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The Effect of Variations in Drainage on Infiltration Rates in Pore Cylindrical Drainage

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Abstract

Inundation and floods are caused by a combination of factors including lower rain catchment areas, decreasing infiltration rates, and an uneven distribution of rainfall throughout the year, which all combine to create flooding and inundation issues. The alternative option is to install an efficient drainage system that is ecologically friendly, since in addition to its role of accommodating and draining water, it also has the additional purpose of absorbing water into the subsurface soil layer. A pore hole is created at the bottom of the drainage channel in order for the water to be absorbed. There was a desire to investigate the impact of soil texture on the rate of infiltration, therefore this research was conducted. Three kinds of soil were utilized as infiltration medium, namely sandy loam, loam, and clayey loam, all of which were found in the surrounding area. In addition, there are three variants of hole spacing, namely 16 cm, 32 cm, and 48 cm, as well as three variations of flow rate, namely 400 cm3/s, 1500 cm3/s, and 2500 cm3/s, among others. As a consequence of laboratory studies, it has been shown that the impact of changes in flow rate on infiltration discharge is inversely proportional to the flow rate, i.e., the higher the flow rate, the smaller the infiltration discharge that occurs. The reason for this is because it is influenced by the flow velocity.

Introduction

The source of the issue of flooding in urban areas starts with population growth that is much faster than the national average growth rate, owing to urbanization, seasonal migration, and permanent migration, all of which contribute to floods. In the absence of sufficient urban infrastructure and amenities, population expansion results in the disorganization of the use of urban land, which leads to flooding and inundation. In the absence of adequate urban infrastructure and facilities, population growth results in flooding and inundation.

As defined in the field of civil engineering in general, drainage is defined as a technical action that is performed to reduce excess water that may result from rainwater runoff or seepage, as well as excess irrigation water from a given area or land, in order to prevent the area or land from being disturbed. Drainage may also be described as an effort to regulate the salinity of groundwater in order to improve its quality (Clark & Pitt, 2007; ITiwari & Goel, 2017). As a result, drainage encompasses not just surface water but also groundwater resources.

This is the process of water moving through a landscape from above into the soil surface. Infiltration is defined as the downward flow of water through the soil surface and into the soil profile of a certain area of ground. When water seeps into the earth, it makes it accessible for plant development, and groundwater is replenished. Rainwater is separated from runoff, soil moisture, and groundwater via infiltration at the ground surface (Berland et al., 2017).

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Flowing water downhill through the soil profile (infiltration) is closely linked to percolation, which is the movement of water downwards through the soil profile. Percolation is made possible by infiltration of water into the soil (Baram et al., 2012). Because of the moist soil's high infiltration rate, it cannot surpass its high percolation rate.

The quantity of water that may be bound in a given amount of soil texture is determined by the amount of soil moisture content present. Clay soils contain extremely tiny mineral particles and very narrow pore spaces, making them ideal for agriculture (Dexter et al., 2008). Due to the high mineral particle sizes present in sandy soils, the pore size of the soil is likewise big. However, the little quantity of pore space found in clayey soils adds significantly to the overall amount of pore space found in the same volume of soil.

As a porous substance, soil allows water to easily pass through the pores between soil particles, indicating that it is permeable. Water in the soil moves from a point of greater energy to a point of lower energy as it moves through the soil. This happens as a result of water seeping into the soil via the pores of the soil. Permeability refers to the ability of water to flow through the pores of the soil in its natural state (Li et al., 2014). Particle size, soil type, and soil density all have an impact on groundwater permeability, as does the presence of water. Infiltration or percolation into the soil is the term used to describe the process of water flowing through the soil via cracks, soil pores, and rocks on its way to the groundwater table (Beven & Germann, 2013; Sprenger et al., 2019). The amount of water that infiltrates into the soil varies based on the amount of water that is present, the soil surface conditions, the soil structure, and the amount of soil and air moisture that is present in the soil. Aspects such as pore size, pore stability, water content, and soil profile all contribute to infiltration capacity determination (Hardie et al., 2014; Kakeh et al., 2020).

