CIVED Journal of Civil Engineering and Vocational Education

EISSN: 2622-6774
Vol 11 No.2 June 2024
http://cived.ppj.unp.ac.id/index.php/CIVED

The Addition of Pore Holes in Paving Blocks in an Effort to Increase Infiltration

Eli Oktovia[1], Totoh Andayono[2*]
[1,2] Civil Engineering Departement, Universitas Negeri Padang, Indonesia
*Corresponding author, email: totoh_andayono@ft.unp.ac.id

Received 16th April 2024; Revision 20th May 2024; Accepted 27th June 2024

ABSTRACT

The problem of waterlogging and surface runoff on impermeable pavement surfaces requires finding new ways to manage water flow, especially from rainwater. The type of permeable pavement that is often used is paving block. The use of paving blocks for pavement materials is expected to reduce puddles that occur after rain. One way is to modify the paving block to be greater in seeping water into the soil. This study aims to determine the extent to which the effect of adding pore holes in paving block can increase water infiltration in surrounding soil. This research was conducted through testing in the Laboratory. The type of research is quantitative with experimental method using a rain simulator tool with variations of paving block. From the research results obtained that the addition of pores in the paving block affects the infiltration that occurs. This is evidenced by the increae in the value of infiltration, the infiltration rate value of normal paving block is 182.92-10.43 mm/hour, 2% ratio is 183.75-10.75 mm/hour, 5% ratio is 190.00-11.30 mm/hour, 7% ratio is 231.33-11.46 mm/hour, 10% ratio is 236.88-17.61 mm/hour. From the test results between pore holes with infiltration rate has a significant relationship of 0.037 (<0,05).

Keywords: *Infiltration; Pore Holes; Horton Model; Paving Block; Rain Simulator.*

INTRODUCTION

Infiltration, which is part of the water cycle, is the entry of water into the soil. Infiltration rates are influenced by permeability, vegetation cover, water volume, rainfall intensity, pre-saturation levels, soil topography and evapotranspiration rates. Factors such as soil type, slope and vegetation cover can affect infiltration capacity. Therefore, infiltration plays an important role in keeping water available on earth and maintaining the ecosystem. Infiltration is also referred to as the way water seeps into the soil through cracks and pores in the soil and rock to reach the groundwater table.

During the rainy season, flooding is prone to occur due to the high intensity of rainfall which reduces water infiltration into the ground. Conversely, during the dry season, droughts and water crises occur due to decreased groundwater supply [1]. Most of the rainwater that falls on the earth's surface immediately becomes runoff because the land is not able to retain water [2]. Flooding and inundation occur due to a decrease in the catchment area of rainwater followed by a decrease in the rate of infiltration, as well as the uneven distribution of rainfall throughout the year which triggers problems related to standing water [3].

To reduce the occurrence of inundation and flooding, it is necessary to make efforts to increase

Journal of Civil Engineering and Vocational Education
EISSN: 2622-6774
Vol 11 No.2 June 2024
http://cived.ppj.unp.ac.id/index.php/CIVED

the infiltration of rainwater by increasing the rate of infiltration into the soil. As well as by increasing the pore holes in the land that has been covered by concrete pavement by replacing it with a land cover that can be penetrated by water [4]. The type of permeable pavement that is often used is paving block.

Paving blocks have been widely recognized as an alternative technology to reduce runoff volume and minimize runoff coefficient values due to their infiltration performance and ability to slow down flow [5]. Pavement construction with paving blocks is excellent in helping to conserve groundwater. Paving blocks are the result of mixing water, cement, and fine aggregate or sand. Paving blocks are available in a wide variety of sizes, shapes, surface textures, and strengths. The use of paving blocks for pavement materials is expected to reduce puddles that occur after rain [6].

Therefore, with the development of current technology, efforts are being made to improve the performance of paving blocks to be more beneficial to water conservation. One way is to modify the paving block to be larger in seeping water into the soil, so that the puddles that occur can be infiltrated optimally. The purpose of the research is to determine the extent to which the effect of adding pore holes in paving blocks can increase water infiltration in the surrounding soil (laboratory test).

METHOD

This research method is quantitative research with the type of experimental method. Quantitative research is an activity of collecting, processing, analyzing, and presenting data based on the number or amount carried out objectively with the aim of solving a problem or testing a hypothesis to develop general principles [7].

