^{-9} m^3/sec or at 0% of sand content and 450 mm/hour of rainfall intensity.

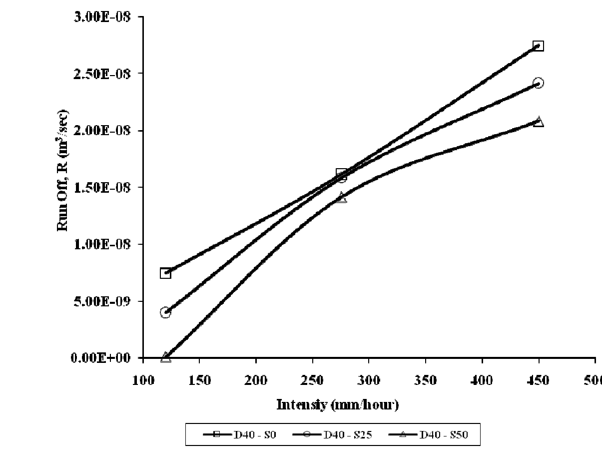

Figure 12. Relation of runoff and rainfall intensity at 40% of soil density ***(D_{40})***

Figure 12 is showing that the runoff rate in 80 % of soil density will reach its maximum value at 2,75 x 10^{-8} m^3/sec or at 0% of sand content and 450 mm/hour of rainfall intensity, while its minimum value at 1,33 x 10^{-10} m^3/sec or at 50% of sand content and 120 mm/hour of rainfall intensity.

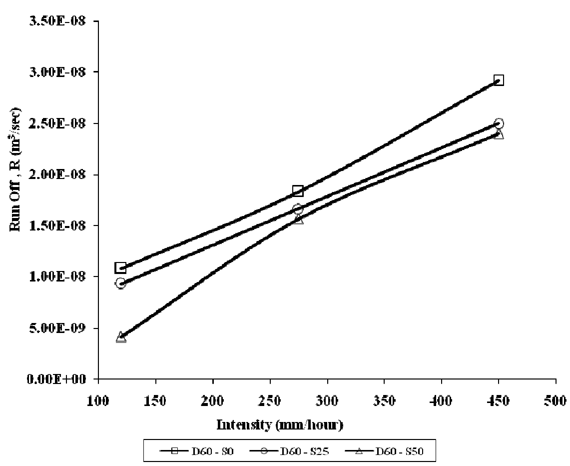

Figure 13. Relation of runoff and rainfall intensity at 60% of soil density ***(D_{60})***

Figure 13 is showing that the runoff rate in 80 % of soil density will reach its maximum value at 2,75 x 10^{-8} m^3/sec or at 0% of sand content and 450 mm/hour of rainfall intensity, while its minimum value at 1,33 x 10^{-10} m^3/sec or at 50% of sand content and 120 mm/hour of rainfall intensity.

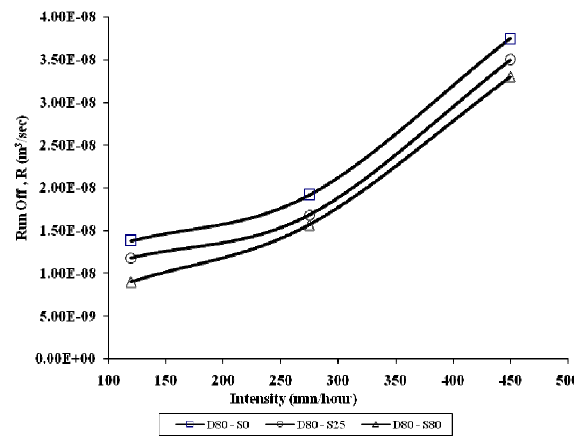

Figure 14. Relation of runoff and rainfall intensity at 80% of soil density ***(D_{80})***

Figure 14 is showing that the runoff rate in 80 % of soil density will reach its maximum value at 3,75 x 10^{-8} m^3/sec or at 0% of sand content and 450 mm/hour of rainfall intensity, while its minimum value at 9,00 x 10^{-9} m^3/sec or at 50% of sand content and 120 mm/hour of rainfall intensity.

The percolation characteristic test obtained that relation between percolation and rainfall intensity is inversely proportional. The increasing of rainfall intensity may followed by the decreasing of percolation rate, while the relation between runoff and rainfall intensity is directly proportional. The increasing of rainfall intensity may followed by the increasing of runoff rate.

