International Journal of Research in Advent Technology, Vol.6, No.6, June 2018
E-ISSN: 2321-9637
Available online at www.ijrat.org

Design of Percolation Meter as a Measuring Instrument of Soil Absorption

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Abstract- Absolutely the measurement of soil absorption is using percolation tests. The result of percolation test used to construct a recharge area or an absorption well. This research is generally intended to analyze soil absorption using percolation meter in minute units per inch and calculate correction meter number for actual measurement result. The experiment was carried out at the absorption area for 6 (six) tubular holes with diameter reach 10 - 30 cm or square by the side 10-30 cm with the distance between holes reach 100 cm. The result of soil absorption measurements between non-percolation meters is almost the same as those using percolation meters. Soil absorption without using percolation meters ranging from 2.0 minutes to 2.4 minutes per inch (holes A1, A3, A5), 3.4 up to 4.3 minutes per inch (holes A2, A4 and A6), 2.0 minutes to 2.6 minutes per inch (hole B1-B6). while soil absorption using percolation meters ranges from 0.5 to 1.1 minutes per inch (hole A1-A6) and 0.5 to 0.7 minutes per inch (hole B1-B6). This shows that the porosity of the soil provided in the experimental hole is uneven (not equally) in its porosity. The reason is when mixing the sand stone with uneven soil, so the porosity or the area of the soil pores are not the same. The result of correction factor measurement is 4. The percolation rate is 40 minutes per inch. Using of percolation meter tool can avoid errors because the drop of the water surface can be known at any time. The patent process on the percolation meter is still requires field test on the real soil so the true correction factor according to percolation Meter specification will found.

Keywords: - Percolation Meter, Soil, Measuring Instrument.

1. INTRODUCTION

Percolation rate is a number indicating the ability of soil to absorb water into the soil and is needed in the preparation of waste water and rain water catchment areas for daily water supply even for water tourism [1]. According to [2], percolation is the movement of ground water from a high place to a lower place, whereas according to the Directorate General of Highways Ministry of Public Works in Book 3 on Guidelines for Investigation and Testing of Basic Ground work for Road Works [3], Percolation is an event the movement of water in the cross-section of the soil to a deeper layer of soil. [4] also defines percolation as a down ward water movement from an unsaturated water zone into a saturated zone.

The event takes place in gravity, a series of rainwater inflow or irrigation water through the soil surface (infiltration) into the soil, and the movement of water in the cross section of the soil (permeability). The speed of water entering into the soil in a given moment and within a certain surface area is called infiltration rate and infiltration capacity [5] . Infiltration provides water to fill the soil, and when the soil is saturated, the excess water will move vertically due to gravity to the deeper soil layer as percolation water, and fill up the sub surface water storage. In percolation terms, also known as percolation rate and percolation capacity.

Infiltration is the process of entering water from the surface into the soil. Percolation is the movement of water flow in the soil (from the zone of aeration to the zone of saturation). Infiltration effect on the start of the occurrence of surface flow and also affect the surface flow rate or run off [6].

Infiltration and percolation are very closely related, and both depend on soil properties, such as soil surface conditions, soil texture, structure and soil organic matter, and dense soil layers at the bottom / impermeable layer [7]. According [8], the number and size of the pore that determines is the number of large pores. The bigger the pore the infiltration capacitance gets bigger too.

So far, the measurement of soil absorption is done through experiments or percolation tests, ie experiments conducted to determine the soil's ability to pass water expressed in units of minutes per inch. Percolation figures from the experimental results are used to construct a recharge area that can be either a recharge area or an absorption well. The experiment was conducted in a location to be used as a recharge area by making 6 holes with a diameter of 10 - 30 cm or a cube with a side of 10 - 30 cm as deep as 60 cm with a distance between holes 100 cm.

The decrease of water in the test hole after 12 - 24 hours of water baiting remains, then the water level is increased to 15 cm above the surface of the gravel and then calculated the time required to absorb water 1 inch up to the last experiment, since the last result is used as reference determination of the amount of absorption rate.