The test object in this study is an equilateral hexagon shape paving block with a side of 10 cm and a thickness of 5.5 cm. This research uses five variations including, normal paving blocks without pore holes, 2% ratio has 1 pore hole, 5% ratio has 4 pore holes, 7% ratio has 5 pore holes, 10% ratio has 7 pore holes. The quality of paving block concrete is K225 kg/cm^2 or 22.5 Mpa which is obtained from the M.Pangat factory located at Jl S. Parman No.174 B, Ulak Karang Selatan. All test specimen samples obtained from the same factory to ensure uniformity in material quality.

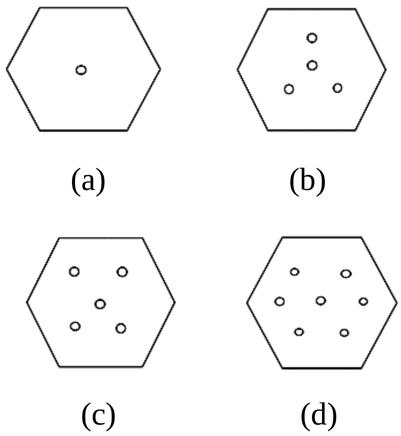

Figure 1. Variations of Porous Paving Blocks

Informations:
(a) Paving block ratio 2% = 1 pore hole

EISSN: 2622-6774
Vol 11 No.2 June 2024
http://cived.ppj.unp.ac.id/index.php/CIVED

(b) Paving block ratio 5% = 4 pore holes
(c) Paving block ratio 7% = 5 pore holes
(d) Paving block ratio 10% = 7 pore holes

Figure 2. Rain Simulator Tool

The research procedure was carried out with running test stages: Running test 1; compressive strength test on paving blocks, Running test 2; infiltration measurement on porous paving blocks and without pore holes using a rain simulator with dimensions of 120 cm x 60 cm x 40 cm.

This research was conducted from January to March 2024. The research was conducted at two locations, the first at the Structures Laboratory of the Department of Civil Engineering, Faculty of Engineering, Padang State University, and the second at the Hydro Laboratory of the Department of Civil Engineering, Faculty of Engineering, Padang State University.

The data collection procedure in this study uses primary data derived from direct tests and measurements carried out by researchers related to the material discussed.

The following is a description of the data analysis of the tests carried out:

1. Compressive Strength
   This compressive strength test is to determine the average value of compressive strength and find out how strong the paving block holds the load under different conditions or before and after the addition of pore holes with the following reference SNI 03-0691-1996:

$$\mathbf{P = F/A}$$

   Information:
   P = compressive strength
   F = maximum compressive load (kgf)
   A = cross-sectional area (cm^2)

2. Infiltration Rate
   The infiltration rate value is calculated using the following formula and continued by depicting it in the form of a curve as in the discussion section:

$$\mathbf{f_c = (\Delta H/\Delta t) \times 60}$$

   Information:

EISSN: 2622-6774
Vol 11 No.2 June 2024
http://cived.ppj.unp.ac.id/index.php/CIVED

fc = infiltration capacity (mm/hour)
ΔH = water table height (mm)
Δt = measurement time interval (hour)

3. Infiltration Capacity
To calculate the infiltration capacity value using the Horton model formula method as shown in the equation below. The Horton parameters sought are fo, fc, and k. The values of these parameters are obtained from measuring the infiltration rate using a rain simulator. Infiltration capacity is calculated using the following equation:

$$\mathbf{fp = fc + (fo\text{-}fc)\ e^{-kt}}$$

Information:
f_p = infiltration capacity (mm/hor)
f_0 = initial infiltration capacity (mm/hour)
f_c = final infiltration capacity (mm/hour)
e = 2,71828
k = geophysical constant
t = time from the beginning of rain (hour)

4. Cumulative Infiltration
To calculate the cumulative infiltration, the integral equation of Horton's model below is used, followed by plotting it on a curve as shown in the results section.

$$\mathbf{f_{(t)} = fc.t\,\frac{(f0 - fc)}{k}(1 - e^{-kt})}$$

Information:
f_t = cumulative infiltration (mm/hour)
f_0 = initial infiltration capacity (mm/hour)
f_c = final infiltration capacity (mm/hour)
e = 2,71828
k = geophysical constant
t = time from the beginning of rain (hour)