Floods and inundation are caused by a reduction in rain catchment areas, which is followed by a reduction in infiltration rates, as well as an uneven distribution of rainfall throughout the year, resulting in flooding and inundation (Mahmoud et al., 2014). An alternate approach is to increase the rate of infiltration or the rate of infiltration into the soil in order to absorb rainfall. When it comes to the amount or ability of water to penetrate the soil surface, the cover and condition of the soil surface have a significant role. The features of the soil, particularly its internal structure, play a role in the pace at which water moves through the soil mass (Helliwell et al., 2013). Pore size and pore stability are the two most significant soil structural components (Dal Ferro et al., 2012).

Water inundation may be reduced via the drainage system, which is one of the methods used to combat floods. Construction of an efficient, ecologically friendly drainage system is required (Almasi et al., 2016; Ching, 2020). This system must not only act to collect and drain water from the road body, but it must also serve as a medium for water absorption into the layers underneath it. In order to minimize runoff caused by the flow of water flowing into the drainage channel building surpassing the maximum designed capacity, this is required as a preventative precaution. Making pores or absorption holes along the bottom of the channel is one of the most effective methods of absorbing water.

This research makes use of a change in the flow rate of the ratio of the infiltration rate as an independent variable, and following the presence of a porous cylinder, it examines infiltration in the drainage channel with a porous cylinder as the dependent variable

Methods

This type of research is an experimental research laboratory test model of cylindrical pore drainage, in which the conditions of the research are designed and arranged in such a way that they are easier for researchers to work with reference to reference sources/literature that is relevant to the research.

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Data acquired directly from physical model simulations in the laboratory are known as primary data. These data include flow rate (Q), water content (w), water level (h), and infiltration rate (I) (f). Second-hand information, also known as secondary information, refers to information gathered from books and articles as well as the findings of previous study, which may have been conducted in the laboratory or in other locations that are relevant to this research. For example, books, reports, journals, and other types of publications.

In line with the study's goals and objectives, data from the laboratory is processed and used as raw material for the analysis of the study's findings. Applied data is relevant data that may be used to aid in the analysis of study findings. The calculation of flow rate (Q), the calculation of Darcy flow rate (Q Darcy), and the calculation of hydraulic gradient/pressure height are all part of the analysis of data about the connection between variables in the research.

Results and Discussion

Effect of Drainage Discharge on Infiltration Discharge in Cylindrical Pore Drainage

Aspects of the drainage model that are verified in this study include the flow rate, which is influenced by the pressure height, the distance between the cylindrical pore holes, the height of the pore cylinder, and the use of vario-pores. This study was conducted to see the infiltration capability of the drainage model carried out in the laboratory using soil made based on the texture of soil samples taken from three flood locations in City X. There were three variants utilized in this research, with Q1 = 0.004 cm3/s, Q2 = 0.0015 cm3/s, and Q3 = 0.0025 cm3/s, respectively, for flow rate. The height of the pore cylinder varies as well, with 15 cm, 10 cm, and 5 cm being the most common measurements. Sandy loam, loam, and loamy soil are the three types of loam that may be found.

The Relationship of Flow Discharge to Infiltration Flow in Sandy Clay Soil Samples

Table 1. Infiltration discharge data for various flow rates, the distance of the pore cylinder holes and the height of the pore cylinders in sandy clay soils

Hole Distance (cm)	Pore Cylinder Height (cm)	Flow Discharge cm3/s	Infiltration Discharge cm^3/s	Infiltration Discharge ml/sec
16	15	0,0004	10,451	10,451
		0,0015	9,962	9,962
		0,0025	9,893	9,893
	10	0,0004	9,869	9,869
		0,0015	9,493	9,493
		0,0025	9,122	9,122
	5	0,0004	8,849	8,849
		0,0015	8,546	8,546
		0,0025	8,329	8,329
32	15	0,0004	7,982	7,982
		0,0015	7,720	7,720
		0,0025	7,452	7,452
	10	0,0004	7,251	7,251
		0,0015	7,670	7,670
		0,0025	7,057	7,057
	5	0,0004	6,748	6,748
		0,0015	6,681	6,681
		0,0025	6,217	6,217
48	15	0,0004	5,011	5,011
		0,0015	4,944	4,944

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		0,0025	4,870	4,870
	10	0,0004	4,853	4,853
		0,0015	4,603	4,603
		0,0025	4,589	4,589
	5	0,0004	4,484	4,484
		0,0015	4,416	4,416
		0,0025	4,360	4,360

Relationship between Flow Flow and Infiltration Flow in Clay Samples

Table 2. Infiltration Flow Data for various flow rates, hole distances, and porous cylinder heights in sandy clay soil