The problem so far in trials is the difficulty in determining the limit of water level down in the test hole as it is based on visual and wet-looking tools as a

hint of water level position. The wet sections are still affected by the capillary system of objects used as a measuring instrument so that it still contains the risk of error so that the necessary tools that can help the accuracy and ease in the process of measurement that until now has not existed.

The percolation meter in this study was designed and designed to facilitate its use as a soil percolation device so that it can be used as a tool to assist the measurement of field recharge rates to be tested through field experiments. This research is generally intended to analyze soil absorption without using percolation meter and by percolation meter in minute units per inch and calculate correction meter number for actual measurement result.

2. RESEARCH METHODS

Pure experimental design used in this study, Post Test Only Control Group Design using 2 (two) treatments consisting of 1 experimental group and 1 control group. The land for percolation test site is a building with a size of 7 meters long, 5 meters wide and 1 meter high with 60 cm thickness of soil test field. The sample size on the experimental design uses the formula:

(r -) (k - 1) ≥ 15 [9]

e.

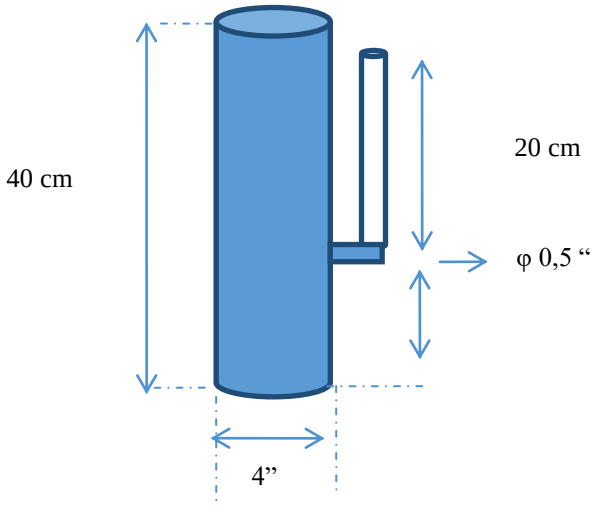

Figure 1. Percolation Meter

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r = number of replication

k = number of treatment.

The amount of treatment 2 (2 kinds of measurement) so that: r ≥ {15: (2 -1)} + 1 obtained a large sample (replication) or r ≥ 16 Replication, the sample size of 32 samples consisted of 16 samples on control and 16 sample (16 replication x 2 treatment groups).

Holes for the percolation test used to test percolation meters at the sixth end of the hole are pretentious as the bottom end of the percolation. Percolation meters are made of 3 "PVC material equipped with control pipes. The tool used to measure the water drop-off time in the percolation hole is the stop watch. Advantages Percolation Meter is easy to make, cheap and easy to operate. Percolation Meter as a catchment device used in percolation tests with specifications:

a. PVC tube φ 4 inches: 60 cm long
b. PVC hole φ 4 inches: 0.5 inches (15 cm from the base)
c. Transparent Pipe φ 0.5 inch as high as 45 cm.
d. Top and bottom border marks 6 inches long.

3. RESULTS

The absorption area is prepared as the original condition and soil conditions at each point (hole) to be used as a measuring place for obtaining absorption numbers by means without using Percolation Meter tool as the common way used by recording the time in minutes to absorb water 1 inch deep . The observation at the water level in the hole experiment of 6 (six) holes and 6 (six) holes using percolation tool Meter which previously did not exist.