RESULT AND DISCUSSION

1. Compressive Strength

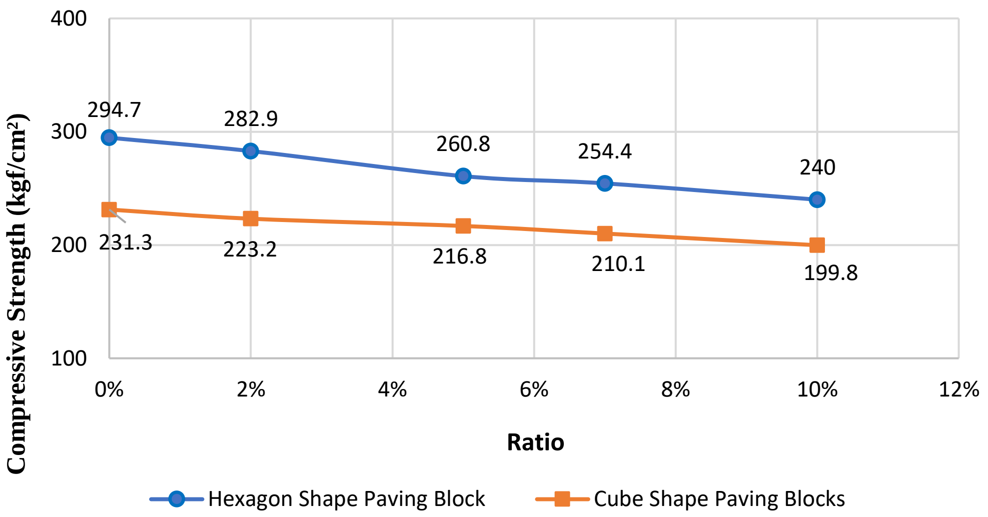

Figure 3. Average Compressive Strength of Paving Block

From Figure 3, it can be seen that the average compressive strength of the paving block decreases as the number of pore holes increases, the cube paving block (SNI shape) shows a lower compressive strength value than the hexagon paving block. Where the compressive strength of paving blocks that have added pore holes up to a ratio of 7% or 5 pore holes still meets the compressive strength standards set based on the reference from SNI-03-0691-1996 with the average compressive strength value of paving blocks for quality B (> 203.9 kgf/cm^2).

2. Infiltration Rate (fc)

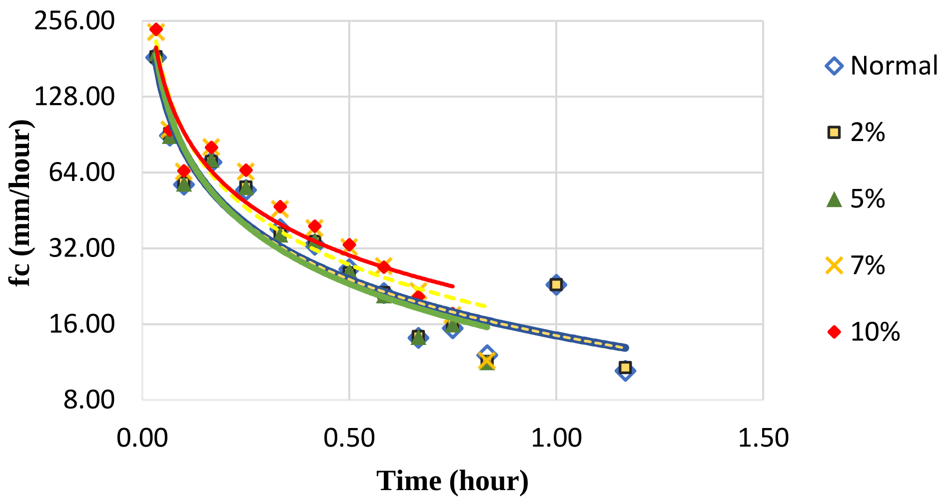

Figure 4. Paving Block Infiltration Rate Curve Recap

Based on the data in Figure 4, it can be seen that the infiltration rate value on normal paving blocks starts at 182.92 mm/hour and is constant at 10.43 mm/hour. Paving block ratio 2% starts at 183.75 mm / hour and is constant at 10.75 mm / hour, paving block ratio 5% starts at 190.00 mm / hour and is constant at 11.30 mm / hour, paving block ratio 7% starts at 231.33 mm / hour and is constant at 11.46 mm / hour, paving block ratio 10% starts at 236.88 mm / hour and is constant at 17.61 mm / hour.