Hole Distance (cm)	Pore Cylinder Height (cm)	Flowing Discharge cm3/sec	Infiltration Discharge cm³/sec	Infiltration Discharge ml/sec
16	15	0,0004	8,502685185	8,503
		0,0015	8,393407407	8,393
		0,0025	8,169277778	8,169
		0,0004	8,094370370	8,094
	10	0,0015	8,017259259	8,017
		0,0025	7,648870370	7,649
		0,0004	7,266370370	7,266
	5	0,0015	6,862805556	6,863
		0,0025	5,215231481	5,215
		0,0004	7,005722222	7,006
	15	0,0015	6,584013889	6,584
		0,0025	6,371798611	6,372
		0,0004	6,371395833	6,371
32	10	0,0015	6,371798611	6,372
		0,0025	6,286305556	6,286
		0,0004	6,143888889	6,144
	5	0,0015	6,052347222	6,052
		0,0025	5,901965278	5,902
		0,0004	4,001587302	4,002
	15	0,0015	3,977710317	3,978
		0,0025	3,754047619	3,754
		0,0004	3,727329365	3,727
48	10	0,0015	3,697547619	3,698
		0,0025	3,672579365	3,673
		0,0004	3,631519841	3,632
	5	0,0015	3,627898810	3,628
		0,0025	3,507880952	3,508

Relationship between Flow and Infiltration Flow in Clay Samples

Table 3. Data of Infiltration Discharge for various flow rates, hole spacing, and porous cylinder height in sandy clay soils

Hole Distance (cm)	Cylinder Pore Height (cm)	Flowing Discharge cm3/sec	Infiltration Discharge cm³/sec	Infiltration Discharge ml/sec
16	15	0,0004	7,898	7,898

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		0,0015	7,674	7,674
		0,0025	7,103	7,103
		0,0004	7,057	7,057
	10	0,0015	6,917	6,917
		0,0025	6,899	6,899
		0,0004	6,671	6,671
	5	0,0015	6,630	6,630
		0,0025	6,590	6,590
		0,0004	6,573	6,573
	15	0,0015	6,352	6,352
		0,0025	6,338	6,338
		0,0004	6,156	6,156
32	10	0,0015	5,966	5,966
		0,0025	5,875	5,875
		0,0004	5,869	5,869
	5	0,0015	5,758	5,758
		0,0025	4,705	4,705
		0,0004	4,484	4,484
	15	0,0015	4,390	4,390
		0,0025	4,258	4,258
		0,0004	3,546	3,546
48	10	0,0015	3,450	3,450
		0,0025	3,130	3,130
		0,0004	2,969	2,969
	5	0,0015	2,923	2,923
		0,0025	2,884	2,884

The Effect of Soil Drainage on Infiltration Discharge

Table 4. Max infiltration discharge data on various soil types

Hole Distance (Cm)	Cylinder Height (cm)	Flowing Discharge (cm3/sec)	Infiltration Discharge (cm³/Sec)		
			Sandy Clay	Clay	Terracotta
16	15	0,0004	10,451	8,503	7,898
32	10	0,0015	7,982	7,006	6,573
48	5	0,0025	5,011	4,002	4,484

A cylindrical pore distance of 16 cm seems to have a higher value than a cylindrical pore distance of 32 cm or 48 cm, which appears to have a greater value than the value of infiltration discharge. Infiltration occurs with an infiltration discharge of 10,451 cm3/s of sandy clay, 8,503 cm3/s of clay, and 7,893 cm3/s of clayey clay at a cylindrical pore spacing of 16 cm, a cylindrical pore height of 15 cm, and a flow rate of 0.0004 cm3/s.

These were carried out under the same circumstances at distances of 32 and 48, with cylinders of 10 and 5 pores and flow rates of 0.0015 and 0.0025 in the second and third samples, respectively. It was discovered that increasing the flow rate has a significant impact on the infiltration discharge. The infiltration discharge decreases in proportion to the flow rate. And the relationship between the infiltration discharge, the pore cylinder height, the hole distance, the infiltration discharge, and soil texture, with the higher the pore cylinder and the small flow rate indicating that the infiltration discharge is increased.