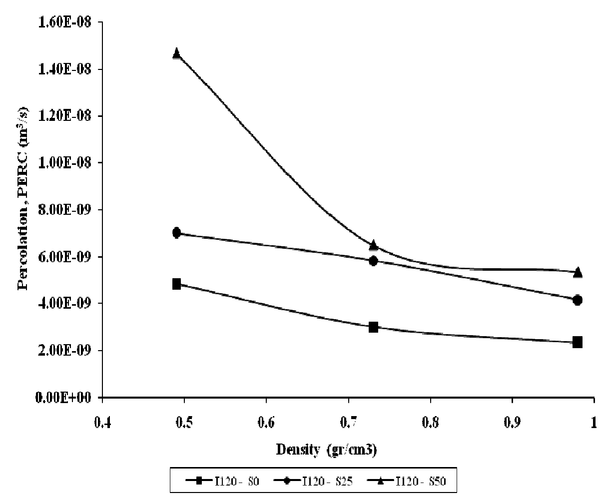

Figure 15 Relation of percolation and soil density for each soil gradation (sand content) at 120 mm/hour of rainfall intensity

Figure 15 is showing that the percolation rate in 120 mm/hour of rainfall intensity will reach its maximum value at 1,47 x 10^{-8} m^3/sec or at 40% of soil density (0,47 gr/cm^3) and 50% of sand content, while its minimum value at 2,33 x 10^{-9} m^3/sec or at 80% of soil density (0,98 gr/cm^3) and 0% of sand content.

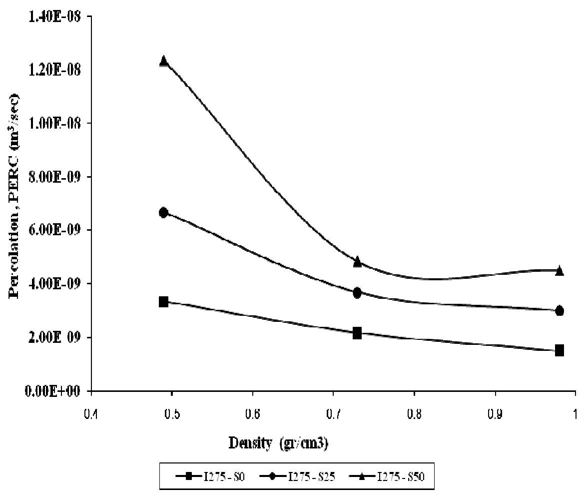

Figure 16 Relation of percolation and soil density for each soil gradation (sand content) at 275 mm/hour of rainfall intensity

Figure 16 is showing that the percolation rate in 275 mm/hour of rainfall intensity will reach its maximum value at 1,23 x $10^{-8}$$m^3$/sec or at 40% of soil density (0,47 gr/cm^3) and 50% of sand content, while its minimum value at 1,50 x 10^{-9} m^3/sec or at 80% of soil density (0,98 gr/cm^3) and 0% of sand content.

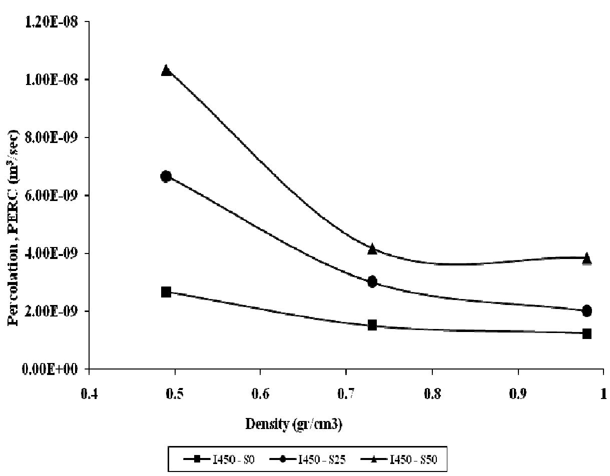

Figure 17 Relation of percolation and soil density for each soil gradation (sand content) at 450 mm/hour of rainfall intensity

Figure 17 is showing that the percolation rate in 450 mm/hour of rainfall intensity will reach its maximum value at 1,03 x 10^{-8} m^3/sec or at 40% of soil density (0,47 gr/cm^3) and 50% of sand content, while its minimum value at 1,23 x 10^{-9} m^3/sec or at 80% of soil density (0,98 gr/cm^3) and 0% of sand content.

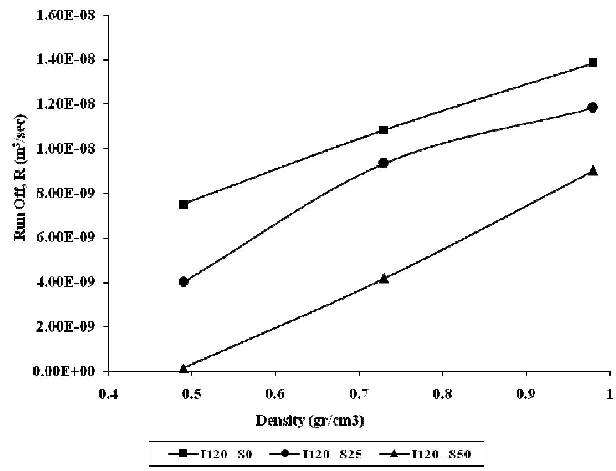

Figure 18 Relation of runoff and soil density for each soil gradation (sand content) at 120 mm/hour of rainfall intensity

Figure 18 is showing that the runoff rate in 120 mm/hour of rainfall intensity will reach its maximum value at 1,38 x 10^{-8} m^3/sec or at 80% of soil density (0,98 gr/cm^3) and 0% of sand content, while its minimum value at 1,33 x 10^{-10} m^3/sec or at 40% of soil density (0,47 gr/cm^3) and 50% of sand content.