3. Infiltration Capacity (fp)

EISSN: 2622-6774
Vol 11 No.2 June 2024
http://cived.ppj.unp.ac.id/index.php/CIVED

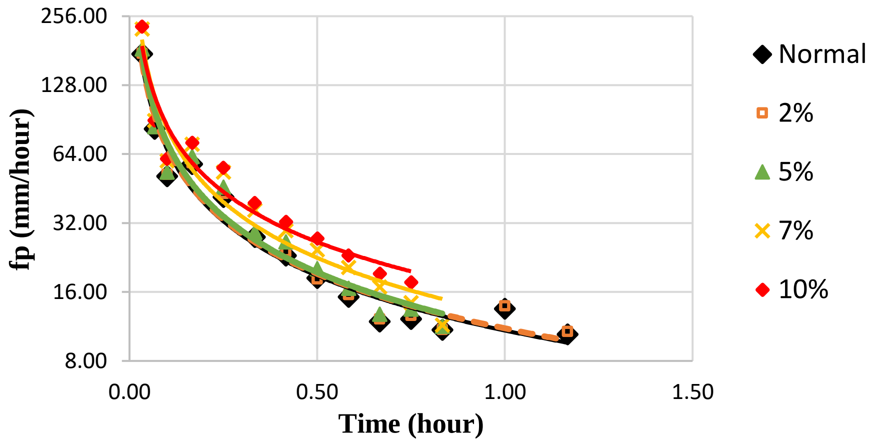

Figure 5. Recap of Paving Block Infiltration Capacity Curve

Based on the data in Figure 5, it can be seen that the infiltration capacity of normal paving blocks has a value of 10.43 mm/hour and reaches a constant point at 1.17 hours. Paving block ratio 2% of 11.30 mm / hour and reached a constant point at 1.17 hours, paving block ratio 5% of 11.30 mm / hour and reached a constant point at 0.83 hours, paving block ratio 7% of 11.46 mm / hour and reached a constant point at 0.83 hours, paving block ratio 10% of 17.61 mm / hour and reached a constant point at 0.75 hours.

4. Cumulative Infiltration (ft)

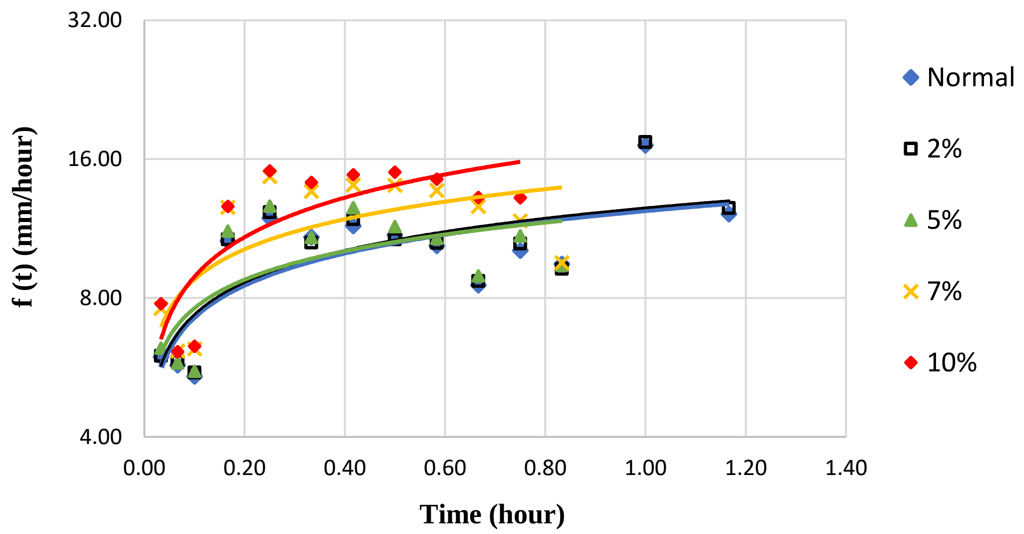

Figure 6. Paving Block Cumulative Infiltration Curve Recap

Based on the data in Figure 6, it can be seen that Cumulative Infiltration on normal paving blocks has a value of 12.17 mm / hour at 1.17 hours. The 2% ratio paving block is 12.54 mm/hour at 1.17 hours, the 5% ratio paving block is 9.42 mm/hour at 0.83 hours, the 7% ratio paving block is 9.55 mm/hour at 0.83 hours, the 10% ratio paving block is 13.21 mm/hour at 0.75 hours.

5. T- Test

Table 1. Value of T Test Between Pore Holes and Infiltration Rate

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	15.415	.362		42.627	.000
	Lubang Pori	.305	.085	.901	3.598	.037

From the results of Table 1, the significance value of the t-test is 0.037 < 0.05. These results indicate that the pore hole variable has an influence on the infiltration rate.