Table 1

Dimension of Land Construction Research

No	KIND OF DIMENSION	SIZE	INFORMATION
1	Length of land building	5,50 meters	Inside
2	Width of land building	4,30 meters	Inside
3	Height of land building	1,00 meter	Foundation and Land
4	Thickness of foundation floor	0,15 meter	Ground floor absorption area
5	High Pipe hole absorption	0,60 meter	Floor base to the surface
6	High absorption area	0,60 meter	Floor base to surface floor
7	Wall thickness	0,25 meter	Wide outer edge to inside edge
8	Hole diameter	4,00 inch	PVC pipe given hole with 0.5 mm drill bit at 6 corners as high as 15 cm from bottom for water outlet as much as each side 15 holes with hole spacing of 0.5 mm

The first measurements were done from 9 am to 11 pm on each hole as 16 times at 6 holes without percolation equipment Meter and on 6 holes by Perkolasi Meter. The measurement of the second stage started at 13.30 to 15.30 at the same hole in a different way (cross over), 6 holes previously measured without percolation equipment Meter replaced by percolation meter and at 6 holes before with percolation meter measured without percolation Meters.

a. The absorption rate is based on the measurement without percolation meter

The absorption meter commonly use to get the absorption rate through percolation test such as in Figure 4.4. The tool used is a 60 cm long ruler connected to the steorophone as a base with a thickness of 5 cm (± 2 inches) in order to float on the surface of the water in the hole used as an indicator of the falling water level after the saturation process. On the ruler is marked the upper and lower bounds along the 6 inches.

Measurement of absorption numbers at 6 holes (A.1 to A.6 hole) and each hole performed as much as 16 times the measurement according to the results of replication chapter method of research on Saturday, August 20, 2016, starting at 09.00 to 11.00 for the first stage without Percolation Meter. The second stage measurements on 6 other holes (B1 to B.6) on the same day at 13.30 to 15.30 as much as 16 times the measurement for each hole in the same way (without Meter Percolation tool). The results of the first and second stage measurements are presented in Table 2 and Table

Table 2

Measurement Result of Infiltration Rate Without Meter Percolation Tool

In A.1 to A.6 Hole

Measurement to	Measurement Results Without Tool Percolation Meter At Hole					
	A.1 (Minute)	A.2 (Minute)	A.3 (Minute)	A.4 (Minute)	A.5 (Minute)	A.6 (Minute)
1	2,1	3,6	2,0	3,4	2,2	3,5
2	2,2	4,1	2,0	3,4	2,2	3,5
3	2,3	4,0	2,1	3,5	2,3	3,4
4	2,2	3,8	2,2	3,4	2,2	3,4
5	2,1	3,9	2,3	3,5	2,3	3,4
6	2,2	4,2	2,2	3,5	2,3	3,6
7	2,2	4,1	2,2	3,6	2,2	3.6
8	2,2	4,1	2,3	3,6	2,2	3,5
9	2,1	4,1	2,3	3,4	2,3	3,5
10	2,2	4,2	2,2	3,6	2,3	3,6
11	2,1	4,2	2,2	3,6	2,3	3,6
12	2,1	4.3	2,1	3,5	2,4	3,6
13	2,2	4,3	2,1	3,5	2,3	3,7
14	2,2	4,3	2,2	3,6	2,3	3,7

15	2,2	4,3	2,2	3,5	2,4	3,6
16	2,3	4,3	2,1	3,5	2,4	3,7
Total	**34,9**	**64,9**	**34,7**	**56,1**	**36,6**	**56,9**
Range	**2,1 – 2,3**	**3,6 – 4,3**	**2,0 – 2,3**	**3,4 – 3,6**	**2,2 – 2,4**	**3,4 – 3,7**
Rate	**2,18 (2,2)**	**4,06 (4,1)**	**2,17 (2,2)**	**3,51 (3,5)**	**2,29 (2,3)**	**3,56 (3,6)**