Because of the smaller grain size of the sandy clay sample, the infiltration discharge was higher in the sandy clay sample than in the clay sample and the loamy clay sample. Compared

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to the sandy clay soil sample, the clay soil sample has much less sand (which has a large dominant soil grain size which has a large pore size and small soil compaction so that the infiltration rate is large). For its part, a clayey clay sample that has almost the same grain size as both big and tiny soil grains has a dense pore size and high soil compaction, while also having a small infiltration discharge, suggesting that it has a small infiltration discharge

Conclusion

According to the findings of the research, the impact of changes in flow discharge on infiltration discharge may be summarized as follows: the higher the flow rate, the smaller the infiltration discharge that occurs. This is due to the fact that it is affected by the flow rate. Based on the findings of the research, it can be inferred that the soil type, flow rate, cylindrical pore height, cylindrical pore hole spacing, and water level are the variables that influence the infiltration discharge. The data gathering must be increasingly numerous and diverse in order to facilitate future study and ensure that the results are clear and correct. In order to conduct additional study, soil density data for each soil sample was gathered and used as a reference material for each soil sample.

References

Almasi, A., Dargahi, A., Ahagh, M., Janjani, H., Mohammadi, M., & Tabandeh, L. (2016). Efficiency of a constructed wetland in controlling organic pollutants, nitrogen, and heavy metals from sewage. *Journal of chemical and pharmaceutical sciences*, *9*(4), 2924-2928.

Baram, S., Kurtzman, D., & Dahan, O. (2012). Water percolation through a clayey vadose zone. *Journal of Hydrology*, *424*, 165-171.

Berland, A., Shiflett, S. A., Shuster, W. D., Garmestani, A. S., Goddard, H. C., Herrmann, D. L., & Hopton, M. E. (2017). The role of trees in urban stormwater management. *Landscape and urban planning*, *162*, 167-177.

Beven, K., & Germann, P. (2013). Macropores and water flow in soils revisited. *Water resources research*, *49*(6), 3071-3092.

Ching, F. D. (2020). *Building construction illustrated*. John Wiley & Sons.

Clark, S. E., & Pitt, R. (2007). Influencing factors and a proposed evaluation methodology for predicting groundwater contamination potential from stormwater infiltration activities. *Water Environment Research*, *79*(1), 29-36.

Dal Ferro, N., Berti, A., Francioso, O., Ferrari, E., Matthews, G. P., & Morari, F. (2012). Investigating the effects of wettability and pore size distribution on aggregate stability: the role of soil organic matter and the humic fraction. *European journal of soil science*, *63*(2), 152-164.

Dexter, A. R., Czyż, E. A., Richard, G., & Reszkowska, A. (2008). A user-friendly water retention function that takes account of the textural and structural pore spaces in soil. *Geoderma*, *143*(3-4), 243-253.

Hardie, M., Clothier, B., Bound, S., Oliver, G., & Close, D. (2014). Does biochar influence soil physical properties and soil water availability?. *Plant and soil*, *376*(1), 347-361.

Helliwell, J. R., Sturrock, C. J., Grayling, K. M., Tracy, S. R., Flavel, R. J., Young, I. M., ... & Mooney, S. J. (2013). Applications of X-ray computed tomography for examining biophysical interactions and structural development in soil systems: a review. *European Journal of Soil Science*, *64*(3), 279-297.

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Kakeh, J., Gorji, M., Mohammadi, M. H., Asadi, H., Khormali, F., Sohrabi, M., & Cerdà, A. (2020). Biological soil crusts determine soil properties and salt dynamics under arid climatic condition in Qara Qir, Iran. *Science of the total environment*, *732*, 139168.

L i, X., Li, J. H., & Zhang, L. M. (2014). Predicting bimodal soil–water characteristic curves and permeability functions using physically based parameters. *Computers and geotechnics*, *57*, 85-96.

Mahmoud, W. H., Elagib, N. A., Gaese, H., & Heinrich, J. (2014). Rainfall conditions and rainwater harvesting potential in the urban area of Khartoum. *Resources, Conservation and Recycling*, *91*, 89-99.

Sprenger, M., Stumpp, C., Weiler, M., Aeschbach, W., Allen, S. T., Benettin, P., ... & Werner, C. (2019). The demographics of water: A review of water ages in the critical zone. *Reviews of Geophysics*, *57*(3), 800-834.

Tiwari, P., & Goel, A. (2017). An overview of impact of subsurface drainage project studies on salinity management in developing countries. *Applied Water Science*, *7*(2), 569-580

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