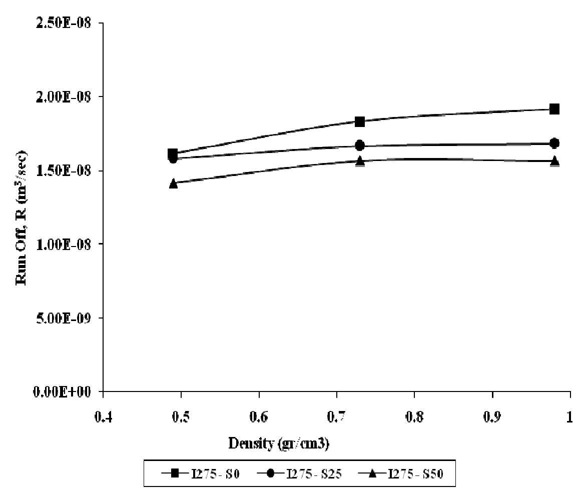

Figure 19 Relation of runoff and soil density for each soil gradation (sand content) at 275 mm/hour of rainfall intensity

Figure 19 is showing that the runoff rate in 275 mm/hour of rainfall intensity will reach its maximum value at 1,92 x 10^{-8} m^3/sec or at 80% of soil density (0,98 gr/cm^3) and 0% of sand content, while its minimum value at 1,42 x 10^{-8} m^3/sec or at 40% of soil density (0,47 gr/cm^3) and 50% of sand content.

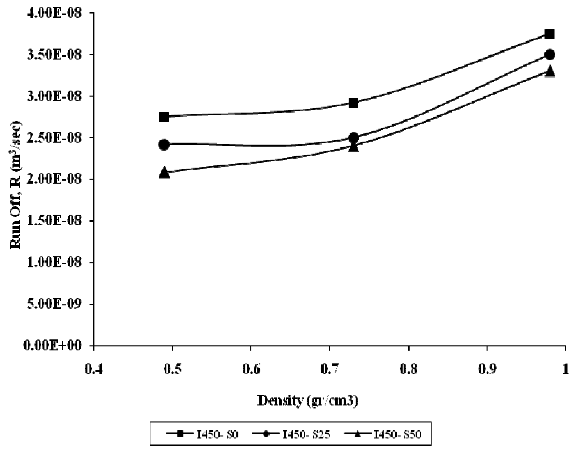

Figure 20 Relation of runoff and soil density for each soil gradation (sand content) at 450 mm/hour of rainfall intensity

Figure 20 is showing that the runoff rate in 450 mm/hour of rainfall intensity will reach its maximum value at 3,75 x 10^{-8} m^3/sec or at 80% of soil density (0,98 gr/cm^3) and 0% of sand content, while its minimum value at 2,08 x 10^{-8} m^3/sec or at 40% of soil density (0,47 gr/cm^3) and 50% of sand content.

The percolation characteristic test obtained that relation between percolation and soil density is inversely proportional. The increasing of soil density may followed by the decreasing of percolation rate, while the relation between runoff and soil density is directly proportional. The increasing of soil density may followed by the increasing of runoff rate.

CONCLUSIONS

The laboratory test result obtained that relation between percolation with rainfall intensity, soil density and soil gradation (sand content) will be given by these folowing points :

1. Relation between percolation and rainfall intensity variations is inversly proportional, the increasing of rainfall intensity may followed by the decreasing of percolation rate. In this test, percolation rate may reach its maximum rate toward the rainfall intensity at 120 mm/hour and it may reach its minimum rate at 450 mm/hour.
2. Relation between percolation and soil density variations is inversly proportional, the increasing of soil density percentage may followed by the decreasing of percolation rate. In this test, percolation rate may reach its maximum rate toward the soil density persentage at 40% (0.49 gr/cm3) and it may reach its minimum rate at 80% (0.98 gr/cm3).
3. Relation between percolation and soil gradation (variation of send content) is directly proportional, , the increasing of sand content percentage may followed by the increasing of percolation rate. In this test, percolation rate may reach its maximum rate toward the sand content persentage at 50% and it may reach its minimum rate at 0%.
4. Through this research, the relation between percolation and variety of rainfall intensity, soil density and soil gradation (variation of sand content persentage) could be obtained which is the best percolation rate may resulted at 1.47x10-8 m3/sec or from the light rainfall intensity (120 mm/hour), 40% of soil density and 50% of send content increment. The worst percolation rate may result at 1.23x10-9 m3/sec or from the hard rainfall intensity (450 mm/hour), 80% of soil density and 0% of sand content increnment.

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