Table 3

Measurement Result of Infiltration Rate Without Percolation Meter

In B.1 to B.6 Hole

Measurement to	Measurement Results Without Percolation Meter At Hole					
	B.1 (Minute)	B.2 (Minute)	B.3 (Minute)	B.4 (Minute)	B.5 (Minute)	B.6 (Minute)
1	2,0	2,3	2,0	2,2	2,1	2,3
2	2,0	2,3	2,0	2,2	2,1	2,3
3	2,2	2,3	2,1	2,3	2,1	2,4
4	2,1	2,4	2,2	2,3	2,2	2,4
5	2,1	2,4	2,2	2,3	2,3	2,4
Measurement to	Measurement Results Without Percolation Meter At Hole					
	B.1 (Minute)		B.1 (Minute)		B.1 (Minute)	
6	2,2	2,4	2,2	2,4	2,3	2,5
7	2,2	2,3	2,2	2,3	2,2	2,4
8	2,3	2,4	2,3	2,4	2,2	2,4
9	2,3	2,3	2,2	2,4	2,3	2,4
10	2,3	2,4	2,2	2,5	2,3	2,4
11	2,3	2,4	2,2	2,4	2,4	2,5
12	2,2	2,5	2,2	2,4	2,4	2,5
13	2,3	2,5	2,2	2,5	2,4	2,5
14	2,2	2,4	2,3	2,6	2,4	2,5
15	2,3	2,5	2,4	2,5	2,4	2,6
16	2,3	2,5	2,4	2,5	2,4	2,6
Total	**35**	**38,1**	**35,3**	**38,2**	**36,5**	**39,1**
Range	**2,0 – 2,3**	**2,3– 2,5**	**2,0 – 2,4**	**2,2 – 2,6**	**2,1 – 2,4**	**2,3 – 2,6**
Rate	**2,18 (2,2)**	**2,38 (2,4)**	**2,21 (2,2)**	**2,39 (2,4)**	**2,28 (2,3)**	**2,44 (2,4)**

The results of soil percolation measurements without equipment percolation Meter in the first and second stage in the experimental land can be concluded the ranged from 2.0 -4.3 minutes per inch with an average ranged from 2.2 to 4.1 minutes per inch . The average of overall (12 holes) reach 2.7 minutes per inch.

b. The absorption rate Using Percolation Meter

Measurement of absorption numbers at 6 holes and each hole performed 16 times starting at 09.00 to 11.00 for the first stage without percolation meter. The second stage of the other (6 holes) was performed on the same day at 13.30 to 15.30, 16 times the measurement for each hole in the same way (with Percolation Meter equipment). The first stage measurement results are presented in Table 4 and Table 5

Table 4

Measurement Result of absorption numbers With Percolation Meter In B.1 to B.6 Hole

Measurement to	Measurement Results With Percolation Meter At Hole (Minute)					
	B.1	B.2	B.3	B.4	B.5	B.6
1	0,5	0,6	0,5	0,5	0,5	0,6
2	0,5	0,6	0,5	0,5	0,5	0,6
3	0,5	0,6	0,5	0,6	0,5	0,6
4	0,5	0,6	0,5	0,6	0,5	0,6

5	0,5	0,6	0,5	0,6	0,5	0,6
6	0,6	0,6	0,5	0,6	0,5	0,6
7	0,6	0,6	0,5	0,6	0,5	0,6
8	0,6	0,6	0,6	0,6	0,6	0,6
9	0,6	0,6	0,6	0,6	0,6	0,6
10	0,6	0,6	0,6	0,6	0,6	0,6
11	0,6	0,6	0,6	0,6	0,6	0,6
12	0,6	0,6	0,6	0,6	0,6	0,6
13	0,6	0,6	0,6	0,6	0,6	0,7
14	0,5	0,6	0,6	0,6	0,6	0,7
15	0,6	0,7	0,6	0,6	0,6	0,7
16	0,6	0,7	0,6	0,6	0,6	0,7
Total	**9**	**9,8**	**8,9**	**9,4**	**8,9**	**10**
Range	**0,5 – 0,6**	**0,6 – 0,7**	**0,5 - 0,6**	**0,5 – 0,6**	**0,5 - 0,6**	**0,6 – 0,7**
Rate	**0,56**	**0,61**	**0,56**	**0,59**	**0,56**	0,63
(Rounding)	**(0,6)**	**(0,6)**	**(0,6)**	**(0,6)**	**(0,6)**	**(0,6)**