CONCLUSION

The conclusion obtained from this research is that the addition of pores in paving blocks affects the infiltration that occurs. This is evidenced by the increase in infiltration value. where the infiltration value increases along with the increase in the number of pores in the paving block. Then from the results of the t-test data analysis using SPSS software, it is found that the pore holes have a significant relationship to the infiltration rate where the significance value of the pore hole variable is 0.037 (< 0.05). The addition of pore holes affects the rate of water infiltration into the surrounding soil.

REFERENCE

[1] D. Ulfiana, N. S. Ristianti, N. Bashit, and Y. E. Windarto, "Sistem Paving Block Lolos Air untuk Mendukung Konsep Water Sensitive Urban Design di Kecamatan Bayat Kabupaten Klaten," Media Komunikasi Teknik Sipil, vol. 28, no. 1, pp. 90-98, Jul. 2022. https://doi.org/10.14710/mkts.v28i1.43103

[2] Desti, I., & Ula, A. (2021). Analisis Sumber Daya Alam Air. *Jurnal Sains Edukatika Indonesia (JSEI)*, *3*(2).

[3] Nanda, A., & Nurnawaty, N. (2015). Kapasitas Infiltrasi Tanah Timbunan dengan Tutupan Paving Blok (Uji Model Laboratorium).

[4] Fiki, D. A. (2020). Penambahan Lubang Pori pada Paving Blok dalam Upaya Mengurangi Limpasan Air Permukaan *The Addition Pore Hole On Paving Block In Effort To Reduce Surface Water Runoff* (Doctoral dissertation, Universitas Mataram).

[5] Yasa, I. W., & Supriyadi, A. (2020). Koefisien Limpasan Permukaan pada Perkerasan Paving Block Berpori. *Ganec Swara*, *14*(2), 721-731. https://doi.org/10.35327/gara.v14i2.158

[6] Fauzi, A., Handayani, N. K., Trinugroho, S., & Nurchasannah, Y. (2023). Analisis Kuat Tekan dan Daya Serap *Paving Block* Menggunakan Pasir Sungai Samin pada Variasi

Panjang Serat Ijuk. *Civeng: Jurnal Teknik Sipil dan Lingkungan*, *4*(1). http://dx.doi.org/10.30595/civeng.v4i1.14850

[7] Duli, N. (2019). *Metodologi Penelitian Kuantitatif: Beberapa konsep dasar untuk penulisan skripsi & analisis data dengan SPSS*. Deepublish.

[8] Harjadi, B. (2020). *Tindakan Konservasi Menyelamatkan Produktivitas Lahan dan Ketersediaan Air dalam Tanah*. Deepublish.

[9] Asmorowati, E. T., Rahmawati, A., Sarasanty, D., Kurniawan, A. A., Rudiyanto, M. A., Nadya, E., & Nugroho, M. W. (2021). *Drainase Perkotaan*. Perkumpulan Rumah Cemerlang Indonesia.

[10] Nanda, A. R. (2022). *Subtitusi Konstanta Horton untuk Analisis Kapasitas Infiltrasi*. Nas Media Pustaka.

[11] Tawakal, G. I., & Lesmana, R. Y. (2022). Analisis Kapasitas Infiltrasi pada Variasi Tutupan Lahan dengan Metode Horton di Kota Palangkaraya. *Briliant: Jurnal Riset dan Konseptual*, *7*(3), 804-814. http://dx.doi.org/10.28926/briliant.v7i3.994

[12] Wirosoedarmo, R. (2019). *Teknik irigasi permukaan*. Universitas Brawijaya Press.

[13] Hutagaol, R. R. (2015). *Konservasi Tanah dan Air (Buku Ajar)*. Deepublish.

[14] Rosdiana. (2018). "Upaya Konservasi Sumber Daya Air Yang Inovatif dalam Merancang Pemanfaatan Sumber Daya Alam." *Jurnal Hutan Tropika* 13 (2): 121–29. https://doi.org/10.36873/jht.v13i2.301

[15] Wulansari, R., & Rezamela, E. (2021). Pendugaan laju run off dan infiltrasi dengan rainfall simulator sederhana pada berbagai kondisi tanah Andisol di perkebunan teh. JPP (Jurnal Pengelolaan Perkebunan), 2(2):51-58. https://doi.org/10.54387/jpp.v1i1.9

[16] Indriatmoko, R. H., Kristyawan, I. P. A., & Shoiful, A. (2015). Pengukuran Infiltrasi dalam Kawasan Teknopark Pelalawan. *Jurnal Air Indonesia*, *8*(2). https://doi.org/10.29122/jai.v8i2.2372