Table 5

Measurement Result of absorption numbers With Percolation Meter In A.1 to A.6 Hole

Measurement to	Measurement Results With Percolation Meter At Hole (Minute)					
	A.1	A.2	A.3	A.4	A.5	A.6
1	0,5	1,1	0,5	0,9	0,5	0,6
2	0.5	1,1	0,5	0,9	0,5	0,6
3	0,5	1,1	0,5	0,9	0,6	0,6
4	0.5	1,1	0,5	0,9	0,6	0,6
5	0,5	1,1	0,6	0,9	0,6	0,6
6	0,5	1,1	0,6	0,9	0,6	0,6
7	0,5	1,0	0,6	0,9	0,6	0,6
8	0.5	1,0	0,6	0,9	0,6	0,6
9	0,5	1,0	0,6	0,9	0,6	0,6
10	0.5	1,0	0,6	0,9	0,6	0,6
11	0,5	1,0	0,6	0,9	0,6	0,6
12	0,5	1,0	0,5	0,9	0,6	0,6
13	0,5	1,0	0,5	0,9	0,6	0,7
14	0.5	1,0	0,5	0,9	0,6	0,7
15	0,5	1,0	0,5	0,9	0,6	0,7
16	0.5	1,0	0,5	0,9	0,6	0,7
Total	**8,0**	**16,6**	**8,7**	**14,4**	**9,4**	**10**
Range	**0,5**	**1,0 – 1,1**	**0,5 – 0,6**	**0,9**	**0,5 – 0,6**	**0,6 – 0,7**
Rate	0,5	1,0	**0,54**	0,9	0,59	0,63
(Rounding)	**(0,5)**	**(1,0)**	**(0,5)**	**(0,9)**	**(0,6)**	**(0,6)**

Based on the results of soil percolation measurements using percolation meter in the first stage (holes B.1 to B.6) and the second stage (holes A.1 to A.6) on the experimental field of Environmental Health Poltekkes Kemenkes Surabaya can be concluded ranging from 0.5 to 1.1 minutes per inch with an average of 0.5 to 1 minute per inch and an average total absorption rate of 12 holes by 0.6 minutes per inch.

c. Correction factor using percolation Meter

The correction factor of Percolation Meter is based on the measurement result on the same hole (A.1 to A.6 and B1 to B.6) by dividing the measurement result without percolation Meter with the measurement result presented in table 6

Table 6

Average Measurement Result of Percolation Rate Without and With Percolation Meter on Hole A.1 to A.6 and Hole B.1 to B.6

Measurement to	Without Percolation Meter Tool (Minute)	Using Percolation Meter Tool (Minute)	Correction Factor
Hole A.1	2,2	0,5	4,2
Hole A.2	4,1	1	4,1
Hole A.3	2,2	0,5	4,2
Hole A.4	3,5	0,9	3,9
Hole A.5	2,3	0,6	3,8
Hole A.6	3,6	0,6	6
Hole B.1	2,2	0,6	3,7
Measurement to	Without Percolation Meter Tool (Minute)	Using Percolation Meter Tool (Minute)	Correction Factor
Hole B.2	2,4	0,6	4
Hole B.3	2,2	0,6	3,7
Hole B.4	2,4	0,6	4
Hole B.5	2,3	0,6	3,8
Hole B.6	2,4	0,6	3,8
Total	**31,8**	**7,7**	**49,2**
Range	**2,2 – 4,1**	**0,5 – 1**	**3,7 – 6**
Rate	**2,65 (2,7)**	**0,64 (0,6)**	**4,1 (4)**

Based on table 6 show that the average number of the absorption in A.1 to A.6 hole without percolation Meter reach the results 2.7 minutes per inch, while the measurement using Perkolation Meter reach the absorption number to 0 , 6 minutes per inch , so it can be concluded that the correction number of 4. Means the results of soil absoption using percolation Meter multiplied by 4 as a correction factor to get the real absorption number.

4. DISCUSSION

The results of soil absorption measurements on 6 holes (A.1, A.2, A.3, A.4, A.5 and A.6) and 6 other holes (B.1, B.2, B.3, B.4, B.5 and B.6) measured without the percolation Meter showed almost the same in each test hole of 16 times although there are differences in other holes. Similar measurements occur in experimental holes A.1, A.3, A.5, ranging from 2.0 min to 2.4 min per inch, except in holes A.2, A.4 and A.6 ranging from 3.4 to 4.3 minutes per inch, while in the experimental hole B1 to B.6 is relatively the same, the range from 2.0 to 2.6 minutes per inch. This shows that the porosity of the soil provided in the experimental hole is not equally. The reason is when mixing sirtu (rock sand mixture) with uneven garden soil, so the porosity or the area of the soil pores are not the same.

The results of measurements on the same hole (A.1 to A6 and B.1 to B2) were performed 16 times the measurements on each hole by using Percolation Meter showed the same result. In hole B1 to B.6 ranges from 0.5 to 0.7 minutes per inch, while in holes A.1 to A.6 ranges from 0.5 to 1.1 minutes per inch.

This shows that the porosity of the soil (the ratio of air volume to the usual soil mass volume expressed in percent) provided in the experimental hole unevenly porosity as well as on the measurement without the percolation meter. The results of percolation test on land using percolation meter want to get the easy way, simple and more accurate tool because it involves visual activity to know the drop of water level through the water surface which can occur error due to the capillary nature of the object. The use of Percolation meter tool can avoid errors because the drop of the water surface can be known at any time. The patent process on the percolation meter tool was requires field test on the real land to find the true correction factor according to percolation meter specification is needed.

Using the percolation meters on the real land was want to equalize the effect of confounding variables on real soil conditions, the same as texture (the proportion of each grain or grain forming the soil), the structure (the arrangement of the soil grains), the soil moisture that can affect the water infiltration, while the material content is suspended in water and carried out by using the same water and time together (Ministry of Public Works Directorate General of Highways, Bina Maga) [3].

Based on the results of the research on the artificial land showed that the correction factor percolation meter is 4, meaning that the actual absorption rate must be multiplied 4. For example: the result of measurement of soil percolation with percolation Meter is 10 minutes per inch, then percolation rate is 40 minutes per inch. Testing of Percolation Meter before patented, it is necessary to do further research on real hole so will find the

absorption number which really shows the soil absorption power from the water passing through the pores. The research procedure is done the same way and done with no tools and with percolation meter (Cross Over). The saturation process is carried out for 24 hours because after 24 hours, the water flow is considered uniform, and the percolation rate can be determined [10].

5. CONCLUSION

The use of percolation meter can avoid errors because the drop of the water surface can be known at any time. It can be seen that the results of soil absorption measurements between those not using percolation meters are similar to those using percolation meters. The soil absorption without using percolation meters ranging from 2.0 to 2.4 minutes per inch (holes A1, A3, A5), 3.4 to 4.3 minutes per inch (holes A2, A4 and A6), 2.0 to 2.6 minutes per inch (hole B1-B6). while the soil absorption ranges from 0.5 to 1.1 minutes per inch (hole A1-A6) and 0.5 to 0.7 minutes per inch (hole B1-B6) with correction factor of 4. The meaning of the correction factor 4 is the actual absorption rate must be multiplied 4. For example: the result of the measurement of the soil absorption using percolation meter is 10 minutes per inch, so the percolation rate is 40 minutes per inch.

6. SUGGESTION

The patent process on the percolation meter tool from this research was requires field test on the real land so will found the true correction factor according to percolation meter specification.

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